2017 COMBINED

EPOS /POSNA

EPOSNA ANNUAL MEETING

MAY 3–6, 2017 • BARCELONA, SPAIN

FINAL PROGRAM

Annual Meeting Program Chairs:
Darko Anticevic, MD, PhD & Anthony Stans, MD

Pre-Course Program Chairs:
Rudolf R. Ganger, MD & Jeffrey R. Sawyer, MD

Local Hosts:
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Jorge Knörr, MD
Marius Aguirre Cañadell, MD

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Manuel Cassiano Neves, MD
Jeffrey Sawyer, MD
Susan Scherl, MD

POSNA extends sincere appreciation to
K2M
for their support for the production of the Final Program Book

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ACKNOWLEDGMENTS

The European Paediatric Orthopaedic Society gratefully acknowledges the following for their generous financial support during 2017.

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The Pediatric Orthopaedic Society of North America gratefully acknowledges the following for their generous financial support during 2017.

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WELCOME

Dear Colleagues,

On behalf of our local hosts Jorge Knörr, Julio De Pablos, and Marius Aguirre Cañadell, our Program Chairs Darko Anticevic and Tony Stans, and the staff and volunteers at EPOS and POSNA who worked to make this historic meeting a success, we welcome you to Barcelona for the 2017 EPOSNA Meeting. After years of planning, led by our planning committee (Deborah Eastwood, Pierre Lascombes, Peter Newton, Peter Waters and Muharrem Yazici) the first combined Annual Scientific Meeting of EPOS and POSNA, with our special guests SLAOTI and APPOS, will take place May 3-6, 2017 in Barcelona, Spain. This will be the largest pediatric orthopaedic scientific meeting in history, with over 1,300 abstracts submitted, over 200 presentations and 200 posters and e-posters.

The meeting begins on Wednesday morning with the Pre-Course entitled: "Cutting-Edge Pediatric Orthopaedics 2017: A Global Perspective," with Rudolf Ganger and Jeffrey Sawyer as Co-Chairs. The scientific sessions begin Wednesday afternoon, and run through Saturday morning. Wednesday evening is the Opening Ceremony highlighted with a lecture by Prof. Carolina Garcia Estévez on the architectures of Barcelona, from Antonio Gaudí and the Cerdà Eixample to the work of Enric Miralles in the Barcelona Olympic Games. A cocktail reception is to follow. Industry workshops will be held Wednesday and Thursday between morning and afternoon sessions, and the EPOS and POSNA annual business meetings are Friday at lunch time. Friday night is the Gala dinner at the historic Casa Llotja de Mar, in the heart of the Barcelona, and should be an extraordinary evening, bringing together both societies. Please note you must register separately for this event.

Barcelona is one of the world's great cities and an outstanding venue for this event. Situated between the mountains and the Mediterranean Sea, it is home to the Sagrada Familia Church (by Gaudi), the Picasso Museum and the 1992 Olympics; it is safe and affordable; the people are friendly and welcoming; and the art, architecture, food, weather are second to none.

We welcome you to this extraordinary meeting that will bring together world experts and old friends in a truly spectacular setting.

Manuel Cassiano Neves, MD, President of EPOS and
James McCarthy, MD, MHCM, President of POSNA

BIENVENIDO

Dear Friends and Colleagues,

As the local hosts, we give you the warmest welcome to EPOSNA 2017 in Barcelona. Both, Manuel Cassiano and Jim McCarthy, their wives and respective teams, have organized a great Scientific and Social Programme.

To this end, we do not only have the support of leading professionals and speakers but also the best congress centre, as both EPOS and POSNA deserve for a gathering of such calibre: namely the *Palau de Congressos de Catalunya* that provides top quality assembly rooms and also a spacious setting for the Commercial Exhibition, presenting the latest technical and technological developments in our specialty.

The ultimate aims of the EPOSNA Meeting are obviously science and scholarly exchange, but it is also evident that such goals are easier to achieve when the venue offers the very best atmosphere, as well as excellent tourism and leisure activities. In this aspect Barcelona has it all.

Barcelona is Art: a visit to the city's many art galleries and museums is highly recommended, as well as catching a performance at the *Liceu*, the *Palau de la Musica* or any of the many concert halls and theatres.

Barcelona is Architecture: after the introduction to Barcelona's architecture given during the EPOSNA Meeting, by Professor Carolina García in the H. Steel Lecture, it would be inexcusable not to visit the ultimate exponents of Catalan *Modernisme* (our own particular *Art Nouveau*), such as the buildings created by Gaudí and by Domenech, to cite just two examples.

Barcelona is Style: it is Light and it is Gastronomy but, above all, Barcelona is City. Take a stroll around Barcelona - not only visiting the famous *Güell Park*, *Ramblas*, *Paseo de Gracia*, etcetera but also the nooks and crannies of the *Gothic Quarter*, the *Boquería* market and so many other interesting places, then take a break at one of the wonderful bars or restaurants that fill the city. You will remember it forever...

Barcelona is the place!

Local Hosts, EPOSNA 2017, Barcelona

Julio de Pablos, MD

Jorge Knörr, MD

Marius Aguirre Cañadell, MD

WELCOME TO BARCELONA

WELCOME TO BARCELONA

The capital of Spain's Catalonia region, Europe's largest metropolis on the Mediterranean coast and Spain's second-largest city, Barcelona is a place rich in culture and history.

TOUR GUIDE

Experience Barcelona with your own personal tour guide from Robbcn. Robb is an official licensed tour guide of the Catalonia region and a specialist in Barcelona and its surroundings. He offers a variety of tours allowing you to see Barcelona in many different ways. Visit www.robbcn.com to see tours offered.

GETTING AROUND

METRO, FGC OR TRAM

The simplest and most convenient way to get around the city. Fares: Single Ticket 2,15€ / T-10 Card: 9,95€

BUS

Fares: Single Ticket 2,15€ / T-10 Card: 9,95€

BIKE

A different way to explore the city, Barcelona offers many different options to tour and get around the city by bike.

TAXI

For information on how to get around the city, visit Barcelona Turisme: www.barcelonaturisme.com/wv3/en/page/5/getting-around-the-city.html

LOCAL ATTRACTIONS

To make the most of your time in Barcelona, and more information on the city visit: barcelonaturisme.com

MARKETS

Perhaps one of the best ways to experience the city is by visiting one of Barcelona's many markets. There are 39 food markets and 4 markets selling additional goods spread out among the different neighborhoods.

SHOPPING

On Passeig de Gràcia and around the Portal del Angel and carrer Pelai.

BARCELONA HIGHLIGHTS

For those with less time to spare, our highlights tour squeezes the city's best sights into just half a day. The tour takes in Montjuïc hill, the Olympic Park with its stunning panoramic views of the city, the beautiful tree-lined La Rambla, the harbor and Gaudí's world famous masterpiece, the Sagrada Familia.

A funicular takes you up to Montjuic, its Castle and Olympic Ring. The MNAC (National Art Museum of Catalunya), has one of the most complete collections of Romanesque art in the world. The "Martinez Restaurant" offers rich Mediterranean food.

The Tibidabo Mountain, with the amusement park and the Church "Sagrado Corazon", copied from the Sacré Coeur from Paris. The restaurant "Mirablau" offers the great views. On the mountainside, the "Asador de Aranda", offers an excellent Castilian lamb.

THE OLD TOWN & LA RAMBLA

Stroll through the narrow streets and squares of the old city on this half-day walking tour, and get an authentic taste of La Rambla and the lively and historic neighborhoods surrounding the impressive Gothic Cathedral.

THE GOTHIC QUARTER and PICASSO MUSEUM

Delve into the charm and mystery of medieval Barcelona with this half-day walking tour. Visit the Cathedral and stroll through the surrounding narrow streets, stopping to enjoying the unique collection of works by Pablo Picasso, the world-renowned cubist artist who spent much of his youth in the city.

THE WORLD OF GAUDI

The astonishing architecture of Antoni Gaudí deserves at least a half-day tour in Barcelona. Do not miss the chance to admire his numerous works, including La Pedrera, Güell Park and his magnum opus, the magnificent La Sagrada Familia, still under construction 88 years after Gaudi's death.

MONTJUIC HILL: ART & GARDENS

Take a relaxing trip away from the hustle and bustle of downtown Barcelona and enter the world of Montjuïc. This majestic hill affords spectacular views of the surrounding area, and offers a calming contrast to the kinetic energy of the city. Take in the glorious gardens and beautiful Magic Fountain, or soak up the culture at the Spanish Village, The Joan Miro Foundation or The MNAC (Muse Nacional D'art De Catalunya).

BARCELONA HIGHLIGHTS

MUSEUMS

MUSEU NACIONAL D' ART DE CATALUNYA

Palau Nacional, Parc de Montjuïc, Barcelona 08038 • 93-622-0376

MONTJUÏC. Named a national museum in 1990, this is the world's greatest collection of Romanesque mural paintings and home also to an impressive array of 14th and 15th century Gothic art.

MUSEU D' ART CONTEMPORANI

Plaza Angels, 1, Barcelona 08001 • 93-481-3368 • 93-412-0810

OLD TOWN. Noteworthy ensemble of regional, national and international contemporary art. Most material is from the last 50 years and represents a wide range of mediums. Museum hosts a variety of periodic events such as concerts, seminars, and lectures. Gift shop has a great selection of unique items.

MUSEU PICASSO

Carrer Montcada, 15-23, Barcelona 08003 • 93-256-30-00

OLD TOWN. Two adjoining medieval palaces comprise this remarkable museum that houses 4,251 of the artist's early works, engravings, pottery, sculpture, and lithographs. Picasso, who spent much of his youth in Barcelona, donated this collection to the museum as a token of his affection for the city.

RESTAURANT GUIDE

ORNINA TASTING CULTURES, is inspired by a fusion of mediterranean cultures, offering an innovative cuisine with a clear gastronomic philosophy on market products and seasonal ingredients. The restaurant has a cozy dining room, lounge zone, terrace and Music Club where you can enjoy a cocktail and chill. A warm and inviting environment inspired by Arabic design.

B-24, situated at the Fairmont Rey Juan Carlos I lobby, offers a creative tapas selection without forgetting the local touch, combined with live piano music during the afternoons and DJ's at night in a large open space.

WINDSOR, essential place to taste Catalan haute cuisine in a sophisticated Modernist style space, with interior garden terrace. Beautiful quiet areas that are perfect for a meeting, incredible wine selection and an unbeatable service.

MAREA ALTA, offers smoked and grilled fish in a high-rise space with 360-degree views at the Colon Building in Barcelona. It's the ambitious project of renowned chef Enrique Valenti. Its incomparable views of the city combined with the highest quality product and a entire floor below the restaurant dedicated to Cocktails & sangrias gives a great added value to this place.

GENERAL MEETING INFORMATION

LEARNING OBJECTIVES

Objective 1: Discuss and understand at least three new developments in pediatric orthopaedics from outside your home continent.

Objective 2: Assess the outcomes of at least two new techniques or practices.

Objective 3: Understand the impact of advances in basic science on future pediatric orthopaedic practice.

Objective 4: Identify a quality, safety, and value initiative to implement in your practice.

ACCREDITATION

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American Academy of Orthopaedic Surgeons and POSNA. The American Academy of Orthopaedic Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

CONTINUING MEDICAL EDUCATION

The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of **22** AMA PRA Category 1 Credits™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

EPOSNA is granted **21** European CME Credits (ECMEC) by the European Accreditation Council for Continuing Medical Education (EACCME). Each medical specialist should claim only those hours of credit that he/she spent in the educational activity.

This conference is Eucomed approved. EthicalMedTech

DISCLAIMER

The material presented at EPOSNA has been made available by the European Paediatric Orthopaedic Society and Pediatric Orthopaedic Society of North America for educational purposes only. The material is not intended to represent the only, nor necessarily best, method or procedure appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the faculty which may be helpful to others who face similar situations.

EPOS and POSNA disclaims any and all liability for injury or other damages resulting to any individual attending EPOSNA and for all claims which may arise out of the use of the techniques demonstrated therein by such individuals, whether these claims shall be asserted by physician or any other person.

INSURANCE/LIABILITIES

POSNA and EPOS will not be held liable for personal injuries or for loss or damage to property incurred by participants or guests at the Pre-Course or Meeting, including those participating in tours and social events. Participants and guests are encouraged to take out insurance to cover losses incurred in the event of cancellation, medical expenses or damage to or loss of personal effects when traveling outside their own country.

POSNA and EPOS cannot be held liable for any hindrance or disruption of the Meeting arising from natural, political, social or economic events or other unforeseen incidents beyond its control. Registration of a participant implies acceptance of this condition.

GENERAL MEETING INFORMATION

DISCLOSURE

Each faculty member in this meeting has been asked to disclose if he or she has received something of value from a commercial company or institution, which relates directly or indirectly to the subject of their presentation.

An indication of the participant's disclosure appears after his or her name as well as the commercial company or institution that provided the support. The Academy, POSNA and EPOS do not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the meeting.

FDA STATEMENT

Some drugs or medical devices demonstrated at this meeting may not have been cleared by the FDA or have been cleared by the FDA for specific purposes only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Academy policy provides that 'off label' uses of a drug or medical device may be described in the Academy's CME activities so long as the "off label" use of the drug or medical device is also specifically disclosed (ie., it must be disclosed that the FDA has not cleared the drug or device for the described purpose). Any drug or medical device is being used "off label" if the described use is not set forth on the product's approval label.

- ◆ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

ABOUT EPOS and POSNA

EPOS
European Paediatric Orthopaedic Society

ABOUT EPOS

The European Paediatric Orthopaedic Society (EPOS) was founded in 1981, in Paris by a group of five paediatric orthopaedic surgeons. The first EPOS meeting was held in Paris and was attended by 13 surgeons. Now the society has more than 300 surgeons spread around the world.

EPOS MISSION STATEMENT

To increase the quality of care of children with orthopaedic conditions.

POSNA
PEDIATRIC ORTHOPAEDIC SOCIETY OF NORTH AMERICA

ABOUT POSNA

The Pediatric Orthopaedic Society of North America (POSNA) is a group of professionals comprised mostly of pediatric orthopaedic surgeons. We are board certified in orthopaedic surgery and have participated in additional training to become specialized in the care of children's musculoskeletal health and our practice reflects this dedication. We, as a group, strive to become the authoritative source on such care through appropriate research that will lead to the best evidence-based patient care.

POSNA MISSION STATEMENT

To improve the care of children with musculoskeletal disorders through education, research, and advocacy.

GENERAL MEETING INFORMATION

ONSITE REGISTRATION INFORMATION

ON-SITE Registration

EPOSNA MEETING REGISTRATION

POSNA or EPOS Member	$600
Non-Member	$800
Resident/Fellow/Trainee*	$400
RN/PA/Allied Health	$475
Low & Low-Middle Income Countries	$300
POSNA/EPOS Senior Members	$275
Industry/Exhibit Representative	$700
Accompanying Person	$125
Children (1-17)	FREE

PRE-COURSE REGISTRATION

POSNA or EPOS Member	$125
Nonmember	$175
RN/PA/Allied Health	$100
Resident/Fellow/Trainee*	$100

**Residents/Fellows/Trainees registering on-site will require showing either a training status ID or letter from your program director to get the R/F/T rate.*

SPEAKER READY ROOM INFORMATION

EPOSNA REQUIRES ALL ELECTRONIC PRESENTATIONS TO BE MADE USING THE CENTRAL COMPUTER SYSTEM. No Laptop computers will be allowed Note: All presentations (including concurrent sessions) MUST be uploaded in the Speaker Ready Room located in the Exhibition Hall.

Hours of Operation:

Tuesday, May 2	4:00 PM – 6:00 PM
Wednesday, May 3	7:00 AM – 6:00 PM
Thursday, May 4	7:00 AM – 6:00 PM
Friday, May 5	7:00 AM – 6:00 PM
Saturday, May 6	7:00 AM – 12:00 PM

We request that all presentations be received prior to the meeting. This year presentations may be submitted online at http://www.speakerreadyroom.com beginning February 22, 2017. The site will be available 24 hours a day, seven days a week until April 27 , 2017 at 5:00 PM CDT, 11:59 CEST. After that date please bring your presentation with you to Barcelona on a USB Flash drive. The 'Speaker Ready Area' will be in the Exhibition Hall and will be available for last minute uploading, changes and reviewing of talks. Please check in as early as possible.

E-POSTER PRESENTERS

E-Posters presenters will be displayed in Hall O.

POSTER PRESENTERS

The poster boards will be located in Hall O. The boards will be numbered corresponding to your Poster Number.

NATIONAL SOCIETY POSTER PRESENTERS

The poster boards will be located in Hall-1.

GENERAL MEETING INFORMATION

LANGUAGE

English will be the official language EPOSNA.

NO SMOKING POLICY

Smoking is not permitted during any meeting or event.

NO CAMERAS OR VIDEO CAMERAS

Cameras or video cameras may not be used in any portion of the scientific session.

NO REPRODUCTIONS

No reproduction of any kind including audio tapes and videotapes may be made of the presentations at this meeting without the prior written permission of EPOS and POSNA. EPOS and POSNA reserves all of its rights to such material and commercial reproduction is specifically prohibited.

PHOTOGRAPHS

Registration and attendance at, or participation in, EPOS and POSNA activities constitutes an agreement by the registrant to allow EPOS and POSNA to use and distribute (both now and in the future) the registrant's or attendee's image in EPOS and POSNA member communications and promotional materials.

SAFETY

EMERGENCY NUMBER AT PALAU DE CONGRESSOS DE CATALUYNA: EXT. 333

EMERGENCY: CALL 112

FIRST AID

First Aid- **Palau De Congressos De Catalunya**

Hours of Operation
Tuesday-Saturday ……7:00 AM–6:00 PM

LOST AND FOUND

Lost and Found- **Palau De Congressos De Catalunya**
From **Palau De Congressos De Catalunya** House Phone: 5880

LEVELS OF EVIDENCE FOR PRIMARY RESEARCH QUESTIONS

Types of Studies				
	Therapeutic Studies—Investigating the Results of Treatment	**Prognostic Studies—Investigating the Effect of a Patient Characteristic on the Outcome of Disease**	**Diagnostic Studies—Investigating a Diagnostic Test**	**Economic and Decision Analyses—Developing an Economic or Decision Model**
Level I	• High-quality randomized controlled trial with statistically significant difference or no statistically significant difference but narrow confidence intervals • Systematic review[2] of Level-I randomized controlled trials (and study results were homogeneous[3])	• High-quality prospective study[4] (all patients were enrolled at the same point in their disease with ≥80% follow-up of enrolled patients) • Systematic review[2] of Level-I studies	• Testing of previously developed diagnostic criteria in series of consecutive patients (with universally applied reference "gold" standard) • Systematic review[2] of Level-I studies	• Sensible costs and alternatives; values obtained from many studies; multiway sensitivity analyses • Systematic review[2] of Level-I studies
Level II	• Lesser-quality randomized controlled trial (e.g., <80% follow-up, no blinding, or improper randomization) • Prospective[4] comparative study[5] • Systematic review[2] of Level-II studies or Level-I studies with inconsistent results	• Retrospective[6] study • Untreated controls from a randomized controlled trial • Lesser-quality prospective study (e.g., patients enrolled at different points in their disease or <80% follow-up) • Systematic review[2] of Level-II studies	• Development of diagnostic criteria on basis of consecutive patients (with universally applied reference "gold" standard) • Systematic review[2] of Level-II studies	• Sensible costs and alternatives; values obtained from limited studies; multiway sensitivity analyses • Systematic review[2] of Level-II studies
Level III	• Case-control study[7] • Retrospective[6] comparative study[5] • Systematic review[2] of Level-III studies	• Case-control study[7]	• Study of nonconsecutive patients (without consistently applied reference "gold" standard) • Systematic review[2] of Level-III studies	• Analyses based on limited alternatives and costs; poor estimates • Systematic review[2] of Level-III studies
Level IV	Case series[8]	Case series	• Case-control study • Poor reference standard	• No sensitivity analyses
Level V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

1. A complete assessment of the quality of individual studies requires critical appraisal of all aspects of the study design.
2. A combination of results from two or more prior studies.
3. Studies provided consistent results.
4. Study was started before the first patient enrolled.
5. Patients treated one way (e.g., with cemented hip arthroplasty) compared with patients treated another way (e.g., with cementless hip arthroplasty) at the same institution.
6. Study was started after the first patient enrolled.
7. Patients identified for the study on the basis of their outcome (e.g., failed total hip arthroplasty), called "cases," are compared with those who did not have the outcome (e.g., had a successful total hip arthroplasty), called "controls."
8. Patients treated one way with no comparison group of patients treated another way.

This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK. For more information, please see. www.cebm.net.

2017 EPOSNA MEETING PROGRAM AT A GLANCE

Palau De Congressos De Catalunya, Barcelona, Spain

TUESDAY, MAY 2

EPOS Board of Directors Meeting	9:00 AM–6:00 PM	Press Room I
POSNA Board of Directors Meeting	8:00 AM–2:00 PM	Press Room II
Registration	4:00 PM–6:00 PM	Hall O
POPS Meeting	8:30 AM–5:30 PM	Sala A

WEDNESDAY, MAY 3

Registration	7:00 AM–6:00 PM	Hall O
Pre-Course	8:00 AM–12:00 PM	Auditorium
Coffee Break	9:45 AM–10:05 AM	Exhibition Hall
Lunch Break	12:00 PM–1:00 PM	Exhibition Hall
Industry Symposia* – BioMarin	12:45 PM–1:45 PM	Sala F
Industry Symposia* – NuVasive	12:45 PM–1:45 PM	Sala J
Scientific Program	**2:00 PM–6:02 PM**	Auditorium
Hip	2:04 PM–3:52 PM	Auditorium
Coffee Break	3:53 PM–4:13 PM	Exhibition Hall
Spine	4:14 PM–6:02 PM	Auditorium
Evening		
Opening Ceremony	6:30 PM–7:50 PM	Auditorium
Welcome Reception	8:00 PM–9:30 PM	Fairmont Hotel Pool

THURSDAY, MAY 4

Registration	7:00 AM–6:00 PM	Hall O
Scientific Program	**8:00 AM–12:02 PM**	Auditorium
Trauma	8:04 AM–9:52 AM	Auditorium
Coffee Break	9:53 AM–10:13 AM	Exhibition Hall
Quality, Safety & Value (QSV)	10:14 AM–12:02 PM	Auditorium
Lunch Break	12:02 PM–1:00 PM	Exhibition Hall
Industry Symposia* – OrthoPediatrics	12:45 PM–1:45 PM	Auditorium
Industry Symposia* – EOS Imaging	12:45 PM–1:45 PM	Sala A
Industry Symposia* – Zimmer	12:45 PM–1:45 PM	Sala H1-H2
Industry Symposia* – K2M	12:45 PM–1:45 PM	Sala H3
Industry Symposia* – OrthoFix	12:45 PM–1:45 PM	Sala F
Industry Symposia* – Pega Medical	12:45 PM–1:45 PM	Sala J
Industry Symposia* – NuVasive	12:45 PM–1:45 PM	Multipurpose Room

*Non-CME Session

THURSDAY, MAY 4 (CONTINUED)

Concurrent Session I		
Neuromuscular I	2:00 PM–3:48 PM	Auditorium
Break	3:49 PM–4:09 PM	Exhibition Hall
Neuromuscular II	4:10 PM–5:58 PM	Sala H1-H2
Concurrent Session II		
Basic Science	2:00 PM–3:48 PM	Sala F
Break	3:49 PM–4:09 PM	Exhibition Hall
Sports	4:10 PM–5:58 PM	Sala F
Concurrent Session III		
Upper Extremity	2:00 PM–3:48 PM	Sala H1-H2
Break	3:49 PM–4:09 PM	Exhibition Hall
Lower Extremity	4:10 PM–5:58 PM	Auditorium
Young Member Forum	6:00 PM–7:00 PM	Sala H1-H2

FRIDAY, MAY 5

Registration	7:00 AM–6:00 PM	Hall O
Scientific Program	**8:00 AM–12:11 PM**	Auditorium
Basic Science Award Papers	8:04 AM–9:04 AM	Auditorium
EPOSNA Presidential Speaker	9:05 AM–9:25 AM	Auditorium
Coffee Break	9:26 AM–9:46 AM	Exhibition Hall
Clinical Award Papers	9:47 AM–11:27 AM	Auditorium
Pro Maximus Awards	11:28 AM–11:38 AM	Auditorium
Distinguished Achievement Award	11:39 AM–11:49 AM	Auditorium
EPOS Presidential Transfer	11:50 AM–12:00 PM	Auditorium
POSNA Presidential Transfer	12:01 AM–12:11 PM	Auditorium
Lunch Break	12:12 PM–1:00 PM	Exhibition Hall
EPOS General Assembly	12:20 PM–1:50 PM	Room J
POSNA Business Meeting	12:20 PM–1:50 PM	Multipurpose Room
SLAOTI Symposia	12:50 PM–1:50 PM	Sala F
APPOS Symposia	12:50 PM–1:50 PM	Sala H1-H2
Concurrent Session IV		
Club Foot	2:00 PM–3:48 PM	Auditorium
Break	3:49 PM–4:09 PM	Exhibition Hall
Foot and Ankle	4:10 PM–5:58 PM	Sala H1-H2
Concurrent Session V		
Spine	2:00 PM–3:48 PM	Sala H1-H2
Break	3:49 PM–4:09 PM	Exhibition Hall
Hip	4:10 PM–5:58 PM	Auditorium
Concurrent Session VI		
Infection/Tumors	2:00 PM–3:48 PM	Sala F
Break	3:49 PM–4:09 PM	Exhibition Hall
Congenital/Syndromes	4:10 PM–5:58 PM	Sala F
Evening		
Gala Dinner	7:30 PM–10:00 PM	Casa Llotja de Mar

SATURDAY, MAY 6

Registration	7:00 AM–12:00 PM	Hall O
POSNA 2nd Board of Directors Meeting	8:00 AM–9:00 AM	Press Room II
Scientific Program	**8:00 AM–12:05 PM**	Auditorium
Trauma	8:05 AM–9:53 AM	Auditorium
Coffee Break	9:54 AM–10:14 AM	Exhibition Hall
Lower Extremity/Hip	10:15 AM–12:03 PM	Auditorium
EPOS 2nd Board of Directors Meeting	12:20 PM–1:20 PM	Press Room I

EthicalMedTech

This conference is Eucomed approved

FULL PROGRAM CAN BE FOUND ON THE EPOSNA 2017 MEETING APP.

Access the EPOSNA 2017 meeting app by downloading the My POSNA app from the Apple App or Google Play store.

OPENING CEREMONY

Palau De Congressos De Catalunya, Barcelona, Spain

WEDNESDAY, MAY 3

6:30 PM–6:40 PM

WELCOME

EPOS President: *Manuel Cassiano Neves, MD*
POSNA President: *James McCarthy, MD, MHCM*
Local Hosts: *Julio de Pablos, MD; Jorge Knörr, MD; Marius Aguirre Cañadell, MD*

6:40 PM–6:50 PM

INTRODUCTION OF DISTINGUISHED GUESTS

- EPOS Board of Directors
- POSNA Board of Directors
- International Presidents
- EPOS and POSNA New Members
- Distinguished Achievement Award Recipient
- Pro Maximus Award Recipients
- Presidential Guest Speaker
- EPOS Fellows
- COUR Visiting Scholars

6:50 PM–7:10 PM

PRESENTATION POSNA AWARDS

Angela S.M. Kuo Memorial Award – *Christina Kuo, MD*
St. Giles Young Investigator Award – *James McCarthy, MD, MHCM*
Arthur H. Huene Award – *James McCarthy, MD, MHCM*
POSNA Humanitarian Award – *James McCarthy, MD, MHCM*
POSNA Special Effort and Excellence Award – *James McCarthy, MD, MHCM*

PRESENTATION OF EPOS AWARDS

EPOS Award for Excellence in Paediatric Orthopaedic Education – *Manuel Cassiano Neves, MD*

7:10 PM–7:25 PM

RECOGNITION OF INDUSTRY SPONSORS

Manuel Cassiano Neves, MD and *James McCarthy, MD, MHCM*

7:25 PM–7:30 PM

INTRODUCTION STEEL LECTURER

Julio de Pablos, MD

7:30 PM–7:50 PM

STEEL LECTURE

Carolina B. García Estévez, PhD, Barcelona School of Architecture
"*Barcelona, Between the Straight and Bent Line: Architectures from Gaudí to Miralles*"

8:00 PM–9:30 PM

WELCOME RECEPTION

Fairmont Swimming Pool

2017 COMBINED EPOS /POSNA EPOSNA PRE-COURSE

CUTTING-EDGE PEDIATRIC ORTHOPAEDICS 2017: A GLOBAL PERSPECTIVE

Chairs: **Rudolf Ganger, MD** and **Jeffrey R. Sawyer, MD**

WEDNESDAY, MAY 3
8:00 AM – 12:00 PM

DESCRIPTION
This activity will highlight the similarities and differences in the European (EPOS) and North American (POSNA) perspective on the diagnosis and treatment of 4 challenging problems in pediatric orthopaedics:

1) Slipped Capital Femoral Epiphysis (SCFE)
2) Complex Early Onset Scoliosis (EOS) Patients
3) Neuromuscular Patients with Hip Subluxation/Dislocation
4) Complex Pediatric Fractures

This will provide the participants with a world-wide perspective in the diagnosis and treatment of these difficult problems. These presentations and question and answer sessions will be led by expert speakers and moderators from EPOS and POSNA who are thought-leaders in their fields.

LEARNING OBJECTIVES
Upon completion of this program, participants should be able to:

Objective 1:	To gain a global perspective in the diagnosis and treatment of complex pediatric orthopaedic problems/conditions.
Objective 2:	To facilitate international discussion and collaboration regarding these problems and conditions.
Objective 3:	To gain an understanding of how different health care systems influence the diagnosis and treatment of complex pediatric problems.
Objective 4:	To highlight areas of future international study in pediatric orthopaedics.

ACCREDITATION
This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American Academy of Orthopaedic Surgeons and the Pediatric Orthopaedic Society of North America. The American Academy of Orthopaedic Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

CONTINUING MEDICAL EDUCATION
The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of 3.75 AMA PRA Category 1 Credits™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

EthicalMedTech
This conference is Eucomed approved

PRE-COURSE
CUTTING-EDGE PEDIATRIC ORTHOPAEDICS 2017: A GLOBAL PERSPECTIVE

Palau De Congressos De Catalunya, Barcelona, Spain

WEDNESDAY, MAY 3
8:00 AM – 12:00 PM

8:00 AM–8:05 AM	**INTRODUCTION** ***Rudolf Ganger, MD**, Vienna, Austria* and ***Jeffrey R. Sawyer, MD**, Memphis, TN*
8:05 AM–8:55 AM	**APPROACH TO THE HIP (SCFE)** Moderators: **Manuel Cassiano Neves, MD**, Lisbon, Portugal and **James R. Kasser, MD**, Boston, MA
8:05 AM–8:20 AM	EPOS Speaker – ***Manoj Ramachandran, FRCS**, London, United Kingdom*
8:20 AM–8:35 AM	POSNA Speaker – ***Daniel J. Sucato, MD, MS**, Dallas, TX*
8:35 AM–8:55 AM	Q&A
8:55 AM–9:45 AM	**APPROACH TO THE SPINE (EOS)** Moderators: **Dror Ovadia, MD**, Tel Aviv, Israel and **Michael G. Vitale, MD**, New York, NY
8:55 AM–9:10 AM	POSNA Speaker – ***John B. Emans, MD**, Boston, MA*
9:10 AM–9:25 AM	EPOS Speaker – ***Carol C. Hasler, MD**, Basel, Switzerland*
9:25 AM–9:45 AM	Q&A
9:45 AM–10:05 AM	Break
10:05 AM–10:55 AM	**APPROACH TO THE NEUROMUSCULAR (HIP)** Moderators: **Reinald Brunner, MD**, Basil, Switzerland and **Dennis R. Wenger, MD**, San Diego, CA
10:05 AM–10:20 AM	EPOS Speaker – ***Gunnar Hagglund, MD**, Lund, Sweden*
10:20 AM–10:35 AM	POSNA Speaker – ***Jon R. Davids, MD**, Sacramento, CA*
10:35 AM–10:55 AM	Q&A
10:55 AM–11:45 AM	**APPROACH TO COMPLEX PEDIATRIC FRACTURES** Moderators: **Pierre F. Lascombes, MD**, Geneva, Switzerland and **James H. Beaty, MD**, Memphis, TN)
10:55 AM–11:10 AM	POSNA Speaker – ***John M. (Jack) Flynn, MD**, Philadelphia, PA*
11:10 AM–11:25 AM	EPOS Speaker – ***Franck Accadbled, MD**, Toulouse, France*
11:25 AM–11:45 AM	Q&A
11:45 AM-12:00 PM	**WRAP UP** ***Rudolf Ganger, MD**, Vienna, Austria* and ***Jeffrey R. Sawyer, MD**, Memphis, TN*

EPOS extends sincere appreciation to
OrthoPediatrics
for their support of the Pre-Course program

THIRD ANNUAL ARABELLA LEET, MD
YOUNG MEMBER FORUM

THURSDAY, MAY 4
6:00 PM – 7:00 PM

Moderator: EPOS – *Federico Canavese, MD*, *Chamalieres, France*
POSNA – *James O. Sanders, MD*, *Rochester, NY*

6:00 PM–6:12 PM	THE IMPORTANCE OF INTERNATIONAL UNDERSTANDINGS AND FRIENDSHIP FOR INDIVIDUALS AND THE PROFESSION
6:00 PM–6:06 PM	POSNA Speaker – *James R. Kasser, MD*, *Boston, MA*
6:06 PM–6:12 PM	EPOS Speaker – *Alain Dimeglio, MD*, *Montpellier, France*
6:12 PM–6:15 PM	Discussion
6:15 PM–6:27 PM	EXTENDED INTERNATIONAL FELLOWSHIPS – EXPERIENCES, VALUE, AND PRACTICALITIES
6:15 PM–6:21 PM	EPOS Speaker – *Cristina Alves, MD*, *Coimbra, Portugal*
6:21 PM–6:27 PM	POSNA Speaker – *Dan Sucato, MD*, *Dallas, TX*
6:27 PM–6:30 PM	Discussion
6:30 PM–6:42 PM	TRAVELING FELLOWSHIPS AS AN OPPORTUNITY FOR A LIFETIME
6:30 PM - 6:36 PM	POSNA Speaker – *John M. (Jack) Flynn, MD*, *Philadelphia, PA*
6:36 PM–6:42 PM	EPOS Speaker – *Virginie Pollet, MD*, *Rotterdam, Netherlands*
6:42 PM–6:45 PM	Discussion
6:45 PM–6:57 PM	FAMILY, WORK, EXPENSE? MAKING INTERNATIONAL CONNECTIONS WHEN FELLOWSHIPS ARE NOT AN OPTION
6:45 PM–6:51 PM	EPOS Speaker – *André J. Kaelin, MD*, *Chêne-Bougeries,Switzerland*
6:51 PM–6:57 PM	POSNA Speaker – *Charles T. Price, MD*, *Orlando, FL*
6:57 PM - 7:00 PM	Discussion

SPEAKERS and AWARD RECIPIENTS

GEORGE H. THOMPSON, MD
DISTINGUISHED ACHIEVEMENT AWARD

Dr. Thompson is Director of Pediatric Orthopaedics at Rainbow Babies and Children's Hospital, University Hospitals Cleveland Medical Center (UHCMC) and Professor of Orthopaedic Surgery and Pediatrics at Case Western Reserve University in Cleveland, Ohio. He graduated from Oklahoma State University in 1966, the University of Oklahoma School of Medicine in 1970 and did a surgical internship and orthopaedic surgery residency at the University of California Los Angeles (UCLA) Medical Center (1970-1972; 1974-1977). This was followed by a fellowship in pediatric orthopaedics at the Hospital for Sick Children in Toronto, Ontario (1978) with Robert B. Salter, MD. He then joined the faculty at UHCMC (1979). In addition to being the Director of Pediatric Orthopaedic Surgery since 1987 he is the Co-Chair of the Salter Society for the Hospital for Sick Children; Co-Editor, *Journal of Pediatric Orthopaedics*; President/CEO SICOT Foundation; Chairman SICOT-USA; Chairman, Shriner's Hospital for Children Medical Advisory Board; and President-elect International Federation of Pediatric Orthopaedic Societies (IFPOS). He is the Past-President of the Ohio Orthopaedic Society (1997-1999), the Pediatric Orthopaedic Society of North America [POSNA] (2002-2003), and the Scoliosis Research Society [SRS] (2006-2007; 2007-2008) and Past-Deputy Editor of Pediatric Orthopaedics *Journal of Bone and Joint Surgery American* (2003-2005). He has received numerous honors and awards, most notably the UCLA Outstanding Surgical Intern Award (1971), the American Orthopaedic Association (AOA) North American Traveling Fellowship (1979), the POSNA Arthur H. Huene Award (2008), the SRS Lifetime Achievement Award (2013), the University Hospitals Distinguished Physician Award (2014), and he was the first recipient of the Endowed Chair in Pediatric Orthopaedic Surgery (2016), He has had 167 visiting professorships or guest lectureships.

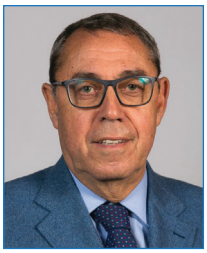
He has published 176 peer-reviewed articles, 91 chapters in textbooks and edited 5 textbooks.
He has presented more than 1,000 state, regional, national and international lectures.

DEBORAH EASTWOOD, MD
2017 PRESIDENTIAL GUEST SPEAKER

Dr. Eastwood is a Consultant Paediatric Orthopaedic Surgeon at Great Ormond Street Hospital and the Royal National Orthopaedic Hospital at Stanmore, in London. She is member of EPOS and served on Executive Committee between 2009-2015 and as EPOS President in 2013-14.

Dr. Eastwood's completed her orthopaedic training at the Birmingham and Bristol Programs, and undertook several paediatric orthopaedic fellowships, at the Royal Children's Hospital in Melbourne and the Hospital for Sick Children in Toronto. Her clinical practice incorporates a wide variety of paediatric orthopaedic conditions, with a particular expertise in children with overgrowth syndromes, metabolic bone disease, neurological conditions, clubfoot and hip dysplasia. During her career Dr. Eastwood has received many awards, including; the Zimar Palmudio SICOT Fellowship (1993); the ABC Travelling Fellowship (1994); Percivall Pott Trainer of the Year (2014) nominated by the trainees on the (regional) Royal London /Barts rotation for teaching/supporting/mentoring and BOTA Trainer of the Year – runner up (2016) nominated by trainees, assessed by educationalists and selected on interview. She was also awarded with the "John Sharrard Award" for the Best Clinical Paper (EPOS 2014) and the Best E- Poster (POSNA annual meeting 2012). She is a member of BSCOS, BOA, and the RCS of England and has editorial responsibilities within Bone and Joint Journal (previously JBJS-B), Journal of Children's Orthopaedics and Injury. She also reviews in a regular/occasional basis for Lancet, British Medical Journal, Annals of the Royal College of Surgeon, Clinical Orthopaedics and Related Research, Haemophilia, British Journal of Infectious Disease and Radiology. During her career she dedicated part of her time to education with numerous educational activities in Europe, South America, United States and China. She has published over 76 peer reviewed scientific articles, numerous book chapters and was the Editor of two textbooks.

EPOS and POSNA are proud to have Dr. Deborah Eastwood as the "Presidential Guest Lecturer" for the EPOSNA meeting.



ERNESTO IPPOLITO, MD
PRO MAXIMUS MERITIS MEDAL RECIPIENT 2017

Prof. Ernesto Ippolito is Professor Emeritus of Orthopaedics and Traumatology - University of Rome "Tor Vergata"- Italy. He did his studies at the University of Rome "La Sapienza" were he got his degree in Medicine and Surgery in 1969 and graduated as an Orthopaedic Surgeon in 1972.

From 1983, he moved to the University of Reggio Calabria were he became Professor of Orthopaedics and Traumatology and head of the department at the hospital of the same University. In 1992, he moved to the University of Rome "Tor Vergata" where he served as full professor of Orthopaedics becoming in 2015 professor emeritus of Orthopaedics and Traumatology at the same University. After two years of training in this area (1977-1980) at the Department of Orthopaedic Surgery of the University of Iowa (USA) under the guidance of Prof. Ignacio Ponseti, he decided to dedicate a big part of his scientific and clinical career to Pediatric Orthopedics. His main fields of work were on clubfoot and to basic research in the field of connective tissues.

He published more than 250 articles mostly studies on the patho-anatomy and histology of some Orthopaedic diseases of the developmental age and the long-term results of case-series of patients with various orthopaedic diseases and trauma treated at the University Hospital of Rome "La Sapienza".

Prof. Ernesto Ippolito, President of EPOS in 2007, has been a dedicated surgeon improving the health care of the children and adolescents and has been serving EPOS on its educational activities with dedication and enthusiasm and in recognition of his activities the EPOS Executive Committee is honoured to recognize him as a Pro Maximis Meritis Award.

MICHAEL MILLIS, MD
PRO MAXIMUS MERITIS MEDAL RECIPIENT 2017

Dr. Michael Millis is a Professor of Orthopedic Surgery at Harvard Medical School, Boston USA. He did his residency at Harvard Combined Orthopedic Surgery Residency Program, 1972-1975 Boston, Massachusetts and was a fellow in Reconstructive Lower Extremity Surgery, AO Fellowship/Professor Heinz Wagner, 1979.

He dedicated his life to children's orthopaedics and in particular to the hip from birth to young adult. He has been very active in research in topics like Development Dysplasia of the Hip, Perthes Disease and Slipped Capital Femoral Epiphysis were he has been leading innovative approaches to these conditions. As a result he was the Founding Director, Child and Adult Hip Program at Boston Children's Hospital dedicated to the development of conservative surgery in the hip.

Dr. Millis has more than 140 articles published in per reviewed journals and has been a guest lecture around the world and has been involved in many educational activities from POSNA and the AAOS to the EPOS annual meetings.

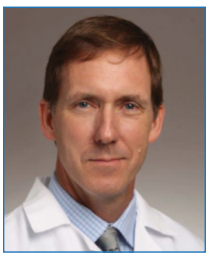
EPOS Executive Committee is honoured to recognize Dr. Michael Millis as a Pro Maximis Meritis Award for the impact that his work had on the life of so many children as well as his contribution to the education of numerous Paediatric Orthopaedic surgeons.

MANUEL CASSIANO NEVES, MD
EPOS PRESIDENT

Dr. Manuel Cassiano Neves is director of the Department of Paediatric Orthopaedics, Hospital Cuf Descobertas in Lisbon, Portugal and is Assistant Professor at the Lisbon University. He has a special interest in hip and foot conditions and as a major experience in children and adolescent trauma. He also devoted his work to Education in Orthopaedics and was the Chair of the "European Education Platform" responsible for setting an European Curriculum of Orthopaedics and Traumatology.

DARKO ANTICEVIC, MD, PHD
EPOS INCOMING PRESIDENT

Prof. Darko Anticevic was elected 2nd Vice-President of EPOS in Marseille and will start his mandate as President in Barcelona. He had his Orthopaedic training in Zagreb, Bologna, Italy (Instituto Ortopedico Rizzoli – A. Del Monte) and Oxford, UK (Nuffield Orthopaedic Centre - R. Duthie); After the graduation he was a fellow in Basle, Switzerland (Felix-Platter Hospital & Children's Hospital, E. Morscher) and New York, NY, USA (Hospital for Joint Diseases - W. Lehman &. A. Grant). Prof. Anticevic is currently the Professor of Orthopaedic Surgery, University of Zagreb, School of Medicine and Senior Consultant at Children's Hospital, Paediatric Orthopaedic Department Zagreb, Croatia. His main fields of interest are diagnostics and non-operative and surgical treatment of paediatric hip and foot problems, residual post-traumatic bone deformities; osteogenesis imperfecta, skeletal dysplasias. He is a member of several scientific societies including EPOS and POSNA and he is currently the President of IFPOS. He published more than 45 papers in peer-reviewed journals and is author of ten chapters in multi-authors' books (in Croatian) and has been a guest lecturer for many societies around the world. He is a member of the Editorial Board of Journal of Paediatric Orthopaedics B, Liječnički Vjesnik, and Pediatrica Croatica. Prof. Anticevic has been a very active member in EPOS since 1996. He was the Chair of the LOC for the very successful 29th EPOS Annual Congress in Zagreb, and participated actively in different EPOS educational activities since 2005 like the BAT courses or the RCC. Since 2013, he is the chair of the Reading Committee and for the EPOSNA meeting, he co-chair the scientific program.



JAMES MCCARTHY, MD, MHCM
POSNA PRESIDENT

James McCarthy, MD, MHCM is the Division Director of Orthopaedic Surgery, Cincinnati Children's Hospital, Alvin Crawford Chair in Pediatric Orthopaedics, and Professor of Orthopaedics Surgery at the University of Cincinnati College of Medicine. He graduated with a BS Engineering from the University of Wisconsin School of Engineering, received his MD from The University of North Carolina School of Medicine, performed his residency at The Cleveland Clinic Foundation, and fellowship at Children's Hospital Colorado. He went on to get his Masters in Healthcare Management at the Harvard School of Public Health. He is the past president of the Limb Lengthening and Reconstruction Society (LLRS), has participated in two traveling fellowships and graduated from the AAOS Leadership Fellows Program. He has over 140 publications and has given over 300 research and invited presentations. His clinical interests include the treatment of pediatric hip disorders; complex limb and spine deformities; children with neuromuscular disorders; gait analysis, and quality improvement and safety initiatives. Dr. McCarthy and his wife Christy recently celebrated their 20th anniversary and they have two children.

RICHARD SCHWEND, MD
POSNA INCOMING PRESIDENT

Richard M. Schwend, MD, is Chief of Orthopaedic Research at the Children's Mercy Hospital, and is Professor of Orthopaedics and Pediatrics, University of Missouri, Kansas City and University of Kansas Medical Center. He graduated with BA Biochemistry from the University of California, MD from St. Louis University Medical School, orthopaedic residency at Harvard Combined Orthopaedic Residency and fellowship at Children's Hospital, Boston. He recently completed the Global Clinical Research Training Program, Harvard University. He is the immediate past chair of the Orthopaedic Section of the American Academy of Pediatrics and is board certified in pediatrics, in addition to Orthopaedics. He was the 2001 Scoliosis Research Society Travelling Fellow and Harvard University, Cave Travelling Fellowship to Bern, Switzerland. He has received the POSNA Humanitarian and the POSNA Special Effort awards. He is Medical Director of the Project Perfect World Ecuador Program, which since 2002 has been developing a pediatric orthopaedic and spine program. His research interests involve program development in regions with limited resources, pediatric spine and chest anatomy and surgical safety. He is a retired Colonel, United States Air Force. Dr. Schwend and his wife Colleen have two children and one granddaughter. In his spare time he enjoys bicycling to work, swimming, fly fishing, reading history, reading about airplanes and travel.

WEDNESDAY, MAY 3, 2017

2:00 PM - 2:04 PM WELCOME REMARKS

HIP

MODERATOR: *Hakan Ömeroglu, MD*
eMODERATOR: *Raul Bisbal, MD*
PRESIDER: *Woody Sankar, MD*

Paper 1 2:04 PM - 2:09 PM
Diagnostic and Treatment Preferences for Developmental Dysplasia of the Hip: A Survey of EPOS and POSNA Members
*Cristina Alves, MD; **Walter Truong, MD**; Michaela Thompson, BA; Joash Suryavanshi, BA; Huong Do, MA; Emily Dodwell, MD*
Hospital for Special Surgery, New York, New York, United States

Paper 2 2:10 PM - 2:15 PM
Developmental Dysplasia of the Hip Presenting Between 12 and 18 Months: Medial Open Reduction or Delayed Anterior Approach Plus Innominate Osteotomy
***Christopher Bache, FRCS (Ortho)**; Mohammad Shahid; Feiran Wu; Rosamond Tansey, MBChB*
Birmingham Children's Hospital, Birmingham, United Kingdom

Paper 3 2:16 PM - 2:21 PM
Patient-Reported Outcomes in Young Adults with Osteonecrosis Secondary to Developmental Dysplasia of the Hip
***Andreas Roposch, FRCS (Ortho)**; Avi Marks, MBChB; Aresh Hashemi-Nejad, FRCS; Mario Cortina-Borja, PhD*
Great Ormond Street UCL Institute of Child Health, Royal National Orthopaedic Hospital, London, United Kingdom

2:22 PM - 2:31 PM Discussion

Paper 4 2:31 PM - 2:36 PM
Secondary Spherical Remodeling from the Healed Stage to Skeletal Maturity in Legg-Calvé-Perthes Disease Treated with Salter Innominate Osteotomy
***Hiroshi Kaneko, MD, PhD**; Hiroshi Kitoh, MD; Masaki Matsushita, MD; Hiroki Furuhashi, MD; Tadashi Hattori*
Nagoya University School of Medicine, Nagoya, Aichi, Japan

Paper 5 2:37 PM - 2:42 PM
Abnormal Growth of the Upper Femur following the Modified-Dunn Procedure
***Ira Zaltz, MD**; Eduardo Novais, MD; Michael Millis, MD; Young Jo Kim, MD; Wudbhav Sankar, MD*
William Beaumont Hospital, Royal Oak, Michigan, United States

Paper 6 2:43 PM - 2:48 PM

Hip Migration Percentage as the Outcome Parameter of Hip Reconstruction in Children with Spastic Hip Disease

Brian Po-Jung Chen, MD; Julieanne Sees, DO; Mutlu Cobanoglu; Lucio Perotti, MD; Kenneth Rogers, PhD; ***Freeman Miller, MD***
Nemours/Alfred I. duPont Hospital for Children, Wilmington, Delaware, United States

2:49 PM - 2:58 PM Discussion

Paper 7 2:58 PM - 3:03 PM

Bernese Treatment Algorithm for Patients with Slipped Capital Femoral Epiphysis (SCFE) has Low Rate of Adverse Events

Kai Ziebarth, MD*; Nadine Kaiser; Thoralf Liebs; Teddy Slongo, MD; Klaus Siebenrock, MD*
University Children's Hospital Bern, Pediatric Orthopedics, Bern, Switzerland

Paper 8 3:04 PM - 3:09 PM

Bernese Periacetabular Osteotomy for Severe Acetabular Dysplasia: Are the Good Clinical Results Maintained at Long-term Follow-up?

Jeffrey Petrie, MD*; Kayla Thomason, BS; Geneva Baca; Perry Schoenecker, MD; John Clohisy, MD*
Washington University School of Medicine, Saint Louis, Missouri, United States

Paper 9 3:10 PM - 3:15 PM

Do Compensatory Anterior Pelvic Tilt and Lumbar Lordosis Decrease Following Bilateral Periacetabular Osteotomy?

Erika Daley, MD; Nickolas Nahm, MD; Denise Koueiter; ***Ira Zaltz, MD***
William Beaumont Hospital, Royal Oak, Michigan, United States

3:16 PM - 3:25 PM Discussion

Paper 10 3:25 PM - 3:30 PM

Reverse Periacetabular Osteotomy to Uncover the Hip in Pincer Impingement

Stephanie Pun, MD*; Michael Merz, MD; Garrett Bowen; Andreas Hingsammer, MD; Yi-Meng Yen, MD; Young Jo Kim, MD; Michael Millis, MD*
Stanford University and Boston Children's Hospital, Stanford, California and Boston, Massachusetts, United States

Paper 11 3:31 PM - 3:36 PM

Is Osteotomy Better than Resection for Painful, Dislocated Hips in Cerebal Palsy?

Priscella Chan; Angela Hsu, BS; Jenna Godfrey, MD; Selina Silva, MD; Rachel Goldstein, MD; Deirdre Ryan, MD; ***Paul Choi, MD****; Robert Kay, MD*
Children's Hospital Los Angeles, Los Angeles, California, United States

Paper 12 3:37 PM - 3:42 PM

Outcomes of Primary Total Hip Arthroplasty Compared to Conversion Arthroplasty After Failed Hip Preservation Surgery in Patients Less than 30 Years of Age

Jakub Sikora-Klak, MD; ***Vidyadhar Upasani, MD****; James Bomar; Dennis Wenger, MD; Jesal Parekh, PhD; Scott Ball, MD*
Rady Children's Hospital, San Diego, California, United States

3:43 PM - 3:52 PM Discussion

3:53 PM - 4:13 PM Break

SPINE

MODERATOR: *Peter O. Newton, MD*
eMODERATOR: *Dror Ovadia, MD*
PRESIDER: *A. Noelle Larson, MD*

Paper 13 4:14 PM - 4:19 PM
Vancomycin Powder Lowers Infection Rate in Growing Rod Surgery in Early Onset Scoliosis: A Preliminary Report
George Thompson, MD; *Connie Poe-Kochert, RN; Christina Hardesty, MD; Jochen Son-Hing, MD; R. Justin Mistovich, MD*
Rainbow Babies and Children's Hospital, Cleveland, Ohio, United States

Paper 14 4:20 PM - 4:25 PM
Topical Vancomycin in Pediatric Spine Surgery Does Not Reduce Surgical Site Infection: A Retrospective Cohort Study
Sumeet Garg, MD; Nikki Bloch, BA; Morgan Potter; Claire Palmer, MS; Nicole Michael, BA; ***Courtney O'Donnell, MD***; *Mark Erickson, MD*
Children's Hospital Colorado, Aurora, Colorado, United States

Paper 15 4:26 PM - 4:31 PM
Early Deep Surgical Site Infection following 740 Primary Single-stage Pediatric Scoliosis Surgery: A Multivariate Analysis of Risk Factors
Jerry Du, MD; Connie Poe-Kochert, RN; George Thompson, MD; Jochen Son-Hing, MD; Christina Hardesty, MD; ***R. Justin Mistovich, MD***
Rainbow Babies and Children's Hospital, Cleveland, Ohio, United States

4:32 PM - 4:41 PM Discussion

Paper 16 4:41 PM - 4:46 PM
2-year Follow-up in Spine Clinical Research: An Adequate Benchmark?
Firoz Miyanji, MD; *Amer Samdani, MD; Suken Shah, MD; Maty Petcharaporn, BS; Jahangir Asghar, MD; Burt Yaszay, MD; Harry Shufflebarger, MD; Randal Betz, MD; Peter Newton, MD*
BC Children's Hospital, Vancouver, British Columbia, Canada

Paper 17 4:47 PM - 4:52 PM
Surgery for the Adolescent Idiopathic Scoliosis Patients after Skeletal Maturity: Now or Later?
Baron Lonner, MD; Yuan Ren; Robert Bess, MD; Michael Kelly, MD; Han Jo Kim, MD; ***Burt Yaszay, MD***; *Virginie Lafage, PhD; Firoz Miyanji, MD; Peter Newton, MD*
Mount Sinai Hospital, New York, New York, United States

Paper 18 4:53 PM - 4:58 PM
Evolution of Surgery for Adolescent Idiopathic Scoliosis over 20 Years: Have Outcomes Improved?
Baron Lonner, MD; Yuan Ren; Burt Yaszay, MD; Patrick Cahill, MD; Suken Shah, MD; Randal Betz, MD; Amer Samdani, MD; Harry Shufflebarger, MD; ***Peter Newton, MD***
Mount Sinai Hospital, New York, New York, United States

4:59 PM - 5:08 PM Discussion

Paper 19 5:08 PM - 5:13 PM

Is the Story Over? Curve Progression after Bracing in AIS

Elizabeth Hubbard, MD; *Rachel Mednick Thompson, MD; Chan-Hee Jo, PhD; Donald Virostek; Lori Karol, MD*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

Paper 20 5:14 PM - 5:19 PM

Maturity Indicators and Adolescent Idiopathic Scoliosis: Evaluation of the Sanders Maturity Scale

Kevin Neal, MD; *Eric Shirley, MD; Gary Kiebzak, PhD*
Nemours Specialty Care, Jacksonville, Florida, United States

Paper 21 5:20 PM - 5:25 PM

A Novel Method of Predicting Pulmonary Function of AIS Patients Undergoing PSF on Routine Radiographs

Vishwas Talwalkar, MD; *Ryan D. Muchow; Alison Dittmer, MD; John Whitaker, BS; Cale Jacobs, PhD; Henry Iwinski, MD*
Lexington Shriners Hospital for Children, Lexington, Kentucky, United States

5:26 PM - 5:35 PM Discussion

Paper 22 5:35 PM - 5:40 PM

Decreasing Blood Loss in Pediatric Idiopathic Scoliosis Surgery: The Efficacy and Pharmacokinetic Profile of Intravenous Tranexamic Acid

Susan Goobie; ***Michael T. Hresko, MD***; *Robert Brustowicz, MD; Elisabeth Dwyer; John Emans, MD; Michael Glotzbecker, MD; Daniel Hedequist, MD; Lawrence Karlin, MD; Mary Ellen McCann; Andres Navedo, MD; Luis Pereira, PhD; Navil Sethna, MD*
Boston Children's Hospital, Harvard Medical School, Boston, Massachusetts, United States

Paper 23 5:41 PM - 5:46 PM

A Novel Risk Severity Score for Early Onset Scoliosis Predicts SSI Rates Ranging From 5.7% to 79.6%

Hiroko Matsumoto, MA; David Roye, MD; Nicholas Feinberg, BA; John Smith, MD; Amer Samdani, MD; Michael Glotzbecker, MD; Jeffrey Sawyer, MD; David Skaggs, MD; ***Michael G. Vitale, MD, MPH***; *Growing Spine Study Group; Children's Spine Study Group*
Columbia University Medical Center, New York, New York, United States

Paper 24 5:47 PM - 5:52 PM

♦ Successes and Failures Following Spinal Growth Tethering for Scoliosis

Peter Newton, MD; *Wataru Saito; Burt Yaszay, MD; Carrie Bartley, MA; Tracey Bastrom, MA*
Rady Children's Hospital, San Diego, California, United States

5:53 PM - 6:02 PM Discussion

♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

THURSDAY, MAY 4, 2017

8:00 AM - 8:04 AM OPENING REMARKS

TRAUMA

MODERATOR: *Pierre Lascombes, MD*
eMODERATOR: *Steven L. Frick, MD*
PRESIDER: *Bjarne Møller-Madsen, MD*

Paper 25 8:04 AM - 8:09 AM
Does Delay to Surgery in Type III Supracondylar Humerus Fractures Lead to Longer Surgical Times and More Difficult Reductions?
Pooja Prabhakar; ***Christine Ho, MD***
Children's Medical Center, Dallas, Texas, United States

Paper 26 8:10 AM - 8:15 AM
What is an "Acceptable Reduction" for Supracondylar Humerus Fractures in Children?
Unni Narayanan, FRCSC*; William Wood, MD; Yongyao Tan, MSc;*
James Turner, FRCS (Ortho); Anshika Gangwar, MD
The Hospital for Sick Children, Toronto, Ontario, Canada

Paper 27 8:16 AM - 8:21 AM
Flexion–extension Cross Pinning of Supracondylar Humeral Fractures in Children: Does It Really Increase Stability and Prevent Ulnar Nerve Injury?
Utai Rudich, MD; Doron Keshet; Mikhail Zaidman; Alexander Katsman;
Mark Eidelman, MD
Rambam Healthcare Center, Haifa, Israel

8:22 AM - 8:31 AM Discussion

Paper 28 8:31 AM - 8:36 AM
Complications Associated with Lateral Humeral Condylar Fractures in Children
Rafael Escobar, MD*; Luis Moraleda, MD; Jesus Diez; Gaspar Gonzalez, MD*
Hospital Universitario La Paz, Madrid, Spain

Paper 29 8:37 AM - 8:42 AM
No Difference in Time to Full ROM, Union or Incidence of Complications in a Matched Cohort of Operative versus Non-Operatively Treated Displaced Medial Epicondyle Fractures
Stephanie Mayer, MD; Derek Axibal, MD; Brian Ketterman; Anne Skelton, BS;
Patrick Carry, MS; Gaia Georgopoulos, MD; ***Nancy Miller, MD***
Children's Hospital Colorado, Aurora, Colorado, United States

Paper 30 8:43 AM - 8:48 AM
To Fix or Not to Fix: Fracture Type and Outcomes of Operative vs Nonoperative Management of Pediatric Humeral Shaft Fractures
Todd Milbrandt, MD*; Maureen O'Shaughnessy; Annalise Larson, MD;*
William Shaughnessy, MD; Anthony Stans, MD; Ernest Young, MD
Mayo Clinic, Rochester, Minnesota, United States

8:49 AM - 8:58 AM Discussion

Paper 31 8:58 AM - 9:03 AM

Effect of NSAID Use In the Acute Phase of Skeletally Immature Bone Healing: A Prospective, Randomized, Blinded, Controlled Trial

***Julia Nuelle, MD**; Kelsie Coe, BA; Harvey Oliver, MD; James Cook; Daniel Hoernschemeyer, MD; Sumit Gupta, MD*
University of Missouri Hospital and Clinics/Missouri Orthopaedic Institute, Columbia, Missouri, United States

Paper 32 9:04 AM - 9:09 AM

Risk of Fracture and 25-OH Vitamin D Level in Pediatric Population

***David M. Farrington, MD**; Marisol Martínez Vázquez, MMED (Ortho); Francisco Downey-Carmona, MD; Jose Lirola, MD; José Manuel Martínez Salas*
Hospital Infantil Virgen del Rocío, Seville, Spain

Paper 33 9:10 AM - 9:15 AM

Pediatric Supracondylar Humerus Fractures: Does After-hours Treatment Influence Outcomes?

*Julius A. Bishop, MD; **Gabrielle M. Paci, MD**; Kali R. Tileston, MD; John Vorhies, MD*
Stanford University Hospital and Clinics, Palo Alto, California, United States

9:16 AM - 9:25 AM Discussion

Paper 34 9:25 AM - 9:30 AM

Descriptive Epidemiology of Adolescent Clavicle Fractures: Early Results from the FACTS (Function After Adolescent Clavicle Trauma and Surgery) Prospective, Multi-Center Cohort Study

***Henry Ellis, MD**; Philip Wilson, MD; G. Li, MD; Andrew Pennock, MD; Jeffrey Nepple, MD; Donald Bae, MD; Kyna Donohue; Leslie Kalish; FACTS Study Group; Benton Heyworth, MD*
Boston Children's Hospital, Boston, Massachuestts, United States

Paper 35 9:31 AM - 9:36 AM

To Nail or Plate Forearm Fractures in the Adolescent: Using Bone Age as Guide

***Arjandas Mahadev, MD**; Si Heng Sharon Tan; Sumanth Gera*
KK Women's and Children's Hospital, Singapore

Paper 36 9:37 AM - 9:42 AM

Pediatric Forearm Fractures Are Effectively Immobilized with a Sugar-Tong Splint Following Closed Reduction

***Janet Walker, MD**; Vishwas Talwalkar, MD; Domingo Molina, MD; Alison Dittmer, MD; Mitchell Wattles, MD; Cale Jacobs, PhD; Scott Riley, MD; Henry Iwinski, MD; Ryan D. Muchow, MD*
University of Kentucky, Lexington, Kentucky, United States

9:43 AM - 9:52 AM Discussion

9:53 AM - 10:13 AM Break

QUALITY, SAFETY and VALUE

MODERATOR: *James McCarthy, MD, MHCM*
eMODERATOR: *Jaroslav Czubak, MD*
PRESIDER: *Deborah Eastwood, MD*

Paper 37 10:14 AM - 10:19 AM
Significant Reductions in Surgical Site Infection (SSI) In Spinal Fusion Patients Using a Bundled Intervention Approach
Amy McIntosh, MD; *Kerry Wilder*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

Paper 38 10:20 AM - 10:25 AM
Bundles, Surveillance and Committees: Results of an All-Out Assault on Spinal Fusion Surgical Site Infection
Christian Refakis, BA; ***John M. (Jack) Flynn, MD***
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

Paper 39 10:26 AM - 10:31 AM
Development of Consensus-based Best Practice Guidelines (BPG) for Postoperative Care following Posterior Spinal Fusion for AIS
Nicholas Fletcher, MD; *Michael Glotzbecker, MD; Michelle Marks, MA; Mark Abel, MD; Suken Shah, MD; Burt Yaszay, MD; Peter Newton, MD*
Emory University, Atlanta, Georgia, United States

10:32 AM - 10:41 AM Discussion

Paper 40 10:41 AM - 10:46 AM
Cost Effectiveness Analysis of Operative versus Non-Operative Treatment for Adolescent Idiopathic Scoliosis
Michelle Marks, PT, MA; *Amit Jain, MD; Michael Kelly, MD; Lawrence Lenke, MD; Thomas Errico, MD; Khaled Kebaish, MD; Paul Sponseller, MD*
The Johns Hopkins Hospital, Baltimore, Maryland, United States

Paper 41 10:47 AM - 10:52 AM
Decreasing Unexpected Returns to Orthopaedic Hand Clinic: Improving Efficiency of Health Care Delivery While Decreasing Medical and Non-Medical Costs
Kevin Little, MD; *Roger Cornwall, MD; Stephanie Pinkstock, PA-C; Emily Dastillung; Lisa McFadden*
Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, United States

Paper 42 10:53 AM - 10:58 AM
Implementation of a Dedicated Clubfoot Clinic Significantly Decreases the Occurrence of Major Unplanned Clubfoot Surgery: A Quality Improvement Initiative
Robin Baschal; Susan Graham, PA; Karen Whalen; Alexander Jones, BA; Debbie Burke, PA-C; Patrick Carry; Gaia Georgopoulos, MD; ***Nancy Miller, MD***
Children's Hospital Colorado, Aurora, Colorado, United States

10:59 AM - 11:08 AM Discussion

Paper 43 11:08 AM - 11:13 AM
Training Effect of Using A Mobile App-Based Simulation for the Treatment of Pediatric Septic Arthritis – A Pilot Study
Benjamin Shore, MD; *Andre Chow, MBBS; Ali Bahsoun, MBBS; Donald Bae, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 44 11:14 AM - 11:19 AM
A Coordinated Discharge Pathway Following Posterior Spinal Fusion for Neuromuscular Scoliosis Associated with GMFCS 4/5 Cerebral Palsy Resulted in a 50% Decrease in Complications and a 25% Shorter Length of Stay
Nicholas Fletcher, MD; *Laura Bellaire, MD; Christine Bowman, MD; Laura Ward; Robert Bruce, MD*
Emory University, Atlanta, Georgia, United States

Paper 45 11:20 AM - 11:25 AM
Complications of Peripheral Nerve Blocks following Pediatric Knee Surgery
Robert Tamai, BA; Brian Sullivan, BS; ***Rushyuan Lee, MD***
The Johns Hopkins Hospital, Baltimore, Maryland, United States

11:26 AM - 11:35 AM Discussion

Paper 46 11:35 AM - 11:40 AM
Utilization of a Wide Array of Non-Validated Outcome Scales in Pediatric Orthopedic Publications: Can't We All Measure the Same Thing?
Emily Dodwell, MD; Walter Truong, MD; Sahana Somasegar, BS; Michaela Thompson, BA; Kunal Agarwal, MS; Meghan Price, BS; Joash Suryavanshi, BA; ***Peter Fabricant, MD***
Hospital for Special Surgery, New York, New York, United States

Paper 47 11:41 AM - 11:46 AM
Clinical Assessment of Generalized Ligamentous Laxity Using a Single Test: Is Thumb-to-Forearm Flexion Enough?
Sean Cahill, BA; Melinda Sharkey, MD; ***Cordelia Carter, MD***
Yale University, New Haven, Connecticut, United States

Paper 48 11:47 AM - 11:52 AM
Why is SCFE Decreasing While Obesity is Increasing?
Andrew Howard, MD; *Benjamin Escott, MBBS; James Rofaiel, MD; Robert Ravinsky, MD; Bheeshma Ravi, MD*
Hospital for Sick Children, Toronto, Ontario, Canada

11:53 AM - 12:02 PM Discussion

12:02 PM - 1:00 PM Lunch

CONCURRENT SESSION I: NEUROMUSCULAR I

MODERATOR: *Patricia Fucs, MD*
eMODERATOR: *Unni G. Narayanan, MD*
PRESIDER: *Melinda Witbreuk, MD*

Paper 49 2:00 PM - 2:05 PM
Hip Surveillance for Children with Cerebral Palsy: A Survey of the POSNA Membership
Benjamin Shore, MD; *Michael Shrader, MD; Unni Narayanan, MD; Freeman Miller, MD; H. Kerr Graham, MD; Kishore Mulpuri, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 50 2:06 PM - 2:11 PM
Is There a Consensus in Diagnosing and Preventing Hip Dislocation in CP Patients?
Prof. Bettina Westhoff; *Nikolai Jung; Volker Mall; Ruediger Krauspe, MD*
University Hospital Duesseldorf, Duesseldorf, Germany

Paper 51 2:12 PM - 2:17 PM
Radiation Prophylaxis for Hip Salvage Surgery in Cerebral Palsy – Can We Reduce the Incidence of Heterotopic Ossification?
Brian Snyder, MD; *Eric Davis, BS; Kathryn Williams, MS; Karen Marcus, MD; Travis Matheney, MD; Benjamin Shore, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

2:18 PM - 2:27 PM Discussion

Paper 52 2:27 PM - 2:32 PM
Trochanteric Sparing Proximal Femoral Resection for Spastic Hip Arthritis
Jonathan Schoenecker, MD; *Jennifer Bauer, MD; Perry Schoenecker, MD*
Vanderbilt University Medical Center, Nashville, Tennessee, United States

Paper 53 2:33 PM - 2:38 PM
San Diego Pelvic Osteotomy in Patients with Closed Triradiate Cartilage
Jozef Murar, MD; Stephanie Ihnow, MD; Luciano Dias, MD; ***Vineeta Swaroop, MD***
Ann and Robert H Lurie Childrens Hospital of Chicago, Chicago, Illinois, United States

Paper 54 2:39 PM - 2:44 PM
Long-term Outcome of Hip Instability Following Non-surgical and Surgical Interventions in Children with Cerebral Palsy
Walter Strobl, MD
Clinic For Pediatric Orthopaedics & Neuro-Orthopaedics, Rummelsberg, Bavaria, Germany

2:45 PM - 2:54 PM Discussion

Paper 55 2:54 PM - 2:59 PM
Is Percutaneous Myofascial Lengthening of Medial Hamstrings as Effective and Safe as the Open Procedure?
Toni Mansour, MD; Joseph Derienne, MD; Saliba Eliw; Ayman Assi, PhD;
Ismat Ghanem, MD
University of Saint Joseph, Beirut, Lebanon

Paper 56 3:00 PM - 3:05 PM

Minimal Invasive Multi-level Surgery Allows Early Mobilisation by Locomotion Therapy in Children and Young Adults with Cerebral Palsy

Walter Strobl, MD
Clinic For Pediatric Orthopaedics & Neuro-Orthopaedics Rummelsberg, Rummelsberg, Bavaria, Germany

Paper 57 3:06 PM - 3:11 PM

Longitudinal Follow-up of Children with Cerebral Palsy after Single-Event Multilevel Surgery

Anja Van Campenhout, PhD, MD
University Hospital Leuven, Leuven, Belgium

3:12 PM - 3:21 PM Discussion

Paper 58 3:21 PM - 3:26 PM

The Role of Hip Power in the Treatment of "Stiff Knee"

Brunno Moreira, MD*; Tasos Karakostas; Luciano Dias, MD*
Rehabilitation Institute of Chicago, Chicago, Illinois, United States

Paper 59 3:27 PM - 3:32 PM

Factors Influencing Outcomes After Medial Hamstring Lengthening with Semitendinosus Transfer in Patients with Cerebral Palsy

Ki Hyuk Sung, MD*; Chin Youb Chung, MD; Kyoung Min Lee, MD; Myungki Chung; Byung Chae Cho, MD; Seung Jun Moon, MD; Jaeyoung Kim, MD; Gye Wang Lee, MD; Seung Yeol Lee, MD; Tae Gyun Kim, MD; Moon Seok Park, MD*
Seoul National University Bundang Hospital, Seongnam-si, Gyeonggi-do, Republic of Korea

Paper 60 3:33 PM - 3:38 PM

Rectus Femoris Transfer Surgery Leads to Increased Crouch in Children with Cerebral Palsy at GMFCS Levels III and IV

Ted Sousa, MD; Alexander Nazareth, MS; Susan Rethlefsen, PT; Nicole Mueske, MS; Tishya Wren, PhD; Robert Kay, MD; ***Rachel Goldstein, MD***
Children's Hospital Los Angeles, Los Angeles, California United States

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

CONCURRENT SESSION II: BASIC SCIENCE

MODERATOR: *David G. Little, MD*
eMODERATOR: *Cristina Alves, MD*
PRESIDER: *Todd A. Milbrandt, MD*

Paper 61 2:00 PM - 2:05 PM
Increased Hip Intra-capsular Pressure Decreases Perfusion of the Capital Femoral Epiphysis in a Skeletally Immature Porcine Model
Vidyadhar Upasani, MD; *Raghav Badrinath, MD; Christine Farnsworth, MS; Megan Jeffords, MS; Jericho Hallare; Syed Ahmed, MD; Tim Schrader, MD*
Rady Children's Hospital, San Diego, California, United States

Paper 62 2:06 PM - 2:11 PM
3D Printed Highly Functional Implants for Osteochondral Repair and Bone Ingrowth in a Rodent Model
Matthew Oetgen, MD; *Che-Ying Kuo; Nathan Castro, PhD; Christopher Rossi, MD; John Fisher, PhD; Grace Zhang, PhD; Benjamin Holmes*
Children's National Medical Center, Washington, District of Columbia, United States

Paper 63 2:12 PM - 2:17 PM
Combination Antibiotic Therapy Demonstrates a Synergistic Effect in the Treatment of Implant Infection
Howard Park, MD; *Vishal Hegde, MD; Stephen Zoller, MD; Yan Hu; Amanda Loftin; Christopher Hamad, BS; Anthony A. Scaduto, MD; Nicholas Bernthal, MD*
University of California, Los Angeles, Los Angeles, California, United States

2:18 PM - 2:27 PM Discussion

Paper 64 2:27 PM - 2:32 PM
Celecoxib Leads to Impaired Cartilage and Bone Extracellular Matrix Formation in the Growth Plate of Skeletally Immature Mice
Marjolein Caron, PhD; Tessy Castermans; Bert Van Rietbergen, PhD; Lodewijk Van Rhijn; Tim Welting, PhD; ***Adhiambo Witlox, MD***
Maastricht University Medical Center, Maastricht, Netherlands

Paper 65 2:33 PM - 2:38 PM
Sexual Dimorphism in Bone Morphology and Density during Adolescent Growth
Tsz Ping Lam, MD, MBBS; *Ka-Yee Cheuk; Xiaofang Wang; Fiona Yu; Wayne Lee, PhD; Bobby Ng, MD; Alec Lik Hang Hung; Feng Zhu; Huanxiong Chen; Ali Ghasem-Zadeh; Roger Zebaze; Ego Seeman; Jack Cheng, MD*
The Chinese University of Hong Kong, Hong Kong

Paper 66 2:39 PM - 2:44 PM
Obesity Affects Growth Plate Structure and Gene Expression
Shawn Gilbert, MD; *Kenneth Smith, MD; Alan Eberhardt, PhD*
University of Alabama Birmingham, Birmingham, Alabama, United States

2:45 PM - 2:54 PM Discussion

Paper 67 2:54 PM - 2:59 PM

Therapeutic Effect of Metformin in Ischemic Osteonecrosis via Angiopoietin1 Induced Osteoblastic Differentiation

Jung-Ryul Kim, MD
Chonbuk National University, Jeonju, Jeonbuk, Republic of Korea

Paper 68 3:00 PM - 3:05 PM

Heparan Sulfate for OCD Regeneration: An Animal Study

James Hoi Poi Hui, MD*; Jonathan Lee, PhD; Raymond Smith, PhD; Ren Xiafei; Victor Nurcombe, PhD; Simon Cool, PhD*
National University of Singapore, Singapore, Singapore

Paper 69 3:06 PM - 3:11 PM

Enhancing Human Mesenchymal Stem Cells for improved regeneration of OCD Defects

James Hoi Poi Hui, MD*; Hassan Afizah; Ren Xiafei; Ling Ling; Victor Nurcombe, PhD; Simon M. Cool, PhD*
National University of Singapore, Singapore

3:12 PM - 3:21 PM Discussion

Paper 70 3:21 PM - 3:26 PM

Investigation of Regulation and Function of ST2 in controlling Chondrocyte Differentiation

Ehsan Bonyadi Ran, MSc; ***Annelie Weinberg, MD****; Sriveena Srinivasaiah, MSc; Ute Schaefer*
Medical University Graz, Graz, Austria

Paper 71 3:27 PM - 3:32 PM

♦ Fiber Optic Detection of Spinal Ischemia During Vertebral Column Distraction

James Barsi, MD*; Wei Lin, PhD; David Busch, PhD; James Davis, MD; Jakub Tatka, MD; Arjun Yodh, PhD; Thomas Floyd*
Stony Brook University, Stony Brook, New York, United States

Paper 72 3:33 PM - 3:38 PM

Genomewide Association Identifies FSTL5 Associated with Idiopathic Clubfoot

Jonathan Rios, PhD*; Anas Khanshour, PhD; Lucas Rosa Fraga, MSc; Alexandra Diamond; Vanessa De Mello; Julia Kozlitina, PhD; Mitchell Weston; Megan Wilson; Jacqueline Hecht, PhD; B. Stephens Richards, MD; Matthew Dobbs, MD; Neil Vargesson, PhD; Christina Gurnett*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

CONCURRENT SESSION III: UPPER EXTREMITY

MODERATOR: *Manuel Cassiano Neves, MD*
eMODERATOR: *Peter M. Waters, MD*
PRESIDER: *Christine A. Ho, MD*

Paper 73 2:00 PM - 2:05 PM
Arthroscopic Release for Shoulder Internal Rotation Contractures Secondary to Brachial Plexus Birth Palsy in Children Four Years of Age and Older
*David Kahan, MD; **Dan Zlotolow, MD**; T. Gibson, DO; Landon Bulloch; Kaylee Dowling; Grigory Gershkovich, MD; Scott Kozin, MD*
Shriners Hospital for Children, Philadelphia, Pennsylvania, United States

Paper 74 2:06 PM - 2:11 PM
Double versus Single Tendon Transfers to Improve Shoulder Function in Brachial Plexus Birth Palsy
*Dustin Greenhill; William Smith, MD; Frederick Ramsey, PhD; Scott Kozin, MD; **Dan Zlotolow, MD***
Shriner's Hospital for Children, Philadelphia, Pennsylvania, United States

Paper 75 2:12 PM - 2:17 PM
Humeral Lengthening with a Magnetic-Powered Lengthening Nail
*Ahmed Hammouda, MD; Shawn Standard, MD; S. Rozbruch, MD; **John Herzenberg, MD***
International Center for Limb Lengthening, Sinai Hospital of Baltimore, Baltimore, Maryland, United States

2:18 PM - 2:27 PM Discussion

Paper 76 2:27 PM - 2:32 PM
Finger Tip Amputation in New York State: Correlation with Abuse and Neglect
*Christopher Klifto, MD; Jessica Lavery, MS; Raj Karia, MPH; **Alice Chu, MD**; Debra Sala, PT*
NYU Hospital for Joint Diseases, New York, New York, United States

Paper 77 2:33 PM - 2:38 PM
Radial Head Changes in Osteochondritis Dissecans of the Humeral Capitellum
*Mark Wu, BS; Katherine Eisenberg, BS; Kathryn Williams, MS; **Donald Bae, MD***
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 78 2:39 PM - 2:44 PM
Long-term Outcome Following Surgical Treatment of Wrist Contractures in Children with AMC
***Evgeniia Kochenova, MD**; Olga Agranovich, PhD*
Federal State Institution "Research Pediatric Orthopedic Institute named after GI Turner", Saint-Petersburg, Pushkin, Russian Federation

2:45 PM - 2:54 PM Discussion

Paper 79 2:54 PM - 2:59 PM

Incidence of Compartment Syndrome in Patients with Supracondylar Humerus and Floating Elbow Fractures

Alysia Robertson, MD; Erica Gonzalez, BA; Lisa Wilsford; Theodora Browne, BA; Sha'Tia Safford; Lee Haruno, BS; Ifeoma Inneh; ***Jaclyn Hill, MD***
Texas Children's Hospital, Houston, Texas, United States

Paper 80 3:00 PM - 3:05 PM

Divergence between AAOS Appropriate Use Criteria Recommendations and Actual Management of Pediatric Supracondylar Humerus Fractures at a Pediatric Level One Trauma Center

Blaine Todd Bafus, MD*; Joanne Wang, MD; William Morris, MD; Raymond Liu, MD*
University Hospitals/Cleveland Medical Center, Cleveland, Ohio, United States

Paper 81 3:06 PM - 3:11 PM

The Impact of Direction of Displacement, Pin Configuration, and Surgeon Training on Clinical and Radiographic Outcomes in Type III Pediatric Supracondylar Humerus Fractures

Andrew Livermore, MD; ***Jason Sansone, MD****; Scott Hetzel, MS; Maxwell Machurick, BA; Jason Browne, BA; Ken Noonan, MD*
University of Wisconsin, Madison, Wisconsin, United States

3:12 PM - 3:21 PM Discussion

Paper 82 3:21 PM - 3:26 PM

A Retrospective Review of 10 Years of Pediatric Both Bone Forearm Fractures: Comparison of Single Bone versus Both Bone Fixation

Tyler Keller, MD; Ashley Miller, MD; ***Kevin Little, MD***
Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, United States

Paper 83 3:27 PM - 3:32 PM

Variation Amongst Pediatric Orthopaedic Surgeons When Treating Medial Epicondyle Fractures

Meghan Hughes, MPH; Karan Dua, MD; Nathan O'Hara; Brian Brighton, MD; Theodore Ganley, MD; William Hennrikus, MD; Martin Herman, MD; Joshua Hyman, MD; J. Todd Lawrence; Charles T. Mehlman, DO, MPH; Norman Otsuka, MD; Richard Schwend, MD; Ken Noonan, MD; Brian Smith, MD; Paul Sponseller, MD; ***Joshua Abzug, MD***
University of Maryland, Baltimore, Maryland, United States

Paper 84 3:33 PM - 3:38 PM

Non-operative Management of Stable Pediatric Osteochondritis Dissecans of the Capitellum

Emily Niu, MD; Donald Bae, MD; Frances Tepolt, MD; ***Mininder Kocher, MD***
Boston Children's Hospital, Boston, Massachusetts, United States

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

CONCURRENT SESSION I: NEUROMUSCULAR II

MODERATOR: *Ignacio Sanpera-Trigueros, MD*
eMODERATOR: *Ashok Johari, MD*
PRESIDER: *Christina K. Hardesty, MD*

Paper 85 4:10 PM - 4:15 PM
The Effect of Co-Surgeon on Outcomes in CP Spine Surgery
***Rachel Mednick Thompson, MD**; Oussama Abousamra, MD; Meryl Ludwig, MD; Freeman Miller, MD; Kirk Dabney, MD; Julieanne Sees, DO*
Nemours A.I. Dupont Hospital for Children, Wilmington, Delaware, United States

Paper 86 4:16 PM - 4:21 PM
Assessing the Risk/Benefit Ratio of Surgery in CP: Is Surgery Worth It?
***Firoz Miyanji, MD**; Suken Shah, MD; Amer Samdani, MD; Baron Lonner, MD; Burt Yaszay, MD; Jahangir Asghar, MD; David Clements, MD; Peter Newton, MD*
British Columbia Children's Hospital, Vancouver, British Columbia, Canada

Paper 87 4:22 PM - 4:27 PM
Perioperative Management of Patients with Cerebral Palsy Undergoing Scoliosis Surgery: Survey of Surgeon Practices
***Mohan Belthur, MD**; Liam Bosch, BA; William Wood, MD; Carla Boan; Michael Shrader, MD; Freeman Miller, MD*
Phoenix Children's Hospital, Phoenix, Arizona, United States

4:28 PM - 4:37 PM Discussion

Paper 88 4:37 PM - 4:42 PM
The Use of Guided Growth Technique for Coxa Valga in Cerebral Palsy Children
*Hsiang-Chieh Hsieh; **Kuan-Wen Wu, MD**; Ting-Ming Wang, MD; Ken Kuo, MD;*
National Taiwan University Hospital, Taipei, Taiwan

Paper 89 4:43 PM - 4:48 PM
Reverse Periacetabular Osteotomy in the Treatment of Neurogenic Hip Dysplasia in Cerebral Palsy
Andrew Georgiadis, MD; Vivek Dutt; Susan Novotny; Walter Truong, MD;
Tom Novacheck, MD
Gillette Children's Specialty Healthcare, St. Paul, Minnesota, United States

Paper 90 4:49 PM - 4:54 PM
Does Correction of Femoral Lever-Arm Influences the Effect of Selective Dorsal Rhizotomy on Gait in Children with Spastic Diplegic Cerebral Palsy?
Anja Van Campenhout, PhD
University Hospital Leuven, Leuven, Belgium

4:55 PM - 5:04 PM Discussion

Paper 91 5:04 PM - 5:09 PM

The Effect of Scoliosis Surgery on Pulmonary Function in Spinal Muscular Atrophy Type II Patients

Shih-Hsiang Chou, MD; *Pochih Shen; Cheng-Chang Lu, MD; Jian-Chih Chen; Chih-Ming Kao; Yin-Chun Tien*
Kaohsiung Medical University Hospital, Kaohsiung City, Taiwan

Paper 92 5:10 PM - 5:15 PM

Improvement of Pulmonary Function Measured by Patient-Reported Outcomes in Patients with Spinal Muscular Atrophy after VEPTR Surgery

Michael G. Vitale, MD, MPH; *David Roye, MD; John Mueller, BS; Hiroko Matsumoto, MA; Patrick Cahill, MD; Peter Sturm, MD; John Smith, MD; Children's Spine Study Group*
Columbia University Medical Center, New York, New York, United States

Paper 93 5:16 PM - 5:21 PM

The Impact of Pamidronate on the Progression of Vertebral Fractures in Patients with Duchenne Muscular Dystrophy Undergoing Corticosteroid Treatment

Emily Schaeffer, PhD; *Miles Jaques; Chris Reilly, MD*
British Columbia Children's Hospital, Vancouver, British Columbia, Canada

5:22 PM - 5:31 PM Discussion

Paper 94 5:31 PM - 5:36 PM

The Alteration of Lower Limbs' Muscle Size During Growth in Ambulant Children with Cerebral Palsy

Abir Massaad, PT; Ayman Assi, PhD; Ziad Bakouny, MSc; Wafa Skalli, PhD; Saliba Eliw; ***Ismat Ghanem, MD***
University of Saint Joseph, Beirut, Lebanon

Paper 95 5:37 PM - 5:42 PM

A Novel Risk Severity Score to Predict Pediatric Spine Surgical Site Infection in Patients with Cerebral Palsy Ranges from 0.88% to 23.3%

David Roye, MD; *Hiroko Matsumoto, MA; Chun Wai Hung; Jeanne Franzone, MD; Nicholas Feinberg, BA; William Mackenzie, MD; Michael Troy, BS; Brendan Striano, BA; John M. (Jack) Flynn, MD; David Skaggs, MD; Michael Glotzbecker, MD; Michael G. Vitale, MD, MPH*
Columbia University Medical Center, New York, New York, United States

Paper 96 5:43 PM - 5:48 PM

Long-term Outcomes after Distal Femoral Extension Osteotomy and Patellar Tendon Advancement in Individuals with Cerebral Palsy

Tom Novacheck, MD; *Elizabeth Boyer; Jean Stout, PT; Jennifer Laine, MD; Sarah Gutknecht; Lucas Araujo De Oliveira; Meghan Munger, MPH; Michael Schwartz, PhD*
Gillette Children's Specialty Healthcare, St. Paul, Minnesota, United States

5:49 PM - 5:58 PM Discussion

CONCURRENT SESSION II: SPORTS

MODERATOR: *Mininder S. Kocher, MD*
eMODERATOR: *Franck Accabled, MD*
PRESIDER: *Jennifer M. Weiss, MD*

Paper 97 4:10 PM - 4:15 PM
Comparison of Early Lower Extremity Functional Recovery in Pediatric Patients following Anterior Cruciate Ligament Reconstruction Using Transphyseal Hamstring versus Physeal-Sparing IT Band Autograft
Benton Heyworth, MD; *Lyle Micheli, MD; Dai Sugimoto; Sara Collins; Mininder S. Kocher, MD*
Boston Children's Hospital / The Micheli Center for Sports Injury Prevention, Boston, Massachusetts, United States

Paper 98 4:16 PM - 4:21 PM
Magnetic Resonance Imaging Detection of Meniscal Injuries in Pediatric and Adolescent Patients with Anterior Cruciate Ligament Tears
Alana Munger, BS; Nicholas Gonsalves, BA; Emily Clarke, BS; Curtis VandenBerg, MD; ***James Pace, MD***
Children's Hospital Los Angeles, Los Angeles, California, United States

Paper 99 4:22 PM - 4:27 PM
Analysis of Failure and Outcomes After Revision Medial Patellofemoral Ligament Reconstruction
Shital Parikh, MD
Cincinnati Children's Hospital, Cincinnati, Ohio, United States

4:28 PM - 4:37 PM Discussion

Paper 100 4:37 PM - 4:42 PM
The Warm-up Pprogramme "FIFA 11+ Kids" in Prevention of Injuries in Children's Football: A Cluster Randomized Controlled Trial
Jiri Chomiak, MD; *Roland Rössler; Astrid Junge; Mario Bizzini; Evert Verhagen, PhD; Karen Aus Der Fünten, MD; Jiri Dvorak; Eric Lichtenstein; Tim Meyer; Florian Beaudouin; Oliver Faude*
Charles University and Hospital Na Bulovce, Prague, Czech Republic

Paper 101 4:43 PM - 4:48 PM
Arthroscopic Capsulolabral Reconstruction for Posterior Shoulder Instability Is Successful in Adolescent Athletes
Justin Arner, MD; ***Michael McClincy, MD***; *James Bradley, MD*
University of Pittsburgh, Pittsburgh, Pennsylvania, United States

Paper 102 4:49 PM - 4:54 PM
12 Year Follow Up of Autologous Chondrocyte Implantation (ACI) for Knee Juvenile Osteochondritis Dissecans (JOCD)
Jennifer Beck, MD; *Dai Sugimoto; Lyle Micheli, MD*
Boston Childrens Hospital, Boston, Massachusetts, United States

4:55 PM - 5:04 PM Discussion

Paper 103 5:04 PM - 5:09 PM

Pediatric ACL Reconstruction and Return to the Operating Room: Graft Failure is Less Than Half of the Story

Christopher Defrancesco; Eileen Storey, BA; John M. (Jack) Flynn, MD; ***Theodore Ganley, MD***
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

Paper 104 5:10 PM - 5:15 PM

Risk of Graft Failure after All-Epiphyseal ACL Reconstruction Compared to Adult-Type ACL Reconstruction with Hamstrings Autograft Tissue in Young Athletes

Mark Paterno PT; ***Eric Wall, MD****; Staci Thomas; Shital Parikh, MD; Timothy Hewett, PhD; Laura Schmitt*
Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, United States

Paper 105 5:16 PM - 5:21 PM

Early Results and Safety of the "Hybrid" Physeal Sparing ACL Reconstruction in Skeletally Immature Athletes

Carl Nissen, MD*; Regina Kostyun; Robert Willson, MD; Matthew Milewski, MD*
Elite Sports Medicine/Connecticut Childrens Medical Center, Hartford, Connecticut, United States

5:22 PM - 5:31 PM Discussion

Paper 106 5:31 PM - 5:36 PM

♦ Arthroscopic Implantation of Meniscal Scaffold for the Treatment of Irreparable Meniscal Injury - Preliminary Study

Michal Walczak, MD
Wiktor Dega Orthopaedic Hospital, Poznan, Poland

Paper 107 5:37 PM - 5:42 PM

Effect of Meniscal Tear on Strength and Functional Performance in Young Athletes at 6 Months Following Anterior Cruciate Ligament Reconstruction with Hamstring Autograft

Lauren Redler, MD; Dai Sugimoto; Ashley Tisosky, MD; Mininder S. Kocher, MD; Lyle Micheli, MD; ***Benton Heyworth, MD***
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 108 5:43 PM - 5:48 PM

Are Basketball and Soccer Risk Factors for Juvenile Osteochondritis Dissecans of the Trochlea? A Cohort Study of 34 Trochlear Lesions

Daniel Green, MD*; Meghan Price, BS; Maria Tuca, MD; Jason Silberman, BA; Eva Luderowski, BA*
Hospital for Special Surgery, New York, New York, United States

5:49 PM - 5:58 PM Discussion

♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

CONCURRENT SESSION III: LOWER EXTREMITY

MODERATOR: *Rudolf Ganger, MD*
eMODERATOR: *Amy L. McIntosh, MD*
PRESIDER: *Elke Viehweger, MD*

Paper 109 4:10 PM - 4:15 PM
Transplantation of Autologous Culture-Expanded Bone Marrow Cells and Platelet Rich Plasma for Bone Regeneration-Comprehensive Clinical Study of the Lower Limb Lengthening
Hiroshi Kitoh, MD; *Kenichi Mishima; Masaki Matsushita, MD; Hiroshi Sugiura; Akiko Kitamura; Naoki Ishiguro, MD*
Nagoya University Graduate School of Medicine, Nagoya, Japan

Paper 110 4:16 PM - 4:21 PM
Simultaneous Acute Femoral Deformity Correction and Gradual Limb Lengthening Using the Retrograde PRECICE® Femoral Nail: Technique and Clinical Results
Christopher Iobst, MD; *Scott Nelson, MD; S. Rozbruch, MD; Austin Fragomen, MD*
Nemours, Orlando, Florida, United States

Paper 111 4:22 PM - 4:27 PM
The Creation and Validation of a Bone Age Atlas Utilizing Knee MRIs
Andrew Pennock, MD; *John Manning, MD; James Bomar*
Rady Children's Hospital, San Diego, California, United States

4:28 PM - 4:37 PM Discussion

Paper 112 4:37 PM - 4:42 PM
Sagittal Plane Deformity after Temporary Epiphysiodesis for Correcting Leg Length Discrepancy
Hiroki Furuhashi, MD; *Hiroshi Kaneko; Koji Iwata; Tadashi Hattori*
Aichi Children's Health and Medical Center, Obu, Aichi, Japan

Paper 113 4:43 PM - 4:48 PM
Can We Predict Amount of Correction Using Guided Growth Around the Knee?
Barry Danino, MD; *Robert Roedl, MD; John Herzenberg, MD; Lior Shabtai, MD; Grill Franz, MD; Unni Narayanan, MD; Eitan Segev, DMed; Shlomo Wientroub*
Dana Children's Hospital, Tel-Aviv Sourasky Medical Center, Tel Aviv, Israel

Paper 114 4:49 PM - 4:54 PM
Is Proximal Fibula Epiphysiodesis Necessary When Performing a Proximal Tibial Epiphysiodesis?
Jonathan Boyle, MD; Marina Makarov; ***David Podeszwa, MD***; *Jennifer Rodgers, MA; John Birch, MD*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

4:55 PM - 5:04 PM Discussion

Paper 115 5:04 PM - 5:09 PM

Assessment of Femoral Deformity in Blount's Disease

*Anati Ngcakani, MD; **Gregory Firth MMED (Ortho)**; Yammesh Ramguthy, MBChB; Anthony Robertson, PhD*
University of Witwatersrand, Johannesburg, South Africa

Paper 116 5:10 PM - 5:15 PM

Risk Factors for Short-Term Morbidity in Pediatric Orthopedic Patients Undergoing Pelvic and Femoral Osteotomies

***Dorothy Harris, MD**; Erica Gonzalez, BA; Cody Sanderson, BS; Wei Zhang, PhD; Ifeoma Inneh; Lee Haruno, BS; John Dormans, MD*
Texas Children's Hospital, Houston, Texas, United States

Paper 117 5:16 PM - 5:21 PM

8 Plate Epiphysiodesis: Are We Creating an Intra-articular Deformity?

*Ritesh Sinha; **Elhanan Bar-On, MD**; Daniel Weigl, MD; Eyal Mercado; Tali Becker, MD*
Schneider Children's Medical Center, Petah Tikva, Israel

5:22 PM - 5:31 PM Discussion

Paper 118 5:31 PM - 5:36 PM

Results of Progressive Limb Lengthening in High-Frequency Distraction Mode Associated with Hydroxyapatite-Coated Intramedullary Nailing

Dmitry Popkov, MD
Russian Ilizarov Centre, Kurgan, Russian Federation

Paper 119 5:37 PM - 5:42 PM

♦ Intramedullary Lengthening Nails and MRI Compatability

***Scott Nelson, MD**; Charles Gomez, MD*
Loma Linda University, Loma Linda, California, United States

Paper 120 5:43 PM - 5:48 PM

The Importance of Considering Ultimate Height in the Treatment of Limb Length Discrepancy

*Alexander Rascoe, MD; Eric Peng, BA; Jonathan Copp, MD; **Raymond Liu, MD***
Rainbow Babies and Children's Hospitals at Case Western Reserve University, Cleveland, Ohio, United States

5:49 PM - 5:58 PM Discussion

6:00 PM–7:00 PM

YOUNG MEMBER FORUM

THIRD ANNUAL ARABELLA LEET, MD
YOUNG MEMBER FORUM

♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

FRIDAY, MAY 5, 2017

8:00 AM - 8:04 AM OPENING REMARKS

QSVI AWARD PAPER
Presented by: *Peter Armstrong, MD*

BASIC SCIENCE AWARD PAPERS

MODERATOR: *Benjamin Alman, MD*
eMODERATOR: *Andreas Roposch, MD*
PRESIDER: *Jonathan G. Schoenecker, MD*

Paper 121 8:04 AM - 8:09 AM

♦ Development of a Novel Non-Invasive Growth Plate Ablation Treatment Using Magnetic Resonance Imaging-guided High-Intensity Focused Ultrasound (MR-HIFU)

Pavel Yarmolenko, PhD; Olumide Aruwajoye, PhD; Haydar Celik, PhD; Robert Staruch, PhD; Debra Szczepanski; Karun Sharma; Aerang Kim; Kavita Prakash; Avinash Eranki; Rajiv Chopra, PhD; Peter Kim; Matthew Oetgen, MD; ***Harry Kim, MD***
Texas Scottish Rite Hospital and Children's National Medical Center, Dallas, Texas and Washington, District of Columbia, United States

8:10 AM - 8:14 AM Discussion

Paper 122 8:14 AM - 8:19 AM

An Ex Vivo 3 Dimensional Organotypic Culture Model of the Physis: A First Attempt to Stimulate Endochondral Ossification of the Growth Plate In Vitro

Sriveena Srinivasaiah, MSc; Giuseppe Musumeci; Sepideh Mostofi; Ehsan Bonyadi Ran; Ute Schaefer; ***Annelie Weinberg, MD***
Medical University of Graz, Graz, Austria

8:20 AM - 8:24 AM Discussion

Paper 123 8:24 AM - 8:29 AM

Comparison of Transphyseal Neck-Head Tunneling (TNHT) versus Multiple Epiphyseal Drilling (MED) on Femoral Head Healing Following Ischemic Osteonecrosis

Harry Kim, MD*; Olumide Aruwajoye, PhD; Felipe Do Monte; Audrey Kim; Matthew Phipps, PhD*
Texas Scottish Rite Hospital, Dallas, Texas, United States

8:30 AM - 8:34 AM Discussion

Paper 124 8:34 AM - 8:39 AM

♦ Effects of Early Anti-inflammatory Cytokine Treatments On Bone Bridge Formation Following Growth Plate Injury

Fulya Ustunkan, MD*; Keng Lin Wong; Zheng Yang, PhD; Wei Seong Toh; Azlina Abbas, MD; Kamarul Tunku; James Hoi Poi Hui, MD; Eng Lee, MD*
National University of Singapore, Singapore

8:40 AM - 8:44 AM Discussion

♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

Paper 125 8:44 AM - 8:49 AM
Are Serum Bone Metabolic Markers Associated with Abnormal BMD and Bone Phenotypes in AIS?
Bobby Ng, MD, *Huanxiong Chen, PhD; Wayne Lee, PhD; Ka-Yee Cheuk; Eric Yu; Fiona Yu; Elisa Tam, PhD; Tsz Ping Lam, MBBS; MD; Alec Lik Hang Hung; Feng Zhu; X. Edward Guo, PhD; Jack Cheng, MD*
The Chinese University of Hong Kong, Hong Kong, Hong Kong

8:50 AM - 8:54 AM Discussion

Paper 126 8:54 AM - 8:59 AM
Genome and Virulence Determinants of Staphylococcus aureus Causing Acute Hematogenous Osteomyelitis
Angela Collins, MD; Naureen Tareen, MPH; Min Soo Kim, MSc; Edward Wakeland; Prithvi Raj, PhD; Kyle Mercadante; Jiwoong Kim, MS; ***Lawson Copley, MD***
Children's Medical Center Dallas, Dallas, Texas, United States

9:00 AM - 9:04 AM Discussion

9:05 AM–9:25 AM EPOSNA PRESIDENTIAL SPEAKER
Deborah Eastwood, MD

9:26 AM–9:46 AM Break

CLINICAL AWARD PAPERS

MODERATOR: *Alain Dimeglio, MD*
eMODERATOR: *Lori A. Karol, MD*
PRESIDER: *Antonio Andreacchio, MD*

Paper 127 9:47 AM - 9:52 AM
Research for Fetal Myelomeningocele Repair
Cesar Fontecha, MD*; Margarita Codinach; Jose Luis Peiro, PhD*
Vall d'Hebron Hospital, Barcelona, Spain

9:53 AM - 9:57 AM Discussion

Paper 128 9:57 AM - 10:02 AM
Increased Rate of Malignancy in Children with Syndactyly
Aaron Daluiski, MD*; Yen Chen, MD; Yile Ge, MS; Huong Do, MA*
Hospital for Special Surgery, New York, New York, United States

10:03 AM - 10:07 AM Discussion

Paper 129 10:07 AM - 10:12 AM
Flexion Supracondylar Humerus Fractures: Ulnar Nerve Deficit is a Risk for Open Reduction
Kelly Flynn; Apurva Shah; Kelly Leddy, MS; Christopher Brusalis;
John M. (Jack) Flynn, MD
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

10:13 AM - 10:17 AM Discussion

Paper 130 10:17 AM - 10:22 AM

Non-Operative Management of Salter-Harris II Fractures of the Distal Tibia: No Difference in Functional Outcomes Based on Postreduction Displacement

Adam Margalit; Kranti Peddada, BS; Craig Remenapp, MS; ***Rushyuan Lee, MD***
Johns Hopkins Medicine, Baltimore, Maryland, United States

10:23 AM - 10:27 AM Discussion

Paper 131 10:27 AM - 10:32 AM

Sequential Intravenous High Dose Oral Antibiotics in the Treatment of Osteoarticular Infections in Children – A Randomised Controlled Trial

Haemish Crawford, FRACS*; Karen Tsui, MBChB; Diana Lennon; N. Stott, MD; Lesley Voss; Joanna Stewart, MSc*
Starship Children's Hospital, Auckland, New Zealand

10:33 AM - 10:37 AM Discussion

Paper 132 10:37 AM - 10:42 AM

A Novel MRI Measurement to Assess Patellar Instability: Width of Patellar Tendon Beyond Lateral Trochlear Ridge

R. Justin Mistovich, MD*; John Urwin, BS; Peter Fabricant, MD; J. Todd Lawrence, MD*
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

10:43 AM - 10:47 AM Discussion

Paper 133 10:47 AM - 10:52 AM

Clinical Screening Lowers the Risk of Late Diagnosed Hip Dislocation – Results from 1 Million Children Born in Sweden from 2000 through 2009

Daniel Wenger, MD*; Henrik Duppe; Carl Tiderius*
Lund University, Malmö, Sweden

10:53 AM - 10:57 AM Discussion

Paper 134 10:57 AM - 11:02 AM

Operative Treatment for Perthes Disease Yields Better Outcomes than Non-operative Treatment at 20 Year Follow-up

Daniel J. Sucato, MD, MS*; Adriana De La Rocha, PhD; Lauren Paraison, BA; Harry Kim, MD; John Anthony Herring, MD*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

11:03 AM - 11:07 AM Discussion

Paper 135 11:07 AM - 11:12 AM

Bracing Idiopathic Scoliosis Greater than 40°

Amanda Whitaker, MD*; Alexandra Grzywna, BA; Michael Glotzbecker, MD; Daniel Hedequist, MD; Lawrence Karlin, MD; John Emans, MD; Michael T. Hresko, MD*
Boston Children's Hospital, Boston, Massachusetts United States

11:13 AM - 11:17 AM Discussion

Paper 136 11:17 AM - 11:22 AM
Radiographic, Pulmonary and Clinical Outcomes with Halo Gravity Traction
Lauren Lamont, MD; Chan-Hee Jo, PhD; Sarah Offley, MD; Dong-Phuong Tran, MS; Heather Caine; Kaitlyn Brown; Wendy Wittenbrook; Charles Johnston, MD; ***Brandon Ramo, MD***
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

11:23 AM - 11:27 AM Discussion

11:28 AM–11:38 AM PRO MAXIMUS AWARDS

11:39 AM–11:49 AM DISTINGUISHED ACHIEVEMENT AWARD

11:50 AM–12:00 PM EPOS PRESIDENTIAL TRANSFER

12:01 PM–12:11 PM POSNA PRESIDENTIAL TRANSFER

12:12 PM–1:00 PM Lunch

12:50 PM–1:50 PM SLAOTI SYMPOSIA

12:50 PM–1:50 PM APPOS SYMPOSIA

CONCURRENT SESSION IV: CLUB FOOT

MODERATOR: *Stephanie Böhm, MD*
eMODERATOR: *Matthew B. Dobbs, MD*
PRESIDER: *Anna Ey, MD*

Paper 137 2:00 PM - 2:05 PM
Early Anterior Tibial Tendon Transfer for Clubfoot Patients
Jolita Gintautiene, MD*; Emilis Cekanauskas; Mindaugas Gruzauskas, MD; Rasa Simonaityte*
The Hospital of Lithuanian University of Health Sciences, Kaunas, Lithuania

Paper 138 2:06 PM - 2:11 PM
A 13 Year Follow-up of Split Tendon Transfers for Equinovarus Deformity Secondary to Cerebral Palsy
Peter Smith, MD*; Ann Flanagan; Joseph Krzak; Karen Kruger; Adam Graf, MS; Sahar Hassani, MS*
Shriners Hospitals for Children - Chicago, Chicago, Illinois, United States

Paper 139 2:12 PM - 2:17 PM
Normalization of Foot Motion after Tibialis Anterior Tendon Transfer for Clubfoot Recurrence
Gabriel Mindler, MD*; Andreas Kranzl, PhD; Christof Radler, MD*
Orthopaedic Hospital Speising, Vienna, Austria

2:18 PM - 2:27 PM Discussion

Paper 140 2:27 PM - 2:32 PM
Ponseti Treatment of Clubfeet Results in Less Foot Size Asymmetry than Comprehensive Surgical Releases
Juanita Wallace, MS; Hank White; Samuel Augsburger, MS; Vishwas Talwalkar, MD; Ryan Muchow, MD; Henry Iwinski, MD; ***Janet L. Walker, MD***
Shriners Hospital and University of Kentucky, Lexington Kentucky, United States

Paper 141 2:33 PM - 2:38 PM
Community Ambulatory Activity and Gross Motor Function Following Treatment for Clubfoot at Age 10 Years
Wilshaw Stevens Jr., BS; Kelly Jeans, MSc; Kirsten Tulchin-Francis, PhD; Fernanda Pinarte, MBA; Karina Zapata; ***Lori Karol, MD***
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

Paper 142 2:39 PM - 2:44 PM
Motor Skills in 191 School Children with Idiopathic Clubfoot
Vera Halvorsen, MD*; Vibeke Smith Aulie, PT; William Brox, MD*
Oslo University Hospital, Oslo, Norway

2:45 PM - 2:54 PM Discussion

Paper 143 2:54 PM - 2:59 PM
The Outcome of the Ponseti Method at a Minimum of 5 Years: What Have We Learned?
Lewis Zionts, MD*; Sophia Sangiorgio, PhD; Michael Jew, BS; Rebecca Morgan, BS; Edward Ebramzadeh PhD*
Orthopaedic Institute for Children, Los Angeles, California, United States

Paper 144 3:00 PM - 3:05 PM
Treatment of Neuromuscular and Syndromic (Non-idiopathic) Clubfeet Using the Ponseti Method
Rujuta Mehta, MD*; Alaric Aroojis, MD; Avi Shah*
B J Wadia Hospital For Children, Mumbai - Maharashtra, India

Paper 145 3:06 PM - 3:11 PM
Mid-term Results of the Ponseti Method for Treatment of Clubfoot in Patients with Spina Bifida
Stephanie Ihnow, MD; Meraaj Haleem, BA; Luciano Dias, MD; ***Vineeta Swaroop, MD***
Ann and Robert H. Lurie Children's Hospital of Chicago, Chicago, Illinois, United States

3:12 PM - 3:21 PM Discussion

Paper 146 3:21 PM - 3:26 PM
Can Repeated Ponseti Management for Relapsed Clubfeet Produce the Outcome Comparable to the Case Without Relapse? A Clinical Study in Term of Gait Analysis
Li Zhao, MD*; Yu-Bin Liu*
Xin-Hua Hospital, Shanghai Jiao Tong University School of Medicine, ShangHai, People's Republic of China

Paper 147 3:27 PM - 3:32 PM
Gait Analysis in Children in Middle Childhood with Clubfoot: Posterior-Only Release versus Ponseti Method
Albert Ferrando, MD*; Marta Salom*
Hospital Universitari i Politecnic La Fe, Valencia, Valencia, Spain

Paper 148 3:33 PM - 3:38 PM
Surgical Management of Idiopathic Clubfoot in the United States from 1997-2012: An Analysis of 11,940 Discharges
Brandon Wilkinson, MD; Natalie Glass, PhD; Thomas Cook; ***Jose Morcuende, MD***
University of Iowa Hospitals and Clinics Department of Orthopaedics, Iowa City, Iowa, United States

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

CONCURRENT SESSION V: SPINE

MODERATOR: *Muharrem Yazici, MD*
eMODERATOR: *Ron El-Hawary, MD*
PRESIDER: *Federico Canavese, MD*

Paper 149 2:00 PM - 2:05 PM
Health-Related Quality of Life in Early-Onset Scoliosis Patients Treated Surgically: EOSQ Scores in Traditional Growing Rod versus Magnetically-Controlled Growing Rods
Z. Deniz Olgun, MD*; Michael Doany, BS; Gizem Kinikli; Senol Bekmez, MD; Ismail Aykut Kocyigit; Gokhan Demirkiran, MD; Mehmet Berktas, MD; Muharrem Yazici, MD*
Hacettepe University, Ankara, Turkey

Paper 150 2:06 PM - 2:11 PM
Shilla Growth Guidance-Evolution of a New Procedure: Rate of Complications in the First Two Years Following Implantation in the First 80 Patients
Richard McCarthy, MD*; Frances McCullough, NP*
Arkansas Children's Hospital, Little Rock, Arkansas, United States

Paper 151 2:12 PM - 2:17 PM
Limiting Pre-incision Instrument Uncovered Time via Quality Practice Intervention Decreases VEPTR Implantation Surgical Site Infections
Patrick Cahill, MD*; Diane Hartman, RN; Robert Campbell, MD; John M. (Jack) Flynn, MD; Keith Baldwin, MD; Nikita Lakomkin; Michael Nance, MD; Thane Blinman, MD; Oscar Mayer, MD; Howard Panitch, MD; Lloydine Jacobs, MD; Anthony Capraro; Brian Hanna; Jesse Taylor, MD*
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

2:18 PM - 2:27 PM Discussion

Paper 152 2:27 PM - 2:32 PM
Determinants of Effective Control of Curve Progression Using Calcium and Vitamin D Supplementation in Adolescent Idiopathic Scoliosis – In-depth Analysis of a Randomized Double-blinded Placebo-controlled Trial
Tsz Ping Lam, MBBS*; Benjamin Yip; Ka-Yee Cheuk; Elisa Tam, PhD; Gene Man, PhD; Wayne Lee, PhD; Simon Lee, PhD; Fiona Yu; Feng Zhu; Alec Lik Hang Hung; Bobby Ng, MD; Jack Cheng, MD*
The Chinese University of Hong Kong, Shatin, Hong Kong

Paper 153 2:33 PM - 2:38 PM
Alternatively Repetitive Cast/Brace Treatment without General Anesthesia for Early Onset Scoliosis
Noriaki Kawakami, MD; *Toshiki Saito; Ryoji Tauchi; Kazuki Kawakami; Hiroki Matsui; Taichi Tsuji, MD; Tetsuya Ohara, MD*
Meijo Hospital, Nagoya, Japan

Paper 154 2:39 PM - 2:44 PM
Clinical Impact of Corrective Cast Treatment for Early Onset Scoliosis: Is It Worthwhile Doing to Suppress Scoliosis Progression Prior to Surgical Intervention?
Noriaki Kawakami, MD; *Izumi Komoto, MD; Yoshihiro Dogaki; Toshiki Saito; Ryoji Tauchi; Kazuki Kawakami; Teppei Suzuki; Taichi Tsuji, MD; Uno Koki*
Meijo Hospital, Nagoya, Japan

2:45 PM - 2:54 PM Discussion

Paper 155 2:54 PM - 2:59 PM
Effect of Curve Type in Brace Success in Patients with Idiopathic Scoliosis
Rachel Mednick Thompson, MD; *Elizabeth Hubbard, MD; Chan-Hee Jo, PhD; Donald Virostek; Lori Karol, MD*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

Paper 156 3:00 PM - 3:05 PM
Even if Bracing Fails to Prevent Surgery, It May Benefit the Lumbar Spine in Adolescent Idiopathic Scoliosis
Paul Sponseller, MD; *Moustafa Abou Areda, BA; Adam Margalit, BS*
Johns Hopkins School of Medicine, Baltimore, Maryland, United States

Paper 157 3:06 PM - 3:11 PM
Ultralow Dose Radiation 3D Intraoperative Imaging: How Low Can We Go? An O-Arm, CT Scan, Cadaveric Study
Vishal Sarwahi, MD; *Monica Payares, MD; Stephen Wendolowski, BS; Adam Wollowick, MD; Beverly Thornhill, MD; Dan Wang, MS; Terry Amaral, MD*
Cohen Children's Medical Center, New Hyde Park, New York, United States

3:12 PM - 3:21 PM Discussion

Paper 158 3:21 PM - 3:26 PM
Prospective Evaluation of Outcomes After Selective and "Non-selective" Fusions of C Type Curves in AIS
Brian Kaufman, MD; *Suken Shah, MD; Petya Yorgova, MS; Geraldine Neiss, PhD; Burt Yaszay, MD; Baron Lonner, MD; Kenneth Rogers, PhD*
Nemours / A.I. Dupont Hospital for Children, Wilmington, Delaware, United States

Paper 159 3:27 PM - 3:32 PM
Can Surgical Innovation Decrease Operative Time, Surgeon Variability and Surgical Morbidity in AIS Surgery: A Study of Operative Efficiency
Burt Yaszay, MD; *Baron Lonner, MD; Yuan Ren; Gabrielle Kassin, BS; Peter Newton, MD*
Mount Sinai Hospital, New York, United States

Paper 160 3:33 PM - 3:38 PM
Is It Surgical Volume, Surgeon's Experience, or the Number of Surgeons That Determine Safety, Efficacy, and Efficiency?
Vishal Sarwahi, MD; *Jesse Galina, BS; Stephen Wendolowski, BS; Rachel Gecelter, BS; Dan Wang, MS; Selina Poon, MD; Melanie Gambassi, NP; Jon-Paul DiMauro, MD; Terry Amaral, MD*
Cohen Children's Medical Center, New Hyde Park, New York, United States

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

CONCURRENT SESSION VI: INFECTION/TUMORS

MODERATOR: *Frances A. Farley, MD*
eMODERATOR: *Thomas Wirth, MD*
PRESIDER: *Lawson A.B. Copley, MD*

Paper 161 2:00 PM - 2:05 PM
The Safety and Feasibility of Magnetic Resonance Guided High Intensity Focused Ultrasound to Treat Symptomatic Osteoid Osteoma
Matthew Oetgen, MD; *Karun Sharma; Pavel Yarmolenko, PhD; Haydar Celik, PhD; Avinash Eranki; Ari Partanen, PhD; Anilawan Smitthimedhin, MD; Aerang Kim; Domiciano Santos, MD; Janish Patel, MD; Peter Kim*
Children's National Medical Center, Washington, District of Columbia, United States

Paper 162 2:06 PM - 2:11 PM
Surgical Treatment of Active or Aggressive Aneurysmal Bone Cysts in Children-Revisited
Bulent Erol, MD; *Mert Topkar, MD*
Marmara University Hospital, Istanbul, Turkey

Paper 163 2:12 PM - 2:17 PM
Mid-Term Radiological and Functional Results of Biological Reconstructions of Extremity-Located Bone Sarcomas In Children and Young Adults
Bulent Erol, MD; *Mert Topkar, MD*
Marmara University Hospital, Istanbul, Turkey

2:18 PM - 2:27 PM Discussion

Paper 164 2:27 PM - 2:32 PM
Bedside Aspiration in Children with Septic Arthritis of the Hip Joint. Should We Still Do Arthrotomy?
Pavel Kotlarsky, MD; Doron Keshet; Alexander Katsman; ***Mark Eidelman, MD***
Rambam Healthcare Campus, Haifa, Israel

Paper 165 2:33 PM - 2:38 PM
Septic Arthritis of the Hip in the Newborn and Young Child
Collin May, MD; *Rachel Goldstein, MD; Victoria Prete, BS; James Kasser, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 166 2:39 PM - 2:44 PM
Septic Arthritis of the Hip - Who Needs a Second Look?
Robert Murphy, MD; Leah Nunez, MS; William Barfield, PhD; Joshua Murphy, MD; Nicholas Fuerstenau; David Spence, MD; Derek Kelly, MD; Matthew Dow, MD; ***James Mooney, MD***
Medical University of South Carolina, Charleston, South Carolina, United States

2:45 PM - 2:54 PM Discussion

Paper 167 2:54 PM - 2:59 PM
Improved Diagnosis and Treatment of Pediatric Bone and Joint Infections Using an Evidence-based Treatment Guideline
John Williams, MD*; Hilton Gottschalk, MD; Sarmistha Hauger, MD; Marisol Fernandez; Lynn Thoreson, DO; Rachel Quick, RN; Kyle Kahlden, MD; John McNamara; Ryan Schexnaildre*
Dell Children's Medical Center, Austin, Texas, United States

Paper 168 3:00 PM - 3:05 PM
Does Pre-Culture Antibiotic Administration Lead to Non-Diagnostic Bone and Joint Culture Results in Pediatric Osteomyelitis and Septic Arthritis: A 12-Year Retrospective Review
John Schlechter, DO*; Michael Basso-Williams, DO*
Children's Hospital of Orange County, Orange, California, United States

Paper 169 3:06 PM - 3:11 PM
Wash, Rinse, Repeat: Which Patients Require Serial Joint Irrigation in Pediatric Septic Hip Arthritis?
Kristin Livingston, MD*; Leslie Kalish; Donald Bae, MD; Young Jo Kim, MD; Benjamin Shore, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

3:12 PM - 3:21 PM Discussion

Paper 170 3:21 PM - 3:26 PM
Functional Outcome after Pediatric Osteomyelitis Treated with a Multidisciplinary Evidence-Based Clinical Practice Guideline: 2 Year Follow-up
John Vorhies, MD*; Eduardo Lindsay, MD; Mary Jones; Lori Thornton; Lawson Copley, MD*
Children's Medical Center Dallas, Dallas, Texas, United States

Paper 171 3:27 PM - 3:32 PM
Kingella Kingae the Commonest Cause of Paediatric Septic Arthritis in a Prospective Cohort
Derfel Williams FRCS (Ortho)*; Georgia Antoniou; Peter Cundy; Amit Kochar, MD; Celia Cooper, MBBS; Christina Boros; Nicole Williams*
Women & Children's Hospital, Adelaide, South Australia, Australia

Paper 172 3:33 PM - 3:38 PM
Does Staphylococcus Nasal Decontamination Affect the Rate of Early Surgical Site Infections in Adolescent Idiopathic Scoliosis Surgery?
Cindy Mallet, MD*; Marion Caseris, PhD; Anne-Laure Simon, MD; Virginie Mas, MD; Keyvan Mazda; Brice Ilharreborde*
Robert Debre Hospital, Paris, France

3:39 PM - 3:48 PM Discussion

3:49 PM - 4:09 PM Break

CONCURRENT SESSION IV: FOOT/ANKLE

MODERATOR: *Scott J. Mubarak, MD*
eMODERATOR: *Jorge Knörr, MD*
PRESIDER: *Derek M. Kelly, MD*

Paper 173 4:10 PM - 4:15 PM
Interrater Reliability and Age-Based Normative Values for Radiographic Indices of Syndesmosis and Deltoid Ligament Stability in Children
J. Todd Lawrence, MD; *Nikita Lakomkin; Peter Fabricant, MD; Aristides Cruz, MD; Christopher Brusalis, BA; Nancy Chauvin, MD*
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

Paper 174 4:16 PM - 4:21 PM
Innovative Treatment for Pes Cavo Varus
Ignacio Sanpera-Trigueros, MD; *Laura Corominas Frances; Marta Salom; Julia Sanpera-Iglesias, MD; Guiem Frontera, MD*
Hospital Universitari Son Espases, Palma de Mallorca, Spain

Paper 175 4:22 PM - 4:27 PM
One-stage Correction of Brachymetatarsias Involving the Greater Toe
Huitaek Kim, MD; *Sungmin Hong; Tae Young Ahn; Jeung Seung Hyeon, MD*
Pusan National University, Busan, Republic of Korea

4:28 PM - 4:37 PM Discussion

Paper 176 4:37 PM - 4:42 PM
Resection of Tarsal Coalition and Surgical Correction of the Hindfoot Deformity in One Step
Dario Fracassetti, MD; Desiree Moharamzadeh; ***Maurizio De Pellegrin, MD***
San Raffaele Hospital, Milano, Italy

Paper 177 4:43 PM - 4:48 PM
Arthroscopic Calcaneonavicular Coalition and Too-long Anterior Process of the Calcaneus Resection in Children
Jorge Knörr, MD; *Francisco Soldado; Pedro Domenech, MD; Sergi Barrera-Ochoa; Jerome Sales De Gauzy; Moreno David*
Hospital Sant Joan de Deu, Barcelona, Spain

Paper 178 4:49 PM - 4:54 PM
Calcaneal Lengthening Using Ipsilateral Fibula Autograft in the Treatment of Adolescent Symptomatic Pes Valgus
Tsung-yu Lan, MD; *Chien-Cheng Lai, MD*
Far-estern Memorial Hospital, New Taipei City, Taiwan

4:55 PM - 5:04 PM Discussion

Paper 179 5:04 PM - 5:09 PM

Structural Hydroxyapatite Tricalciumphosphate Graft versus Tricortical Iliac Crest Autograft in Paediatric Calcaneal Lengthening Osteotomies. Results from a Randomised Controlled Noninferiority Trial

Polina Martinkevich, MD; *Ole Rahbek, MD; Maiken Stilling; Line Pedersen, MD; Martin Gottliebsen; Bjarne Møller-Madsen, MD*
Aarhus University Hospital, Aarhus, Denmark

Paper 180 5:10 PM - 5:15 PM

Acute Correction of Congenital Brachymetatarsia in Adolescent and Young Adults

Mark Eidelman, MD; ***Doron Keshet, MD***; *Alexander Katsman*
Rambam Health Care Center, Haifa, Israel

Paper 181 5:16 PM - 5:21 PM

Hemiepiphysiodesis for the Correction of Juvenile Hallux Valgus

Patricia Gomes, MD; *Patricia Rodrigues, MD; Delfin Tavares, MMED (Ortho); Susana Ramos*
Hospital Dona Estefânia - CHLC, Lisboa, Portugal

5:22 PM - 5:31 PM Discussion

Paper 182 5:31 PM - 5:36 PM

Does Pseudarthrosis of the Fibula After Lower Limb Lengthening Predispose Patients to Increase of Ankle Valgus?

Daisuke Kobayashi, MD; *Shinichi Satsuma; Ryosuke Sakata; Maki Kinugasa; Ayana Yamanaka, MD; Yamamoto Tetsuya, MD*
Kobe Children's Hospital, Kobe, Hyogo, Japan

Paper 183 5:37 PM - 5:42 PM

Are Two Radiographic Views as Good as Three Views to Diagnose Ankle Fractures in Children and Adolescents?

Marcel Abouassaly, MD; *Paul Moroz, MD; R. Baxter Willis, MD; Ken Kontio, MD; Francesco Blumetti, MD; Luke Gauthier, MD; Kerri Highmore; Nishard Abdeen, MD; Sandy Tse, MD; Amy Plint; Nick Barrowman, PhD*
Children's Hospital of Eastern Ontario, Ottawa, Ontario, Canada

Paper 184 5:43 PM - 5:48 PM

Below Knee Cast Immobilization of Distal Tibial Physeal Fractures

Clayton T. Vaughan, MD; ***Christopher Souder, MD***; *Jillian McAngus, MD; Gregory Sprowls, BS*
Baylor Scott & White Memorial Hospital, Temple, Texas, United States

5:49 PM - 5:58 PM Discussion

CONCURRENT SESSION V: HIP

MODERATOR: *Michael B. Millis, MD*
eMODERATOR: *Andre Kaelin, MD*
PRESIDER: *Kishore Mulpuri, MD*

Paper 185 4:10 PM - 4:15 PM
Brace Treatment Can Result in Improved Acetabular Indicies in Infantile Dislocated Hips
***Ryan Fitzgerald, MD**; Alexander Schupper; James Bomar; Simon Kelley, MD; Nicholas Clarke, FRCS; Scott Mubarak, MD; Vidyadhar Upasani, MD; R-IHDI Study Group*
Rady Children's Hospital, San Diego, San Diego, California, United States

Paper 186 4:16 PM - 4:21 PM
Open Reduction for Developmental Dysplasia of the Hip: Early Outcomes from A Multi-Centre, International Prospective Cohort Study
*Emily Schaeffer, PhD; Kishore Mulpuri; Wudbhav Sankar, MD; Vidyadhar Upasani, MD; Nicholas Clarke, FRCS; Jose Herrera Soto, MD; Young Jo Kim, MD; Bruce Foster, MD; **Travis Matheney, MD**; R-IHDI Study Group*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 187 4:22 PM - 4:27 PM
Efficacy of Maintaining the Ligamentum Teres in Medial Open Reduction for DDH: A Comparative Study of Shortening/Reattachment versus Excision
*Raghav Badrinath, MD; **Dennis Wenger, MD**; Scott Mubarak, MD; Vidyadhar Upasani, MD*
Rady Children's Hospital, San Diego, California, United States

4:28 PM - 4:37 PM Discussion

Paper 188 4:37 PM - 4:42 PM
Intermediate Results of the Bernese Periacetabular Osteotomy for the Treatment of Hip Instability in Patients with Down Syndrome
***Daniel Maranho, MD**; Young Jo Kim, MD; Michael Millis, MD; Garrett Bowen; Eduardo N. Novais, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 189 4:43 PM - 4:48 PM
Clinical Outcomes of Periacetabular Acetabular Osteotomy Outcomes at Mid-term? A Prospective Multi-center Cohort Study
***Ernest Sink, MD**; John Clohisy, MD; Geneva Baca; Paul Beaule, MD; Young Jo Kim, MD; Michael Millis, MD; David Podeszwa, MD; Perry Schoenecker, MD; Rafael Sierra, MD; Daniel J. Sucato, MD, MS; Robert Trousdale, MD; Ira Zaltz, MD*
Washington University School of Medicine, Saint Louis, Missouri, United States

Paper 190 4:49 PM - 4:54 PM
What is the Impact of PAO Surgery on Patient Function and Activity Levels?
***David Podeszwa, MD**; Jeffrey Petrie, MD; Tonya An, MD; Perry Schoenecker, MD; Ira Zaltz, MD; Young Jo Kim, MD; Michael Millis, MD; Rafael Sierra, MD; Robert Trousdale, MD; Daniel J. Sucato, MD, MS; Ernest Sink, MD; Paul Beaule, MD; John Clohisy, MD; ANCHOR Group*
Washington University School of Medicine, Saint Louis, Missouri, United States

4:55 PM - 5:04 PM Discussion

Paper 191 5:04 PM - 5:09 PM

Determining Hinge Abduction in LCPD: Can We Confidently Make the Diagnosis?

Wudbhav Sankar, MD; *Perry Schoenecker, MD; Ira Zaltz, MD; Patricia Miller, MS; Benjamin Shore, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 192 5:10 PM - 5:15 PM

Triple Innominate Osteotomy versus Shelf Acetabuloplasty for Legg-Calvè-Perthes Hips Presented in the Transitional Stage

Chang Ho Shin; ***In Choi, MD***; *Won Joon Yoo, MD; Tae-Joon Cho*
Seoul National University Children's Hospital, Seoul, Republic of Korea

Paper 193 5:16 PM - 5:21 PM

Can Epiphyseal Unstable SCFE Be Reduced by Closed Reduction with Minimal AVN?

Jonathan Schoenecker, MD; *Holly Leshikar, MD; Emilie Amaro, BS; Megan Mignemi, MD; Jeffrey Martus, MD; Steven Lovejoy, MD; Gregory Mencio, MD*
Vanderbilt University Medical Center, Nashville, Tennessee, United States

5:22 PM - 5:31 PM Discussion

Paper 194 5:31 PM - 5:36 PM

A Nationwide 23-Year Cohort Study of Slipped Capital Femoral Epiphysis in the United Kingdom

Daniel Perry FRCS (Ortho); *David Metcalfe; Matthew Costa, FRCS*
Alder Hey Hospital, Liverpool, United Kingdom

Paper 195 5:37 PM - 5:42 PM

Previous Hip Arthroscopy is Associated with Inferior Early Functional Outcomes after Periacetabular Osteotomy for Acetabular Dysplasia

Benjamin Ricciardi, MD; Kara Fields, MS; Catherine (Sally) Wentzel; Bryan Kelly, MD; ***Ernest Sink, MD***
Hospital for Special Surgery, New York, New York, United States

Paper 196 5:43 PM - 5:48 PM

Outcomes of Hip Arthroscopy in Adolescents: A Comparison of Acute versus Chronic Labral Tears. Two Year Minimum Follow-Up

Lyall J. Ashberg, MD; *John Walsh, MA; Mary R. Close, BS; Itay Perets, MD; Edwin O. Chaharbakhshi, BS; Benjamin G. Domb, MD*
American Hip Institute, Westmont, Illinois, United States

5:49 PM - 5:58 PM Discussion

CONCURRENT SESSION VI: CONGENITAL/SYNDROMES

MODERATOR: *Darko Anticevic, MD, PhD*
eMODERATOR: *Willliam Mackenzie, MD*
PRESIDER: *Ralph Sakkers, MD*

Paper 197 4:10 PM - 4:15 PM
Congenital Pseudarthrosis of the Clavicle: Outcomes Following Surgical and Nonsurgical Management
Carley Vuillermin, MD; *Arin Kim, BS; Donald Bae, MD; Peter Waters, MD; Andrea Bauer, MD*
Boston Children's Hospital, Boston, Massachusetts, United States

Paper 198 4:16 PM - 4:21 PM
Poland Syndrome: Approach to a New Classification. Association with Final Functional Results and Number of Surgeries
Diego Gutiérrez-de la Iglesia, MD; *Laura M. Perez-Lopez; Marisa Cabrera-Gonzalez, MD*
Sant Joan de Déu Children's Hospital, University of Barcelona, Barcelona, Spain

Paper 199 4:22 PM - 4:27 PM
Aetiology of Hand Clawing in MPS Children
Chris Talbot, FRCS (Ortho)
Central Manchester Childrens Hospital, Manchester, United Kingdom

4:28 PM - 4:37 PM Discussion

Paper 200 4:37 PM - 4:42 PM
Lengthening with Monolateral External Fixation versus Intramedullary Nail in Congenital Femoral Deficiency
Ahmed Hammouda, MD; Vivian Szymczuk, MD; Martin Gesheff, BS; Shawn Standard, MD; ***John Herzenberg, MD***
International Center for Limb Lengthening, Sinai Hospital of Baltimore, Baltimore, Maryland, United States

Paper 201 4:43 PM - 4:48 PM
Does the Lateral Malleolus Reconstruction Provide a Stable Ankle Joint in Patients with Fibular Hemimelia?
Milud Shadi; ***Bartosz Musielak, MD***; *Pawel Koczewski*
Dega Hospital, Poznan, Poland

Paper 202 4:49 PM - 4:54 PM
Amputation versus Limb Reconstruction for Fibula Hemimelia: A Systemic Review and Meta-Analysis
Aissam Elmhiregh, MD; Muhammad Riaz, MPH; Abdelsalam Hegazy, MD; ***Talal Ibrahim, MD***
Hamad Medical Corporation, Doha, Qatar

4:55 PM - 5:04 PM Discussion

Paper 203 5:04 PM - 5:09 PM

Guided Growth for Genu Valgum in Patients with Skeletal Dysplasias Can Lead to Hip Deterioration

Vladimir Kenis, MD; *Eugeniy Melchenko; Ali Al Kaissi, DMed; Ekaterina Morenko*
The Turner Institute for Children's Orthopaedics, Saint-Petersburg, Russian Federation

Paper 204 5:10 PM - 5:15 PM

Congenital Pseudoarthrosis of Tibia (CPT): Comparison of the Effect of Lenghtening Rhythm to the Quality of Callus and Complications

Halil Balci, MD; *Tuna Pehlivanoglu, MD; Cengiz Sen; Levent Eralp, MD; Mehmet Kocaoglu*
Istanbul University, Istanbul, Turkey

Paper 205 5:16 PM - 5:21 PM

Surgical Treatment of Lower Limbs Deformities in Pseudoachondroplasia: Influence of Post-Operative Residual Knee Joint Obliquity

Alexandra Brassac; *Philippe Wicart, MD; Christophe Glorion, MD; Zagorka Péjin-Arroyo; Valérie Cormier-Daire; Georges Finidori*
Hôpital Necker-Enfants Malades, Paris, France

5:22 PM - 5:31 PM Discussion

Paper 206 5:31 PM - 5:36 PM

Best Practices in Peri-Operative Management of Patients with Skeletal Dysplasias

Klane White, MD; *Viviana Bompadre, PhD; Michael Goldberg, MD; Michael Bober; Tae-Joon Cho; Julie Hoover-Fong; Melita Irving; William Mackenzie, MD; Shawn Kamps, MD; Cathleen Raggio, MD; Gregory Redding, MD; Samantha Spencer, MD; Ravi Savarirayan; Mary Theroux, MD*
Seattle Children's Hospital, Seattle, Washington, United States

Paper 207 5:37 PM - 5:42 PM

Spondylolisthesis is Common, Early and Severe in Loeys-Dietz Syndrome

Paul Sponseller, MD; *David Kirby, BS*
The Johns Hopkins Hospital, Baltimore, Maryland, United States

Paper 208 5:43 PM - 5:48 PM

Outcomes of Orthopedic Surgery in a Cohort of 49 Patients with X-linked Hypophosphatemic Rickets (XLHR)

Gizard Aliette, MD; *Anya Rothenbuhler, DMed; Zagorka Pejin-Arroyo; Georges Finidori; Christophe Glorion, MD; Benoît De Billy; Agnes Linglart; Philippe Wicart*
CHU Necker, Paris, France

5:49 PM - 5:58 PM Discussion

SATURDAY, MAY 6, 2017

8:00 AM - 8:04 AM OPENING REMARKS
BEST PAPER AWARDS

TRAUMA

MODERATOR: *Susan A. Scherl, MD*
eMODERATOR: *Brian K. Brighton, MD*
PRESIDER: *Elhanan Bar-On, MD*

Paper 209 8:05 AM - 8:10 AM
"Next Day" Exam Reduces Radiation Exposure in Cervical Spine Clearance at a Level 1 Pediatric Trauma Center: A Pilot Study
Venkat Kavuri, MD; Gurpal Pannu, MD; ***Martin Herman, MD***
St. Christopher's Hospital For Children, Philadelphia, Pennsylvania, United States

Paper 210 8:11 AM - 8:16 AM
Operative Treatment of Cervical Spine Injuries Sustained During Youth Sports
Daniel Hedequist, MD*; Michael Glotzbecker, MD*
Children's Hospital Boston, Boston, Massachusetts, United States

Paper 211 8:17 AM - 8:22 AM
Does a Delay in Treatment of Displaced Pediatric Lateral Condyle Fractures Increase the Risk of Complications?
Henry Ellis, MD*; Brandon Hull, MD; Philip Wilson, MD; Shawn Funk, MD; Brandon Ramo, MD*
Texas Scottish Rite Hospital for Children, Dallas, Texas, United States

8:23 AM - 8:32 AM Discussion

Paper 212 8:32 AM - 8:37 AM
An Increasing Rate of Operative Fixation in Four and Five-Year-Old Children with Femoral Shaft Fractures
Ram Alluri, MD*; Andrew Sabour, BS; Nathanael Heckmann, MD; Curtis VandenBerg, MD*
Childrens Hospital Los Angeles, Los Angeles, California, United States

Paper 213 8:38 AM - 8:43 AM
The Effect of Length Stability on the Outcome of Preadolescent Femur Fractures Treated with Flexible Intramedullary Nailing
J. Eric Gordon, MD*; Devon Nixon, MD; Lauren Davis, MPH; Perry Schoenecker, MD; Matthew Dobbs, MD; Scott Luhmann, MD; Mark Miller, MD*
Washington University School of Medicine, St Louis, Missouri, United States

Paper 214 8:44 AM - 8:49 AM
Flexible Intramedullary Nailing has Superior Quality and Value to Plate Fixation of Midshaft Femur Fractures in Children 5-11 Years
Vishwas Talwalkar, MD*; Jerad Allen, MD; Kevin Murr, MD; Cale Jacobs, PhD; Janet Walker, MD; Henry Iwinski, MD; Eric Moghadamian, MD; Ryan D. Muchow, MD*
University of Kentucky, Lexington, Kentucky, United States

8:50 AM - 8:59 AM Discussion

Paper 215 8:59 AM - 9:04 AM
Early versus Late Treatment of Pediatric Femur Neck Fractures: A Systematic Review and Meta-Analysis
Talal Ibrahim, MD; *Nedal Alkhatib, MD; Manaf Younis, MD; Abdelsalam Hegazy, MD*
Hamad Medical Corporation, Doha, Qatar

Paper 216 9:05 AM - 9:10 AM
Clinical Outcomes of Suture versus Screw Fixation of Tibial Spine Avulsion Fractures
Mininder S. Kocher, MD; *Mark Callanan; Brett Flutie; Dennis Kramer, MD*
Boston Childrens Hospital, Boston, Massachusetts, United States

Paper 217 9:11 AM - 9:16 AM
Tillaux and Triplane Fractures: K-wires or Just Screw It?
Shiyao Wang, MD; Neeraj Mishra; ***Arjandas Mahadev, MD***
KK Women's and Children's Hospital, Singapore

9:17 AM - 9:26 AM Discussion

Paper 218 9:26 AM - 9:31 AM
Do All Pediatric Monteggia Fractures with a Complete Ulna Fracture Require Surgical Stabilization?
Ian Foran, MD; Vidyadhar Upasani, MD; Elise Britt, MD; Tracey Bastrom, MA; Charles Wallace, MD; ***Andrew Pennock, MD***
Rady Children's Hospital, San Diego, California, United States

Paper 219 9:32 AM - 9:37 AM
Long-term Results after Sustaining a Monteggia Fracture-dislocation During Childhood
Joaquín De Armas, MD; *Luis Moraleda, MD; Luis Cuadrado Rubio, MD; Maria Valencia, MD; Raul Barco, MD; Enrique Gil-Garay, MD*
Hospital Universitario La Paz, Madrid, Spain

Paper 220 9:38 AM - 9:43 AM
Telemedicine: A Novel Approach to the Teatment of Non-displaced Pediatric Elbow Fractures
Mauricio Silva, MD; *Hemali Panchal; Erin Delfosse, NP; Maria Kazantsev, BS; Edward Ebramzadeh, PhD*
Orthopaedic Institute for Children, Los Angeles, California, United States

9:44 AM - 9:53 AM Discussion

9:54 AM - 10:14 AM Break

LOWER EXTREMITY/HIP

MODERATOR: *Ellen Raney, MD*
eMODERATOR: *David Farrington, MD*
PRESIDER: *Franz Grill, MD*

Paper 221 10:15 AM - 10:20 AM
An Anatomic Study on Whether Femoral Anteversion Originates in the Neck versus the Shaft
Hunter Archibald, BS; Kathleen Petro, MD; ***Raymond Liu, MD***
University Hospitals and Case Western Reserve University School of Medicine, Cleveland, Ohio, United States

Paper 222 10:21 AM - 10:26 AM
Distance from Posterior Menisci to the Popliteal Artery in Children: A Cadaver Study
Alexandra Styhl; Peter Cannamela, BS; Yi-Meng Yen, MD; Aleksei Dingel; Theodore Ganley, MD; ***Kevin Shea, MD***
St. Luke's Health System, Boise, Idaho, United States

Paper 223 10:27 AM - 10:32 AM
3-D Modeling of Lower Extremities with Biplanar Radiographs: Reliability of Measures on Subsequent Examinations
David Westberry, MD*; Ashley Carpenter, BS; Rachel Binkley-Vance, MS*
Shriners Hospital for Children, Greenville, South Carolina, United States

10:33 AM - 10:42 AM Discussion

Paper 224 10:42 AM - 10:47 AM
Dynamic Analysis of Surgical Stabilization Options for Pediatric Patellar Instability
Kerwyn Jones, MD*; Joseph Gabra, PhD; John Elias, PhD*
Akron Children's Hospital, Akron, Ohio, United States

Paper 225 10:48 AM - 10:53 AM
Trochanteric Entry for Femoral Lengthening Nails in Children: Is It Safe?
Ahmed Hammouda, MD*; Julio Jauregui, MD; Martin Gesheff, BS; Shawn Standard, MD; John Herzenberg, MD*
International Center for Limb Lengthening, Sinai Hospital of Baltimore, Baltimore, Maryland, United States

Paper 226 10:54 AM - 10:59 AM
Changes of Sagittal Plane Alignment of Proximal Tibia after Limb Lengthening Surgery
Kwang Won Park, MD; Tae-Jin Lee; Jawoon Lee, MD; Jeong Seongmin; ***Hae Ryong Song, MD***
Korea University Guro Hospital, Seoul, Republic of Korea

11:00 AM - 11:09 AM Discussion

Paper 227 11:09 AM - 11:14 AM
Treatment of Slipped Capital Femoral Epiphysis with Disrupted Junction of the Epi- and Metaphysis by the Modified Dunn Procedure
Kai Ziebarth, MD*; Nadine Kaiser; Thoralf Liebs; Teddy Slongo, MD; Klaus Siebenrock, MD*
University Children's Hospital Inselspital, Bern, University Hospital for Orthopedic Surgery, Inselspital, Bern, Switzerland

Paper 228 11:15 AM - 11:20 AM

The Early Experience with Open Reduction/Dunn Osteotomy for Unstable SCFE: Predictors of Failure

Daniel J. Sucato, MD, MS; *Stephan Zmugg, MD; David Podeszwa, MD; Adriana De La Rocha, PhD*
Texas Scottish Rite Hospital, Dallas, Texas, United States

Paper 229 11:21 AM - 11:26 AM

Diagnosing Slipped Capital Femoral Epiphysis (SCFE) Amongst Various Medical Specialists

Aaron Lam, BA; Suhas Abel Boenerjous; Regina Hanstein; ***Norman Otsuka, MD***
Children's Hospital at Montefiore, Bronx, New York, United States

11:27 AM - 11:36 AM Discussion

Paper 230 11:36 AM - 11:41 AM

Hip Arthroscopy Successfully Treats Femoroacetabular Impingment in Adolescent Athletes

Jody M. Litrenta, MD; *Brian H. Mu, BA; Victor Ortiz, MD; Itay Perets; Austin W. Chen, MD; Benjamin G. Domb, MD*
American Hip Institute, Westmont, Illinois, United States

Paper 231 11:42 AM - 11:47 AM

Does Concurrent Femoral Head-Neck Osteochondroplasty Improve the Long-term Clinical Results of PAO Surgery for Symptomatic Acetabular Dysplasia?

Perry Schoenecker, MD; *Joel Wells; Kayla Thomason, BS; John Clohisy, MD*
Washington University School of Medicine, Saint Louis, Missouri, United States

Paper 232 11:48 AM - 11:53 AM

The Need for Further Corrective Surgery in Developmental Dysplasia of the Hip: Surgical Decision-Making and Practice Variability

Emily Schaeffer, PhD; Wudbhav Sankar, MD; Nicholas Clarke, FRCS; Alaric Aroojis, MD; Charles Price, MD; ***Kishore Mulpuri, MD***; *R-IHDI Study Group*
British Columbia Children's Hospital, Vancouver, British Columbia, Canada

11:54 AM - 12:03 PM Discussion

12:03 PM - 12:05 PM CLOSING REMARKS

PAPER POSTERS

Poster 1
Periosteal Response Following Resection
Rajeev Chaudhary PhD; Ming-Song Lee; Ellen Leiferman; Connie Chamberlain, PhD; Kevin Eliceiri; Wan-Ju Li, PhD; Paul Campagnola, PhD; ***Matthew Halanski, MD***
University of Wisconsin, Madison Wisconsin, United States

Poster 2
Using Arm Length to Predict Upper Extremity Peripheral Nerve Position in Pediatric Orthopaedics
Ryan O'Shea, MD*; William Chu Kwan, MD; Jim Kennedy, MD; Jyoti Panwar; Jennifer Stimec, MD; Mark Camp, MD; Martin Gargan, FRCS (Ortho)*
The Hospital for Sick Children, Toronto, Ontario, Canada

Poster 3
An Analysis of Femoral Version in Patients Undergoing Periacetabular Osteotomy
Ira Zaltz, MD*; Eduardo Novais, MD; Jeffrey Nepple, MD; John Clohisy, MD; Ernest Sink, MD; Wudbhav Sankar, MD*
William Beaumont Hospital, Royal Oak, Michigan, United States

Poster 4
Correlation of Functional and Radiological Results with Three-Dimensional Gait Analysis in Patients with Unilateral Slipped Capital Femoral Epiphysis
Ilhan Bayhan, MD*; Hanifi Ucpunar, MD; Sebahat Aydil; Kubilay Beng, MD; Timur Yildirim, MD; Mehmet Yagmurlu, MD*
Baltalimani Bone Diseases Education and Research Hospital, Istanbul, Turkey

Poster 5
Incidence of Acetabular Dysplasia in Breech Infants following Initially Normal Ultrasound: The Effect of Variable Diagnostic Criteria
Christopher Brusalis, BA; Charles Price, MD; ***Wudbhav Sankar, MD***
Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

Poster 6
Disappearance of Soft Tissue Interpositions after Gradual Reduction using Overhead Traction in Late-Presenting DDH: A Prospective Comparative Study on Serial MRIs Between Pre-Walking and Walking Children
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♦ Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (ie. the drug or medical device is being discussed for an "off label" use).

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Diagnostic and Treatment Preferences for Developmental Dysplasia of the Hip: A Survey of EPOS and POSNA Members

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LOE-Not Applicable–Level V

Purpose: Developmental dysplasia of the hip (DDH) may be diagnosed and treated differently by surgeons around the world. The aim of this study was to elucidate the preferences for DDH diagnosis and treatment between members of both the Pediatric Orthopaedic Society of North America (POSNA) and the European Paediatric Orthopaedic Society (EPOS).

Methods: A 50-question survey was developed and pre-tested in a small group of surgeons. The web-based survey was then distributed to members of POSNA and EPOS. The survey consisted of questions that explored preferences for diagnosis, treatment, and follow-up of DDH. Descriptive statistics were performed, including comparisons between preferences of POSNA and EPOS members.

Results: 517 surgeons from 49 different countries responded; 329 surgeons were POSNA members, 188 were EPOS members, and 25 were members of both societies. 80% of POSNA members and 49% of EPOS members had completed at least one pediatric orthopedic fellowship. The average years in practice was 17.3 years. When diagnosing DDH in infants <6 months old, ultrasound was the preferred modality for diagnosis, with only 3% preferring Xray. Less than 10% of POSNA members perform their own ultrasounds, while approximately half of EPOS members do. The majority of surgeons consider a hip that is covered <20% to be dislocated. Approximately 80% use the Pavlik harness, with a rigid abduction brace being the next most popular selection for both POSNA and EPOS members. In a failing Pavlik harness, the majority will discontinue the brace at 3-4 weeks. POSNA members were more likely than EPOS members to try a rigid abduction brace, if the initial braced failed. The majority of surgeons would not perform a closed reduction before 3 months, and preferred timing for open reduction was 6 months of age. The majority of EPOS members use traction prior to reduction, while most POSNA members do not. Sixteen-percent of surgeons believe that reduction should be delayed until the ossific nucleus is visible radiographically. For a 12 month old infant with acetabular dysplasia, POSNA members were twice as likely to use a hip abduction brace compared to EPOS members.

Conclusion: There is great variation in preferred methods for diagnosing and treating DDH across POSNA and EPOS memberships.

Significance: This survey is the largest transcontinental survey to compile diagnostic and treatment preferences for DDH. When great variations occur, the potential to improve quality through generation of more standardized protocols may exist.

Developmental Dysplasia of the Hip Presenting Between 12 and 18 Months; Medial Open Reduction or Delayed Anterior Approach Plus Innominate Osteotomy

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LOE–Therapeutic–Level III

Purpose: Several different surgical strategies exist for management of developmental dysplasia of the hip (DDH) presenting between 12 and 18 months of age. We aim to compare the radiological results of immediate medial approach open reduction (MAOR) with delayed surgery to 18-22 months such that concomitant anterior open reduction plus innominate (Salter) osteotmy can be performed (AORI).

Methods: We retrospectively identified 20 patients presenting between 12 -18 months who underwent immediate MAOR by a single surgeon (average age 15.5 months). Modified Ludloff approach was used with ligamentum teres tenodesis. Hip spica applied for 12 weeks.
We also identified 24 patients who presented later and underwent AORI between age 18 and 22 months (average age 20 months). Hip spica applied for 10 weeks.
Patient radiographs were assessed by 3 reviewers to determine evidence of avascular necrosis AVN (Kalamchi and MacEwen), acetabular index, severin grade (for patients age 6 year and above). Need for secondary surgery was recorded.
All surgeries performed by senior author.

Results: Minimum follow up 4 years. MAOR group average FU 8.5yrs. AORI group 6.5yrs. Grade of dislocation at presentation comparable between groups.
No cases of redislocation. At latest follow up, no statistically significant difference in terms of AVN or Severin grade although trend towards better results in MAOR group. Overall 98% Severin gd 1/2. Two cases of severe AVN (gd3/4) in AORI group. Single case of gd 2 AVN in MAOR group plus 2 cases of long leg dysplasia.
IN MAOR group 75% of patients required innominate osteotomy as secondary procedure for persistent dysplasia (AI > 30 degrees at 2 yrs).

Conclusion: Both approaches lead to satisfactory radiological outcome with rate of severe AVN (gd2-4) less than 10%. Prolonged follow up will be necessary to asses final outcome.

The majority of patients having MAOR after age 12 months will require innominate osteotomy at later stage. For this reason we would recommend MAOR only for patients presenting with acetabular index less than 35 degrees and before 15 months. Older patients and cases where AI >35 degrees should have surgery delayed until the operating surgeon feels that the boney pelvis is large enough to perform concomitant open reduction and innominate osteotomy.

Significance: To the best of our knowledge this is the first paper to specifically compare medial approach open reduction with anterior open reduction plus innominate osteotomy in this particular age range.

Patient-Reported Outcomes in Young Adults with Osteonecrosis Secondary to Developmental Dysplasia of the Hip

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LOE–Prognostic–Level II

Purpose: To determine (i) the relationsship between osteonecrosis of the femoral head and hip function, physical function and quality of life in adolescents and young adults treated for developmental dysplasia of the hip (DDH) and (ii) how affected children change over 10 years in terms of these outcomes.

Methods: We included 109 patients with a mean age of 19.2 ± 3.8 years with osteonecrosis of the femoral head following treatment (1992-2005) of DDH and 30 age-matched DDH patients without osteonecrosis. All patients completed valid patient-reported outcome measures in 2015/16 to quantify their hip function (maximum score 100); physical function (maximum score 100); and quality of life (maximum score 1). Of these, 39 patients had been followed prospectively since 2006, allowing us to quantify within-person changes over a mean period of 10 years. We graded all radiographs for severity of osteonecrosis (Bucholz-Ogden); acetabular dysplasia (center-edge angle); subluxation; and osteoarthritis (Kellgren-Lawrence). We determined the association between the patient-reported outcomes and radiographic severity of osteonecrosis using mixed effects regression analysis and used repeated measures analysis of variance to quantify person changes over time. We adjusted for age, number of previous operations and acetabular dysplasia.

Results: In 135 patients (168 hips) with and without osteonecrosis, the mean differences (95% confidence interval) in hip function, physical function and quality of life were 0.75 (-6.67, 8.17), -1.97 (-17.58,13.60) and -0.05 (-0.91, 0.36), respectively. Adjusted analysis showed no difference in these outcomes based on radiographic severity of osteonecrosis (p>0.05). Of 39 patients followed over 10 years, 4 had undergone a hip replacement. For the remainder, mean changes (95% confidence interval) in hip function, physical function and quality of life from baseline to current assessment were 7.18 (-2.11, 12.26), -2.11 (-15.47, 11.25), -0.03 (-0.11, 0.05), respectively. Radiographic severity of osteonecrosis was not correlated with the change in patient-reported outcomes over time.

Conclusion: Patients with osteonecrosis secondary to DDH demonstrated high levels of hip function, physical function and quality of life at a mean age of 19 years. Equally, children maintained such high levels over the course of 10 years if their hip survived.

Significance: Osteonecrosis secondary to DDH is a relatively benign disorder even in young adulthood. Overall, affected patients demonstrated minimal disability and a normal quality of life.

Secondary Spherical Remodeling from the Healed Stage to Skeletal Maturity in Legg-Calvé-Perthes Disease Treated with Salter Innominate Osteotomy

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LOE–Therapeutic–Level IV

Purpose: Secondary remodeling of the femoral head in healed Legg-Calvé-Perthes disease (LCPD) after Salter innominate osteotomy (SIO) is unknown. The purpose of this study was to quantitatively analyze the spherical remodeling from the healed stage to skeletal maturity in patients with LCPD undergoing SIO.

Methods: We retrospectively reviewed 50 patients with unilateral LCPD classified as Catterall group III/IV who underwent SIO from 1989 through 2007 and were followed until skeletal maturity. The mean ages at surgery, the start of the healed stage (Waldenström stage IV), and skeletal maturity were 7.5 (range, 6-11), 10.8 (range, 8-15), and 15.1 (range, 13-18) years, respectively. Preoperatively, 41 hips were in the initial stage (stage I) and 9 hips were in the fragmentation stage (stage II). According to the Herring classification, 15 hips were categorized into the B group, 26 hips into the B/C border group, and 9 hips into the C group. The Sphericity Deviation Score (SDS), described by Shah et al (JBJS 2013), was measured using the anteroposterior and lateral radiographs of the pelvis at the start of the healed stage and at skeletal maturity. The SDS of zero indicates complete sphericity of the femoral head. Preoperative and postoperative (2 months after SIO) epiphyseal extrusion (EE) of the femoral head, described by Green et al (JBJS 1981), were also measured. We then investigated various factors potentially relating to the SDS, including age, disease stage, the Herring classification, and EE.

Results: The SDS values at skeletal maturity were significantly lower than those at the healed stage (mean, 10.7 vs. 20.7, $p<0.001$), and the decrease of the SDS was observed in 88% of cases. Significant decrease of the SDS was related to younger age (<10 years at surgery, $p<0.001$; <13 years at the healed stage, $p<0.001$), lower disease stage (the initial stage, $p<0.001$), and lower EE (preoperatively <25%, $p<0.001$; postoperatively <15%, $p<0.001$). There was no significant relationship between the decrease of the SDS and the Herring classification.

Conclusion: Secondary spherical remodeling of the femoral head was observed in most of our cases undergoing SIO. The improvement of the SDS was associated with young age, early stage of the disease, and preoperative and postoperative sufficient coverage of the femoral head.

Significance: This study suggests that**,** in LCPD treated with SIO, secondary spherical remodeling of the femoral head occurs frequently, and age, disease stage, and EE of the femoral head are factors influencing the remodeling.

Abnormal Growth of the Upper Femur following the Modified-Dunn Procedure

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LOE–Therapeutic–Level III

Purpose: The ideal treatment for unstable and severely displaced stable slipped capital femoral epiphysis (SCFE) has increasingly been questioned since the introduction of the modified-Dunn procedure. Conceptually, near-anatomic epiphyseal alignment is preferable to residual SCFE deformity with the potential for long-term complications. However, this must be balanced with surgical risks, most notably osteonecrosis. Currently, there is little known about the long-term growth of the proximal femoral epiphysis following the modified-Dunn procedure. Understanding growth and development of the upper femur following modified Dunn could influence type of treatment and assumption of surgical risk when approaching an unstable or severely displaced epiphysis.

Methods: 110 (M:F 56:54) patients from four institutions who were treated for unstable and severely displaced stable SCFE using the modified-Dunn technique and did not develop AVN were reviewed. The hips were classified temporally and on stability using Loder's criteria. Preoperative and most-recent follow-up radiographs were assessed for AP and lateral epiphyseal angle. Most recent radiographs were assessed for sphericity using Mose criteria and head-neck offset using AP and lateral alpha angle of Nötzli. Stepwise linear regression was used to determine independent predictors of lateral epiphyseal angle, lateral alpha angle, and AP alpha angle. Binary logistic regression was used to examine the effect of independent variables on sphericity. The independent variables used were sex, age, length of follow-up, temporal classification, and Loder classification. $P < 0.05$ was considered significant

Results: The mean age in our series was 12.2 years and average follow-up was 31 months. 60-percent of SCFEs were unstable and 40-percent were stable. 30% were acute, 42% acute-on-chronic, and 28% were chronic. At most recent follow-up, 80-percent of hips were considered to have an aspherical femoral epiphysis. The mean AP alpha angle was 72-degrees (range 30-115) and the mean lateral alpha angle was 52-degrees (range 26-97). There was no association between sphericity and stability, temporal class, sex, or age. There was a significant correlation between length of follow-up and AP alpha angle.

Conclusion: Growth of the proximal femoral epiphysis is abnormal in 80-percent of hips successfully treated using the modified-Dunn. Abnormal growth is independent of preoperative variables but proportional to the length of follow-up.

Significance: Abnormal proximal femoral growth following modified-Dunn is concerning, and serves as a reminder that near anatomic postoperative alignment does not guarantee normal morphology long-term. Although the clinical significance is not yet known, these findings may influence surgical risk-taking and decision-making especially when managing stable, chronic deformities.

Hip Migration Percentage as the Outcome Parameter of Hip Reconstruction in Children with Spastic Hip Disease

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LOE–Therapeutic–Level III

Purpose: To determine whether pre-surgical hip migration percentage (MP) can be used to predict recurrent hip instability in children with spastic hip disease after hip reconstruction.

Methods: Anteroposterior pelvic X-rays of pre-operative evaluation (X0), immediate post-operative follow-up (X1) and the last available follow-up (X2) in children with spastic hip disease who underwent hip reconstruction procedures, varus derotation osteotomy (VDRO) with or without pelvic osteotomy, between 2006 and 2013 were evaluated retrospectively. Femoral-acetabular relationship was graded based on the latest Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS) by Burns et al in 2014. MP and cut-off values of MP in MCPHCS were used to determine the surgical outcomes. An unsatisfactory outcome was defined as a hip which stayed in the same grade or worsened into a lower grade in the follow-up X-Rays, except the grade 1 since it represents the normal hip.

Results: Among 120 included patients, there were 68 males and 52 females. The age at X0 was 10.3±3.6 years, at X1 was 10.5±3.5, and at X2 were 15.7±3.3 years. Immediate follow-up time, X1, was 1.6±6.7 days (range: 0-34 days). Last follow-up time, X2, was 5.2±2.1 years (range: 2-10 years). In total, 216 operated hips were evaluated.
MP at X0 was 36.2±22.4%, at X1 was 5.6±9.1% ($p<0.05$ compares to X0), and at X2 was 11.4±11.3% ($p<0.05$ compares to X0 and X1).
In mild hips (N=92, MP=10-30%), 60 hips (65%) had VDRO only, the other 32 hips (35%) were combined with pelvic osteotomy.
In more severe hips (N=104, MP>30%), 49 hips (45%) had VDRO only, the other 55 hips (55%) had pelvic osteotomy together.
Among MCPHCS grade-2 hips (N=14, MP=10-15%), 28.6% and 57.1% of the hips had unsatisfactory outcome at X1 and X2 respectively. Among MCPHCS grade-3 hips (N=78, MP=15-30%), 29.5% and 44.9% of the hips had unsatisfactory outcome at X1 and X2 respectively. Hips in other MCPHCS grades (grade 1, 4, 5 and 6) only showed from 2.6 to 8.9% of unsatisfactory outcome.

Conclusion: Hip reconstruction provides hip stability in children with spastic hip disease. However, hips with pre-operative MP between 10-30% can be a higher risk group of recurrent hip instability after hip reconstruction surgery.

Significance: The MP cut-offs used in the MCPHCS can be a useful tool to identify the possible recurrent group. Pelvic osteotomy or hip muscle release should be considered as combine procedures of hip reconstruction to this specific group to achieve a long-term satisfactory outcome.

Bernese Treatment Algorithm for Patients with Slipped Capital Femoral Epiphysis (SCFE) has Low Rate of Adverse Events

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LOE– Therapeutic–Level IV

Purpose: Traditionally in situ pinning for most surgeons is the safest method to prevent further slippage of the femoral head while avoiding severe adverse events such as femoral head necrosis. Due to persistent anatomical disorder after in situ pinning the hip function can be altered and subsequent operations are not uncommon.
The modified Dunn procedure in the short term yielded promising results with low complication rates and excellent clinical function of the affected hips by restoring the proximal femoral anatomy in SCFE patients with moderate to severe slips.
Including the experiences in hip surgery of the last two decades the Bernese treatment algorithm for SCFE was developed.
Therefore we asked if this treatment algorithm shows sufficient results regarding hip function and incidence of adverse events compared to the recent literature.

Methods: IRB approval was obtained. We retrospectively reviewed the data of 148 patients underwent treatment for slipped capital femoral epiphysis from 1998-2016. Average age 12.5 years (93 male, 55 female).
20 Patients with uneventful course one year postoperative mentioned in a previous publication had been excluded from this study since they were treated elswhere.
Patients with pre-slips (just loosened physis in the MRI) or minimal displaced SCFE without broken Kline`s Line underwent in situ pinning and offset correction by hip arthroscopy.
In case of an increased slipping angle and suspected alteration of the hip joint due to the decreased offset of the femoral neck patients were treated by surgical dislocation with offset correction alone or by capital reorientation (modified Dunn procedure).
The clinical (ROM, Impingement signs, WOMAC Score, Harris Hip Score) and radiological data of 128 patients have been analyzed.

Results: 8 patients had in situ pinning and hip arthroscopy
5 patients had surgical hip dislocation and offset correction
115 patients had surgical hip dislocation and capital realignment (modified Dunn procedure)
The majority of patients showed excellent clinical and radiological results.
3/128 Patients (2%) had AVN (severe slip, no bleeding of femoral head intraoperatively)
Low rate of adverse events or subsequent operations

Conclusion: Our treatment algorithm depending on the severity of the disease, leads to excellent clinical and radiological results. The complication rate is low compared to the recent literature.

Significance: Level 4 retrospective case series

Bernese Periacetabular Osteotomy for Severe Acetabular Dysplasia: Are the Good Clinical Results Maintained at Long-term Follow-up?

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LOE– Therapeutic–Level IV

Purpose: The Bernese periacetabular osteotomy (PAO) is a well-described intervention which has been shown to be effective in reducing the symptoms of symptomatic acetabular dysplasia. For patients with severe acetabular dysplasia, the efficacy of acetabular reorientation (versus total hip arthroplasty) has been questioned and remains controversial. Long-term outcomes of the PAO for treating severe acetabular dysplasia are very limited. Therefore, the purpose of this study was to analyze the average 10-year clinical and radiographic results of the Bernese PAO in the treatment of skeletally mature patients with symptomatic, severe acetabular dysplasia.

Methods: We retrospectively analyzed patients who underwent PAO for severe acetabular dysplasia as defined by a lateral center edge angle (LCEA) < 5˚ or Severin Classification Group IV or V. All patients had hip pain and sufficient hip joint congruency on radiographs to be considered candidates for PAO. Clinical data collected included patient demographics, standard dysplasia radiographic measurements, modified Harris Hip score (MHHS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Results: The hip preservation database of one of the senior authors was queried and 68 patients (82 hips; 54 female, 14 male) with an average age of 20.7 years were identified who had been treated with PAO for severe acetabular dysplasia. Mean follow up was 10.3 years and mean BMI 24.4 kg/m2. The lateral center edge angle and anterior center edge angle improved a mean of 32.7˚ (from -8.4˚ to 24.2˚, p<0.0001) and 29.1˚ (from -4.9˚ to 26.3˚, p< 0.0001), respectively. The MHHS improved an average of 18.8 points (from 65.2 to 83.9, p<0.0001), the WOMAC subscore for pain improved an average of 21.1 points (65.5 to 83.5, p = 0.001), and SF-12 physical improved 11.8 points postoperatively (from 42.4 to 49.0, p = 0.005). Six hips (9.8%) required conversion to total hip arthroplasty at an average 6.8 years post-PAO. Kaplan-Meier analysis with THA as the endpoint revealed a survival rate (95% confidence interval [CI] of 91% (82%-95%) at 20 years. There were three revision PAOs (4.9%) at an average 40.3 months postoperatively. There were eight grade III complications and no grade IV or V complications.

Table 1. Average 10 year clinical outcome and radiographic measures

	Initial	Follow-up	Average Δ	p = value
UCLA	6.3	7.3	↑ 1.7	0.02
mHHS	65.2	83.9	↑ 18.8	< 0.0001
WOMAC Pain	65.5	83.5	↑ 21.1	0.001
SF12 Physical	42.4	49.0	↑ 11.8	0.005
LCEA measure, degrees	-8.4	24.2	↑ 32.7	< 0.0001
ACEA measure, degrees	-4.9	26.3	↑ 29.1	< 0.0001

Conclusion: We observed minimal clinical (pain, function, and need for arthroplasty) deterioration over time. At an average of 10.3 years, our clinical and radiographic outcomes demonstrate improved hip function and major deformity correction in this population.

Significance: Periacetabular osteotomy is an effective treatment for severe acetabular dysplasia in adolescent and young adult patients.

Do Compensatory Anterior Pelvic Tilt and Lumbar Lordosis Decrease Following Bilateral Periacetabular Osteotomy?

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LOE– Therapeutic–Level IV

Purpose: The kinetic link between lumbar spinal motion and hip motion is well established. Anecdotal reports have suggested that some patients are able to compensate for anterior acetabular deficiency by involuntarily increasing lumbar lordosis and anterior pelvic tilt. At present it is not known whether change in lumbar lordosis and pelvic tilt occur following periacetabular osteotomy. The purpose of this study is (1) to measure preoperative and postoperative alterations in pelvic tilt on standing AP pelvis x-rays obtained preoperatively and minimum 6-month post-operatively, and (2) to describe inter observer reliability of a novel method of measuring pelvic orientation on a standing AP pelvis x-ray.

Methods: 114 patients who underwent bilateral PAO for symptomatic acetabular dysplasia were identified in a single surgeon cohort within a multicenter prospective cohort. 40 patients met inclusion criterion. Standing preoperative and most recent standing post-operative AP pelvis radiographs were used to measure Tonnis angle, anterior wall index (AWI), posterior wall index (PWI), lateral center edge angle (LCEA), and the novel pubic symphysis to sacroiliac index (PS-SI index) (Figure 1) Statistical analysis was performed using the intraclass correlation coefficient (ICC) for inter-rater reliability and paired t-tests for assessing change in measurements from pre- to post-operative.

Results: The inter-rater reliability was excellent for the PS-SI index preoperatively (ICC = 0.986) and postoperatively (ICC = 0.988). There was a significant decrease in the mean PS-SI index preoperatively to postoperatively of 5.58 ± 11.39 (P=0.004). The mean PS-SI index was 95.86 ± 13.71 preoperatively and 90.29 ± 13.71 postoperatively. Overall, 32 patients (80%) had a decrease in pelvic tilt. There was a significant change bilaterally (P<0.001) in the LCEA, Tönnis angle, the PWI, and the AWI.

Conclusion: The PS-SI index is valid and reproducible to measure the height of the pelvic inlet as an assessment of pelvic tilt. This is the first study to demonstrate significant reduction in pelvic tilt following bilateral PAO suggesting that acetabular reorientation affects the position of the lumbar spine and, thus, pelvic orientation.

Significance: We now understand that involuntary compensation for acetabular dysplasia is dynamic and reversible, perhaps explaining reduction in back pain in many patients following correction of acetabular dysplasia. In addition, these findings may influence non-surgical strategies for treating mild acetabular dysplasia such as physical therapy.

Reverse Periacetabular Osteotomy to Uncover the Hip in Pincer Impingement

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LOE– Therapeutic–Level IV

Purpose: Periacetabular osteotomy (PAO) is a versatile acetabular reorienting procedure that can treat both acetabular dysplasia and pincer femoroacetabular impingement (FAI). Anteverting PAO has been described as an effective treatment for pincer impingement caused by acetabular retroversion. However, the clinical results of reverse PAO that uncovers the hip anteriorly and laterally to treat global acetabular over-coverage remains unknown. We sought to describe the indications, surgical technique, and early results of reverse PAO to reduce femoral head coverage in symptomatic hips with FAI due to acetabular over-coverage.

Methods: IRB approval was obtained to retrospectively review cases of symptomatic acetabular over-coverage treated with reverse PAO and that had a minimum of two years follow-up. All hips had atypical intraoperative positioning of the acetabular fragment to uncover the lateral and anterior aspects of the femoral head, with or without anteverting the acetabulum. Prospectively collected pre- and post-operative demographics, WOMAC scores, Modified Harris Hip Score (MHHS), and radiographic measurements consisting of the lateral center edge angle (LCEA), Tönnis angle (TA), and anterior center edge angle (ACEA) were compared using student's t-test.

Results: Between 2004 and 2015, 31 hips (18 left, 13 right) in 26 patients (18 female, 8 male) met the inclusion criteria. Average age at the time of surgery was 19.4 years. Average length of follow-up was 30.4 months. After reverse PAO, femoral head coverage significantly decreased (LCEA 41.7° to 35.3°, $p<.001$; TA -7.4° to -3.7°, $p<.01$; ACEA 44.0° to 35.3°, $p<.0001$). Patients experienced improved post-operative pain, with decreases in WOMAC pain score (from 8.8 to 4.2, $p<.001$) and WOMAC stiffness score (from 3.5 to 1.9, $p<.001$). Patients also experienced improvements in function and quality of life with improvements in WOMAC function score (from 24.8 to 10.0, $p<.001$) and MHHS (from 60.8 to 83.2, $p<.0001$).

Conclusion: Reverse PAO is a technically challenging procedure that provides clinical and radiographic improvement in patients with symptomatic FAI due to acetabular over-coverage.

Significance: Reverse PAO may be an especially useful and appropriate alternative to arthroscopic acetabular rim-trim in complex FAI pathomorphologies.

Is Osteotomy Better than Resection for Painful, Dislocated Hips in Cerebral Palsy?

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LOE– Therapeutic–Level III

Purpose: Many salvage procedures are used to treat painful hip dislocations in people with cerebral palsy (CP). The purpose of this study was to compare the outcomes of four procedures: Schanz osteotomy, the McHale, Girdlestone, and Castle procedures.

Methods: Retrospective review of cerebral palsy patients with painful hip dislocations treated at two institutions between 1990 to 2014 with salvage procedures and at least 6 months follow-up. Variables collected included pain, necessity of revision surgery, and post-operative complications. Pelvis radiographs were evaluated for femoral migration, heterotopic ossification, and bone resorption.

Results: Of the 69 hips (62 patients) which met inclusion criteria, there were 36 McHale procedures, 24 Castles, 4 Girdlestones, and 5 Schanz procedures at a mean patient age of 13.9 years. Nine of 34 McHale patients (26%) experienced orthopedic complications, which was not significantly different than 15% (3/20) Castle and 0% (0/5) Schanz (p=0.36). The Girdlestone group, though only three patients, had a significantly higher orthopedic complication rate (100%) than all other groups (p=0.003). The McHale group required revision surgery more often (14/34, 41%) than Castle (3/20, 15%), p=0.02, but was not significantly different from Girdlestone (1/3, 33%) and Schanz (0/5, 0%), p=0.18. See Table 1. The McHale group demonstrated a lower incidence of heterotopic ossification (7/34, 21%) compared to Castle (11/20, 55%) (p=0.004), but was not significantly different from Girdlestone (3/3, 100%) and Schanz (0/5, 0%), p=0.15. There was no significant relationship between treatment type, medical complications, femur migration, or pain improvement. The McHale group had a higher incidence of bone resorption (16/34, 47%) compared to Castle (1/20, 5%), p=0.0004, but was similar to Schanz (1/5, 20%) and Girdlestone (0/3, 0%), p=0.26.

Conclusion: All four procedures provided pain relief after surgery. The rate of proximal femoral migration was similar following the various salvage procedures, though heterotopic ossification was more common after the Castle procedure. Bone resorption and rate of revision surgery were more commonly seen after the McHale procedure compared to other treatments.

Significance: The current study demonstrates that good pain relief can typically be expected following salvage hip surgery in CP patients with painful, dislocated hips who are not candidates for reconstructive surgery. Though pain relief is typical with these various procedures, the patient and family need to consider other issues including the ability to bear weight post-operatively, the potential need for reoperation, and risks such as heterotopic ossification and bone resorption.

Table 1 Perioperative Findings and Outcomes.

	McHale (n=34)	Castle (n=20)	Girdlestone (n=3)	Schanz (n=5)	P-value
Mean Case Length per hip (min)	179	149	95	164	0.13
Range	75-422	69-272	65-108	140-197	
Mean EBL per hip (mL)	204	132	175	150	0.28
Range	50-700	25-400	100-350	50-300	
Need for Blood Transfusion	5 (15%)	1 (5%)	0 (0%)	0 (0%)	0.65
Mean Length of Stay (days)	3.5	3.1	13.1	1.8	<0.0001***
Range	1-14	1-6	7-18	1-3	
Pain Improvement	25 (74%)	14 (70%)	3 (100%)	3 (60%)	0.82
Medical Complications	6 (18%)	2 (10%)	1 (33%)	0 (0%)	0.46
Orthopaedic Complications	9 (26%)	3 (15%)	3 (100%)	0 (0%)	0.003**
Revision surgery	14 (41%)	3 (15%)	1 (33%)	0 (0%)	0.02*

Outcomes of Primary Total Hip Arthroplasty Compared to Conversion Arthroplasty After Failed Hip Preservation Surgery in Patients Less than 30 Years of Age

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LOE–Therapeutic–Level III

Purpose: Hip preservation surgery is typically recommended for patients under 30 years of age in an attempt to delay or avoid total hip arthroplasty (THA). However, it is not known whether these surgeries complicate or diminish the success of subsequent arthroplasty. The purpose of this study was to compare the early results and complication rates of primary THA (pTHA) and conversion THA (cTHA) in patients less than 30 years of age.

Methods: After obtaining IRB approval, a retrospective review was performed of 56 patients (68 hips) with an average age of 22 years (12-29) who underwent pTHA (n=38) or cTHA (n=30) between 2005 and 2015 at a single institution. Patient demographics including age at time of surgery, diagnosis, type of previous surgery, and bearing surface were recorded. Statistical analyses were used to identify variables correlated with complication or revision rates.

Results: Major complications occurred in 7 cases (10%) including infection (1), dislocation (1), aseptic loosening (2), ceramic head and/or liner fracture (2), and canal perforation with nerve injury (1). Five hips (7.4%) have undergone revision surgery. With the number of cases available, there was no significant difference in major complication rate between pTHA patients (7.9%) and cTHA patients (13.8%) (p=0.694). Additionally, there was no significant difference in revision rate between pTHA (5%) and cTHA (10%) (p=0.648). However, patients with retained implants at the time of cTHA had a significantly higher rate of major complications (25%) compared to patients with no retained implants (4%) (p=0.048).

Conclusion: Young patients represent a challenging cohort due to a preponderance of congenital anatomic abnormalities and previous surgery. As such, surgical complications and revisions are not uncommon in pTHA or cTHA. While previous hip surgery may make subsequent THA more challenging, it does not appear to significantly increase the risk for complication or early revision in these patients as long as retained implants are removed prior to the conversion arthroplasty.

Significance: Hip preservation surgery in patients less than 30 years of age does not significantly increase the risk for complication or early revision. Removal of retained implants prior to the conversion arthroplasty, as previously advised by several international experts, remains sound advice.

Vancomycin Powder Lowers Infection Rate in Growing Rod Surgery in Early Onset Scoliosis: A Preliminary Report

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LOE–Therapeutic–Level III

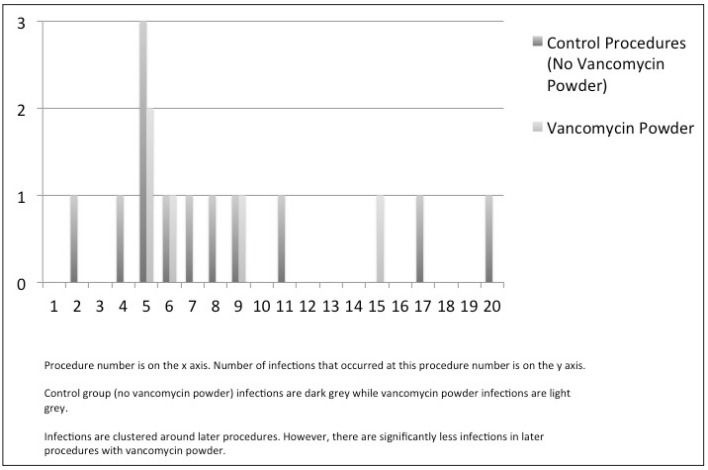
Purpose: Vancomycin powder is proven to be safe in children. However, there is no data on its use to reduce surgical site infections (SSI) in early onset scoliosis (EOS) surgery.

Methods: Using our institutional review board-approved pediatric spine database, we performed a retrospective review of our EOS program from 2010-2016. In 2010, we modified our growing spine care path and later added vancomycin powder. Therefore, we have a standardized perioperative protocol that was divided into a control group without vancomycin powder and an experimental group with vancomycin powder. Inclusion criteria were initial insertion, revision, lengthening, and final fusion procedures. We had a minimum of 90-day follow up to capture all acute SSIs, but included all SSIs within the study period. We excluded patients who had a documented SSI prior to 2010. However, patients with surgeries before 2010 and no prior infections were included for their subsequent procedures.

Results: 36 patients with 191 procedures met inclusion criteria. Seven patients had vancomycin powder for all procedures, 13 patients were mixed (initial surgeries without vancomycin powder) and 16 patients never received vancomycin powder. There were 14 patients (39%) that developed a SSI (12 acute and 2 late). Two patients had multiple infections, though not on consecutive procedures.

There were 85 procedures and 12 infections in the control group (14% per procedure). Many control group infections occurred in later procedures (Table 1).

There were 106 procedures in the vancomycin powder group with 5 infections (4.7% per procedure). This decrease in SSI per procedure was statistically significant (p=0.038, 95% CI). The number needed to treat with vancomycin to prevent a SSI was 11.



Within the vancomycin group, there were 40 procedures in patients where vancomycin powder used for every procedure. This subgroup had 2 infections (5%). Similarly, there were 3 infections (4.5%) in 66 procedures in patients having a history of earlier surgeries without vancomycin powder.

Conclusion: The use of vancomycin powder results in a reduction in SSI by 66% (RRR) and is statistically significant. It appears to be effective even when previous surgeries have been performed without its use.

Significance: This is the first study to report the efficacy of vancomycin powder in a pediatric spinal deformity population. Further study is necessary to follow long-term results, and studies with larger patient cohorts are also indicated.

Topical Vancomycin in Pediatric Spine Surgery Does Not Reduce Surgical Site Infection: A Retrospective Cohort Study

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LOE–Therapeutic–Level III

Purpose: In 2013, our institution implemented the use of topical vancomycin in definitive primary and revision posterior spinal fusion (PSF) as part of our infection control protocol. The purpose of this study is to evaluate the efficacy of topical vancomycin in reducing surgical site infection (SSI) in pediatric patients undergoing PSF.

Methods: After IRB approval, a consecutive series of 531 patients (536 procedures) undergoing primary or revision PSF from January 2010 to December 2014 were retrospectively reviewed to identify the occurrence of SSI. An a priori power analysis based on published results from a similar study determined a minimum of 190 patients were needed in each group to achieve a power of 0.90. All available charts were used. There were 226 procedures where vancomycin powder was used (VANCO) and 310 procedures where it was not (NO VANCO). Exclusion criteria were less than 90 days follow-up, patient greater than 18 at time of surgery, and combined anterior and posterior fusion. Two-sample t-tests, Wilcoxon rank-sum tests and Fisher's exact tests were used to compare the cohorts.

Results: Groups were similar in age, sex, implant density, fusion length, risk categorization (low risk for adolescent idiopathic patients undergoing primary PSF, high risk for all others), and surgical time ($p>0.05$). Patients in NO VANCO had significantly higher blood loss, incidence of intraoperative allogenic transfusion, amount transfused intraoperatively, and clinical follow-up; $p<0.001$. Incidence of SSI in VANCO was 3% (7/226) and in NO VANCO was 2% (6/304); $p=0.4077$. 6/7 of infections occurred in high risk patients in VANCO and 5/6 infections occurred in high risk patients in NO VANCO; $p=1$. Re-operation within one year occurred in 7% (16/226) in VANCO and 4% (13/310) in NO VANCO; $p=0.1762$. Occurrence of other complications, detailed in table 1, was similar between VANCO, 2% (9/226), and NO VANCO, 1% (6/310); $p=0.1913$.

Table 1. Complication types

Complication	VANCO (n=9)	NO VANCO (n=6)
Dehiscence w/out infection	2 (22%)	4 (67%)
Hematoma/Seroma	3 (33%)	0 (0%)
Implant failure	1 (11%)	1 (17%)
Implant malposition	1 (11%)	1 (17%)
Prolonged drainage (>7 days post-op)	1 (11%)	0 (0%)
Pseudoarthrosis	1 (11%)	0 (0%)

Conclusion: There was not a significant association in the use of vancomycin powder and SSI or return to OR within one year. Procedures in the NO VANCO cohort occurred earlier than in VANCO with significantly higher operative blood loss and transfusion.

Significance: Use of vancomycin powder did not reduce incidence of SSI for pediatric patients undergoing PSF at our institution. Due to use of a multidisciplinary developed infection control protocol our institution has a low infection incidence that may require a larger patient cohort to identify significant differences between groups.

Early Deep Surgical Site Infection following 740 Primary Single-stage Pediatric Scoliosis Surgery: A Multivariate Analysis of Risk Factors

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LOE–Prognostic–Level II

Purpose: Deep surgical site infections following pediatric spinal deformity are a source of significant morbidity often requiring secondary surgery, which may affect surgical outcomes and result in additional burden to the healthcare system. Therefore, there is significant interest in identifying modifiable risk factors to decrease the risk of postoperative infections. We sought to identify independent risk factors for infection following primary single-stage pediatric scoliosis surgery.

Methods: 740 consecutive patients who underwent primary single-stage (posterior or anterior-posterior) scoliosis surgery from a single institution prospectively-maintained database were identified. Early deep surgical site infection was defined as infection within 3 months of index procedure requiring surgical intervention consistent with CDC guidelines. A multivariate analysis of demographic, co-morbidities, and peri-operative factors was performed and independent risk factors were identified.

Results: Fourteen patients (1.9%) developed early deep surgical site infection. Independent risk factors for early deep surgical site infection included non-idiopathic (congenital, neuromuscular, and syndromic) types of scoliosis (adjusted odds ratio [aOR]:8.387, 95% confidence interval [95% CI]: 1.818-38.701, p=0.006) and amount of intraoperative crystalloids (aOR: 1.405 per additional liter of fluid, 95% CI: 1.003-1.968, p=0.048). Average crystalloid in the infected group was 3.3 ± 1.2 liters versus 2.5 ± 1.1 liters in the non-infected group (p=0.011). There was no significant difference in weight of patients between cohorts on univariate analysis (p=0.730). However, the infected group had a significantly higher operative time for posterior fusion on univariate analysis (391.7 ± 100.0 minutes versus 332.0 ± 86.7 minutes, p=.011).
Presence of a ventriculo-peritoneal shunt (p=0.020), pelvic extension of the fusion construct (p=0.001) and increased operative time (p=.011) were significant risk factors on univariate analysis. Differences in BMI (p=0.282) and implant material (p=0.410) were not significant risk factors by univariate analysis. Re-dosing of antibiotics intra-operatively after 3 hours of surgery trended on significance as a risk factor (odds ratio: 0.356, 95% CI: 0.098-1.286, p=0.111).

Conclusion: Non-idiopathic scoliosis and amount of intraoperative crystalloids were identified as independent risk factors for early post-operative deep surgical site infection. Further investigation is needed to elucidate the impact of intra-operative re-dosing of antibiotics on early surgical-site infections.

Significance: Patients with non-idiopathic scoliosis may have more co-morbidities and may require different surgical management. These co-morbidities may present as non-modifiable risk factors for deep surgical site infections. Intra-operative fluid management may be a significant modifiable risk factor for early deep surgical-site infections.

Table 1. Univariate and multivariate analysis of risk factors for early infection following pediatric scoliosis surgery

***Multivariate factors in black font

Risk factors	Post-operative infection (n=14)	Control (n=726)	Crude odds ratio	95% confidence interval	P-value
Demographic					
Age (years), mean ± SD	14.1±1.9	13.9±2.3	-	-	0.752
Gender					
# male	7 (50%)	205 (28%)	-	-	0.074
# female	7 (50%)	521 (72%)	0.393	0.136-1.136	
Weight (kg)	54.4±27.2	51.7±16.9	-	-	0.578
BMI	23.6±9.9	21.6±5.8	-	-	0.282
Undernourished (BMI<18)	4 (40%)	158 (24%)	2.076	0.578-7.450	0.271
Co-morbidities					
Gastric tube	1 (7%)	57 (8%)	0.903	0.116-7.026	>0.999
Baclofen pump	1(7%)	14 (2%)	3.912	0.478-31.998	0.251
Ventriculo-peritoneal shunt	2 (14%)	10 (1%)	1.933	2.357-60.411	**0.020**
Asthma	0 (0%)	49 (7%)	-	-	0.616
Pulmonary co-morbidities	1 (7%)	19 (3%)	2.862	0.356-23.012	0.321
Seizures	2 (14%)	81 (11%)	1.327	0.292-6.036	0.664
Pre-operative					
Scoliosis type					
Idiopathic	2 (14%)	448 (62%)	9.669	2.148-43.525	**0.001**
Not idiopathic	12 (86%)	278 (38%)			
Idiopathic vs not idiopathic (multivariate adjusted odds ratio)	-	-	**8.387**	**1.818-38.701**	**0.006**
Breakdown					
Congenital	0 (0%)	20 (3%)	-	-	**<0.001**
Idiopathic	2 (14%)	448 (62%)			
Neuromuscular	9(64%)	210 (29%)			
Syndromic	3 (21%)	48 (7%)			
Intra-operative					
Type of fusion					
Posterior	11 (79%)	656 (90%)	-	-	0.152
Anterior and posterior	3 (21%)	70 (10%)	2.556	0.696-9.380	
System material					
Titanium	9 (64%)	335 (49%)	-	-	0.410
Cobalt chrome	1 (7%)	141 (19%)			
Stainless steel	4 (29%)	230 (32%)			
Operated levels					
# operated levels, mean ± SD	14.8 ± 2.7	13.1 ± 2.5	-	-	**0.016**
Pelvic extension	7 (50%)	123 (17%)	4.902	1.689-14.227	**0.001**
Surgical techniques					
Hook	4 (29%)	343 (47%)	0.447	0.139-1.437	0.187
Universal clamp	0 (0%)	18 (3%)	-	-	1.000
# of universal clamps, mean ± SD	0.0 ± 0.0	0.2 ±1.4	-	-	0.617
Pedicle screw	8 (57%)	616 (85%)	0.238	0.081-0.700	**0.005**
# of pedicle screws, mean ± SD	10.8 ± 9.2	11.3 ± 7.8	-	-	0.838
Sublaminar wiring	7 (50%)	121 (17%)	5.000	1.722-14.514	**0.001**
Surgical time (minutes), mean ± SD					
Anterior fusion (n=3 for infection, 70for noninfection)	231.7 ± 48.0	192.9 ± 54.7	-	-	0.233
Posterior fusion	391.7 ± 100.0	332.0 ± 86.7	-	-	**0.011**

Risk factors		Post-operative infection (n=14)	Control (n=726)	Crude odds ratio	95% confidence interval	P-value
Blood loss (cc), mean ± SD						
Anterior blood loss (n=3 for infection, 70 for noninfection)		97.0 ± 96.7	100.9 ± 146.4	-	-	0.953
Posterior blood loss		955.7 ± 506.7	760.4 ± 520.6	-	-	0.164
Chest tube used		2 (14%)	67 (9%)	1.639	0.359-7.480	0.381
Chest tube blood loss (n=2 for infection, 67 for noninfection)		464.0 ± 475.2	577.4 ± 339.3	-	-	0.645
Hemovac used		13 (93%)	720 (99%)	0.108	0.012-0.965	0.126
Hemovac blood loss (n=13 for infection, 720 for noninfection)		770.5 ± 607.1	607.1 ± 377.9	-	-	0.127
Total blood loss		1772.1 ± 955.1	1437.1 ± 724.9	-	-	0.089
Blood transfusions (U), mean ± SD						
Intraop	Autologous	0.3 ± 0.6	0.1 ± 0.4	-	-	0.350
	Direct donor	0 ± 0	0.0 ± 0.1	-	-	0.781
	Bank	0.5 ± 1.0	0.3 ± 0.6	-	-	0.391
	Cell Saver (cc)	164.7 ± 92.1	145.9 ± 164.7	-	-	0.644
Postop	Autologous	0 ± 0	0.1 ± 0.2	-	-	0.398
	Direct donor	0 ± 0	0 ± 0	-	-	1.000
	Bank	0.3 ± 0.6	0.2 ± 0.5	-	-	0.351
Total blood transfusion (cc), mean ± SD		512.9 ± 416.0	350.7 ± 356.3	-	-	0.093
Intraoperative fluids (cc)						
Crystalloid		3313.1 ± 1207.8	2526.1 ±1139.0	-	-	**0.011**
Crystalloid (multivariate adjusted odds ratio)		-	-	**1.405**	**1.003-1.968**	**0.048**
Fresh Frozen Plasma		0 ± 0	3.5 ± 34.3	-	-	0.703
Platelets		0 ± 0	0.0 ± 0.1	-	-	0.792
Hespan		392.9 ± 349.6	312.8 ± 341.2	-	-	0.385
Albumin		196.4 ± 200.4	139.6 ± 242.0	-	-	0.383
Infection Antibiotic Protocol						
Antibiotics Redosed		3 (21%)	315 (43%)	0.356	0.098-1.286	0.111
Vancomycin powder		2 (14%)	174 (24%)	0.529	0.117-2.385	0.537
Length of Stay (days) (mean ± SD)		6.9 ± 4.6	5.9 ± 5.3	-	-	0.489
Surgical curves						
Preop Curve		72.3 ± 19.3	6158 ± 16.1	-	-	**0.013**
Postop Curve		30.5 ± 14.9	24.6 ± 12.7	-	-	0.101
Percent Curve Correction (%)		58 ± 12%	60 ± 19%	-	-	0.792

2-year Follow-up in Spine Clinical Research: An Adequate Benchmark?

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LOE–Therapeutic–Level III

Purpose: Most long-term follow-up studies report retrospective data, the quality of which remains limited due to inherent biases of retrospective reviews. Prospective databases may overcome these limitations, however, feasibility and costs limit their applications. To date there remains a paucity of evidence-based literature on which recommendations can be made for the ideal length of follow-up for spinal deformity research. Therefore, our aim was to evaluate the added value of follow-up of patients beyond 2 years following surgery for AIS.

Methods: A prospective, longitudinal, multi-center database evaluating surgical outcomes for all AIS patients with post-operative data-points of 6 months, 1 year, 2 year, and 5 year was analyzed. Surgeon-reported complications, SRS-22 scores, and radiographic data were evaluated. Complications requiring either surgical or medical intervention were compared between 2 groups: patients in whom complications developed within 2 years to those in which newly developed complications occurred between >2-5 years.

Results: 536 patients were analyzed. Significant improvement in SRS-22 scores was noted at 2-year post-op with no change at 5-year post-op. Overall complication rate was 33.2%, majority occurring within 2 years (24.8%).The rate of complications occurring >2-5 years requiring intervention was significantly lower than those requiring intervention within 2 years of surgery (4.7% vs 9.7%, p=0.000),however was not negligible. The most common newly observed complication beyond 2 years was pain (1.9%),followed by surgical site infection (SSI) (1.3%) and instrumentation issues (0.56%).There were no significant differences in the rates of crankshaft (p=0.48), instrumentation issues (p=0.56), pseudarthrosis (p=0.19), and SSI (0.13) between the 2 time points.

Conclusion: Despite the majority of complications following AIS surgery occurring within 2 years post-op, there is a non-negligible rate of newly observed complications that occur at >2-5 years post-op. Specifically crankshaft, pseudarthrosis, instrumentation issues, and SSI have similar rates of occurrence at these 2 time points.

Significance: This study emphasizes the importance of long-term, prospective, longitudinal follow-up beyond 2 years in the setting of AIS in providing a more complete picture of surgical outcomes.

Table. Complication rates in 2 year versus >2-5 year follow-up

N = 536	2 year	5 year	P-value
Overall Complication Rate			
Required Intervention	52 (9.7%)	25 (4.7%)	0.000*
No Intervention	81 (14.9%)	20 (3.7%)	0.000*
Total complications	133 (24.8%)	45 (8.4%)	0.000*
Complications Requiring Intervention (N=77)	**52 (9.7%)**	**25 (4.7%)**	
Crankshaft	1 (0.19%)	2 (0.37%)	0.48
Instrumentation related (no pseudarthrosis)	4 (0.93%)	3 (0.56%)	0.56
Pseudarthrosis	1 (0.19%)	1 (0.19%)	-
Pseudarthrosis + Instrumentation	1 (0.19%)	1 (0.19%)	-
Surgical Site Infection	11 (2.1%)	7 (1.3%)	0.13
Neurological	7 (1.31%)	1 (0.19%)	0.000*
Pain	27 (5.0%)	10 (1.9%)	0.000*
Back	14	9	
Shoulder	1	1	
Chest Wall	10	0	
Other	2	0	
Pain During Specific Time points (months)			
0-3	6		
3-6	4		
6-12	5		
12-24	12		
24-60		10	

* - indicates point at which a significant difference ($p<0.05$) found

Surgery for the Adolescent Idiopathic Scoliosis Patients after Skeletal Maturity: Now or Later?

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LOE–Therapeutic–Level IV

Purpose: Informed decision making for operative treatment of the skeletally mature Adolescent Idiopathic Scoliosis (AIS) patient meeting surgical indications requires a discussion of differences in operative morbidity in Adult Scoliosis (AS) vs. AIS. This study evaluated differences in operative data and outcomes between AIS and AS patients based on an estimated natural history of curve progression.

Methods: Twenty-eight AS patients (age 43.7±15.8 yrs; 93% F) were 1:2 matched with 56 mature (Risser 4/5) AIS patients (age 15.7±2.1 yrs) based on gender and curve type as vetted by surgeon consensus in committee. Curve progression of 0.3°/yr for the 1st 10 years following skeletal maturity and a 0.5°/yr thereafter was assumed for the purposes of estimating the increase curve size from AIS to adulthood for the AS counterpart. Operative data, complications, and patient reported outcome measures (PROMs) were evaluated, with minimum 2-year follow-up.

Results: Post-operative major Cobb and %correction were similar between for AS vs. AIS, whereas operative time, %EBL (% total blood volume), length of hospital stay, and total spine levels fused were greater for AS ($p<0.05$). Ten (36%) AS were fused to the pelvis compared to none in AIS ($p<0.0001$). Major complication rate was higher for AS vs. AIS (25% vs. 5.4%; $p<0.05$). Preoperative SRS-22r scores were worse for AS, however AS demonstrated greater improvement in SRS-22r than in the AIS cohort at final follow up. MCID was reached in all but the SRS-22r mental domain in AS and was achieved for all domains in the matched cohort in AIS.

Table. Comparisons between AS and matched AIS groups.

	AS	AIS	p-value
Age (years)	43.7	15.7	n/a
BMI	26.0	21.8	0.0018
Pre-op Cobb	58.3	49.9	0.0003
Post-op Cobb	21.8	19.0	0.1969
% Correction	61.7	61.8	0.5274
Operative time (min)	414.3	281.3	0.0001
EBL (ml)	1403.6	722.9	0.0027
Levels fused	12.9	9.4	<0.0001
Length of Stay	6.3	5.3	0.0043
SRS Scores			
Pre-op Pain	2.9	4.1	<0.0001
Pre-op Image	2.6	3.3	0.0022
Pre-op Function	3.4	4.5	<0.0001
Pre-op Mental	3.7	4.0	0.2772
Pre-op total	3.1	3.9	<0.0001
Post-op pain	3.7	4.5	0.0003
Post-op Image	3.9	4.5	0.0056
Post-op Function	3.9	4.7	0.0003
Post-op Mental	4.0	4.3	0.2684
Post-op Total	3.9	4.5	0.0009

Conclusion: Treatment of the AS patient who has undergone an estimated natural history of progression is characterized by greater levels fused, operative time, EBL and higher complication rates than the AIS counterpart. Longer term F/U of AIS is needed to define the benefits of early intervention of relatively asymptomatic adolescent patients

versus late treatment of symptomatic disease in the adult.

Significance: The crux of the surgeon-family discussion regarding timing of surgery for skeletally mature AIS patients surrounds the natural history of untreated scoliosis and differences in surgical outcomes for adolescents vs. adults. Comparison of treatment outcomes between AIS and adult idiopathic scoliosis counterparts with an estimated natural history of scoliosis progression demonstrated greater levels fused, operative time, EBL and complication rates for adults. These findings can be weighed against the relatively asymptomatic AIS patient when deciding upon treatment modality.

Evolution of Surgery for Adolescent Idiopathic Scoliosis over 20 Years: Have Outcomes Improved?

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LOE–Therapeutic–Level IV

Purpose: Surgical techniques in Adolescent Idiopathic Scoliosis (AIS) surgery have evolved considerably over the past 20 years. We study the trends in the operative management of AIS over this period and their impact on perioperative outcomes.

Methods: 1819 patients (1995-2013) from a prospective AIS surgery registry with 2-year F/U were studied. Operative approach, perioperative parameters, major complication rates, and SRS outcomes were assessed. Linear regression was used to assess the trend of changes over 5-year quartiles.

Results: Mean age at surgery was 14.6±2.1years, 80.2% were females and this remained consistent throughout. Operative time, EBL/level and LOS decreased over the 20 years ($p<0.0001$) (Table). The use of antifibrinolytic (AF) increased from 6.7 to 68.8% in the past 10 years ($p<0.0001$). Number of levels fused increased and LIV was more distal (in relation to stable vertebrae) over time in Lenke 1&2 curves (levels fused 7.97 to 9.94, $p<0.0001$ and 9.8 to 11.0, $p=0.0134$, respectively). Anterior spinal fusion (ASF) in Lenke 1 curves decreased from 81% in the 1st quartile to 0% in the last ($p=0.0429$). ASF for Lenke 5 curves evolved from 78% in the 2nd quartile to 0 in the last. Thoracoplasty performance decreased from 76% to 20.3% ($p=0.1632$). All screw constructs in PSF cases increased from 0 to 98.4% ($p=0.0095$). Anterior release was never performed in the 1st quartile but performed in 4% most recently (NS). 2-year major complication rates decreased over time (18.7% to 5.1%; $p=0.0173$). Increased improvement in SRS scores were observed in pain, image, function and total domains over the 3 quartiles for which this was available.

Conclusion: Evolution of surgical technique in AIS over the past 20 years has resulted in a cessation of anterior only surgery, increasing use of all screw constructs, less blood loss, greater use of AF, shorter operative times and LOS, lower major complications rates and greater improvements in SRS scores.

Significance: Evolution of surgical technique in AIS over the past 20 years has resulted in a cessation of anterior only surgery for single curves, increasing use of all pedicle screw constructs, less blood loss, greater use of antifibrinolytics, shorter operative times and LOS, lower major complication rates and greater improvements in SRS outcome scores.

	1995-1999	2000-2004	2005-2009	2010-2013	p
Age	14.36 ± 2.02	14.53 ±2.07	14.68 ± 2.12	14.57±2.16	0.2368
Female (%)	84.0	82.64	79.31	79.97	0.1000
pre-op Major Cobb (°)	52.16 ± 11.21	50.15 ±11.52	54.81 ±12.50	55.35±12.64	0.0021
PO Major Cobb (°)	24.07 ± 8.60	23.11 ±7.81	22.17 ± 7.76	22.37±7.21	0.0345
Cobb correction (%)	52.63 ± 18.39	53.11 ±15.33	58.82 ±13.59	58.84±13.12	<0.0001
Operative Time	373.15 ±116.45	340.08 ±118.12	269.47 ±116.48	295.05 ±122.66	<0.0001
LOS	10.70 ± 5.39	6.95 ±3.36	5.17 ±2.27	5.27 ±2.41	<0.0001
EBL	1126.69 ± 1009.61	954.98 ±877.08	972.72 ±860.56	901.61 ±749.06	0.0363
EBL/TBV (%)	35.29%	27.39%	28.52%	25.82%	0.0093
EBL/level	129.68 ± 99.31	116.15±86.33	99.71 ±74.43	87.40 ± 64.21	<0.0001
LIV in relation to stable vertebra by Lenke type					
Lenke 1+2	-0.5	-0.53	-0.10	0.21	<0.0001
Lenke 3+4+6	0	-0.47	-0.05	0.04	0.8514
Lenke 5	0	-1.41	-1.25	-1.30	0.6078
# Levels fused by Lenke type					
Lenke 1 (n=833)	7.97 ±2.19	8.10 ±2.31	9.15 ±1.85	9.94 ±1.40	<0.0001
Lenke 2 (n=372)	9.8±2.39	10.69 ±2.72	10.81 ± 1.38	11.03 ±1.23	0.0134
Lenke 3 (n=112)	11.67 ± 3.21	10.2±2.39	10.56 ±2.13	11.02 ± 1.67	0.6637
Lenke 4 (n=62)	14	n/a	11.65 ±1.81	12.58 ±1.28	ND
Lenke 5 (n=272)	13	5.56 ±3.39	7.70 ±3.66	7.11 ±2.96	0.3800
Lenke 6 (n=165)	13	10.69 ±2.87	11.63 ±1.43	10.89 ±2.39	0.2141
Major complication rate (%)	18.67%	12.08%	7.93%	5.09%	0.0173
Neurologic	6.67%	7.17%	4.25%	2.13%	0.0835
SSI	0%	1.51%	1.95%	1.48%	0.2596
Instrumentation	6.67%	2.26%	0.92%	0.49%	0.0917
Pseudoarthrosis	0%	0.75%	0.11%	0.16%	0.9387
Re-operation	12%	5.66%	3.79%	3.12%	0.0913
Pedicle Screw Only (%)	0%	54.69%	96.07%	98.36%	0.0095
%Thoracoplasty	76%	27.92%	32.79%	20.30%	0.1633
Graft Type*					
Allograft	42.9%	54.0%	48.1%	74.83%	0.1713
Rib	28.6%	13.7%	24.2%	20.9%	0.7411
Iliac Crest	28.6%	33.9%	0.3%	0.65%	0.1529
Synthetic	0	0	3.5%	18.6%	0.1371

ND- cannot be determined due to limited data points

*Patients may have multiple Grafts or local autograft

Is the Story Over? Curve Progression after Bracing in AIS

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LOE–Prognostic–Level II

Purpose: Despite successful completion of bracing for AIS, some curves progress after brace cessation. The purpose of this study was to identify the incidence of and risk factors for progression after successful brace management of AIS.

Methods: Patients were prospectively enrolled in this IRB approved study between 2008 and 2013 as part of a larger randomized control trial, and informed consent was obtained for each patient prior to inclusion. Patients treated with orthoses for AIS were prospectively enrolled at brace initiation, followed through successful brace completion and, on average, for 24 months (range 6-56) after brace cessation. Inclusion criteria were curves between 25- 45° and Risser 0, I or II at brace initiation with cessation at Risser IV with curves measuring <50°. Exclusion criteria were cessation before Risser IV or curve progression ≥50° during bracing. Demographics and radiographic measures were collected. Brace compliance was measured using thermocrons. Post-brace curve progression rate was calculated using simple statistics, and progressors were compared to non-progressors using Mann-Whitney, Fisher's exact tests and two-sample t-tests.

Results: 84 patients reached Risser IV in brace with final curves <50° and follow-up after brace discontinuation. The average progression rate in all patients that were successfully braced was 2.36°/year over an average of 2 years immediately following brace discontinuation. 21/83 (25%) later progressed to surgical curve magnitude ≥50° (n=11) or progressed >5° after brace cessation without progression to surgical magnitude (n=10). There were no significant differences between progressors and non-progressors in age or menarchal status at brace initiation or completion, curve magnitude or morphology at initiation, nor was there any difference in duration or compliance with bracing ($p>0.05$). Patients with post-brace surgical progression completed bracing at 46° on average compared to 33° for those who did not progress to surgical magnitude ($p < 0.0001$). Patients who completed bracing at ≥45° had an incidence of post-brace surgical progression of 67%. No patients who completed bracing with curves <40° later failed.

Conclusion: 13% of patients successfully treated for AIS with bracing later progressed to curves of surgical magnitude, and an additional 12% progressed greater than 5° after successful brace completion.

Significance: These results suggest that patients with curves ≥40° at brace completion should be followed into young adulthood after brace completion. Surgical consideration may be given to curves ≥45° given the high risk of progression.

Maturity Indicators and Adolescent Idiopathic Scoliosis: Evaluation of the Sanders Maturity Scale

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LOE–Prognostic–Level IV

Purpose: Bracing is recommended for adolescent idiopathic scoliosis patients with curves between 25 and 40 degrees, who are at least 10 years old, in Risser stages 0, 1, or 2, and premenarchal or less than 1 year postmenarchal. However, curves may naturally not progress or progress despite bracing. Sanders Maturity Scale (SMS), based on a left-hand radiograph, may be the best predictor of the curve acceleration phase of growth where bracing has maximum effect. The purpose of this study was to determine the correlation between Risser and Sanders systems and menarche, and determine if one system can predict the stage of the other.

Methods: Females 8 and 16 years were evaluated for idiopathic scoliosis or spinal asymmetry with PA scoliosis and a left-hand radiograph. Risser 0 with open triradiates was recorded as Risser -1; Risser 0 with closed triradiates was recorded as Risser 0. Pearson correlation coefficients (r) assessed the association between variables.

Results: 656 encounters had scoliosis and hand radiographs on same date. 402 included premenarchal or postmenarchal data. The correlation between Risser and Sanders stages was $r = 0.8984$ ($p<0.0001$). However, the ranges for SMS at each Risser stage were large, indicating that Risser stage is a poor predictor of SMS stage for individual patients. For example, at Risser stage 0, SMS stage ranged between 2 and 7. Average age at menarche was 12.3 years. Correlation between menarche and Risser stage was $r = 0.6773$ ($p<.0001$), and between SMS was $r = 0.7494$ ($p<.0001$). Menarche occurred between Risser stages 0 and 1, and SMS stages 3 and 4. 85% of Sanders 3 patients were Risser 0, with or without open triradiate cartilages. 81% of Risser 1 patients were Sanders 4 or greater, and 86% of Risser 2 patients were Sanders 4 or greater.

Conclusion: SMS stage correlates strongly with Risser stage, and both SMS and Risser correlate with menarche. However, Risser stage is a poor predictor of SMS stage for individuals. Most patients in the curve acceleration phase (between SMS stages 3 and 4) have not reached Risser stage 1, and the majority of patients Risser 1 or greater have already passed the curve acceleration phase (SMS stage 4 or greater).

Significance: Because Sanders Maturity Scale has been shown to be a more accurate predictor of the curve acceleration phase of growth, typically occurring before reaching Risser stage 1, efforts to modify bracing criteria to include the SMS stage appear warranted.

A Novel Method of Predicting Pulmonary Function of AIS Patients Undergoing PSF on Routine Radiographs

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LOE–Prognostic–Level III

Purpose: To identify a way to gain understanding of the pulmonary function of a patient with adolescent idiopathic scoliosis (AIS) based on routine spine radiographs. We developed novel radiographic measurements representative of chest and spinal deformity that are easily measureable on posteroanterior (PA) and lateral (LAT) radiographs in a clinical setting. We aim to correlate this spine-thorax ratio with pulmonary function.

Methods: This is an IRB-approved retrospective study of patients with AIS (Lenke I or II) who had pre-operative pulmonary function testing and radiographs available for review. PA and LAT radiographs of the spine were used to measure thoracic Cobb, thoracic kyphosis from T5-T12, and our novel coronal and sagittal ratios. The coronal ratio was defined as a measurement of the distance from the center of the apical vertebra to each side of the rib cage on a PA radiograph (convex/concave distance). The sagittal ratio was defined as the distance of the center of the apical vertebrae to the sternum in comparison to the posterior rib hump on a lateral radiograph (anterior/posterior distance). FEV1 and FVC %predicted values were extracted from the chart and further categorized according to the American Thoracic Society Impairment Rating scale.

Results: 157 patients (127 female, 30 male; 13.9± 2 years) met inclusion criteria. The coronal and sagittal chest cage ratios significantly correlated with both FVC-based and FEV1-based impairment ratings (coronal: r=-0.28, p <0.001, sagittal: r= -0.29, p <0.001). The magnitudes of the correlations were similar to those between the thoracic Cobb angle and pulmonary function (r=0.21 p< 0.01; r= 0.31 p <0.001, respectively). Then, we analyzed patients with Cobb angles between 50-59 degrees, the range where Cobb angle was less specific, and in these 37 patients the sagittal chest ratio correlated with both impairment ratings (r = -0.33, p=0.46 and r= -0.32, p =0.56). Additionally, a sagittal chest ratio < 1.08 was predictive of poorer FVC (ROC area under the curve =0.82, p=0.02). This threshold accurately identified patients

Figure 1. PA and lateral radiographs demonstrating chest cage ratios as measured from the center of the apical vertebra.

with better pulmonary function (27/32, 84% correct); however, did not consistently identify patients with worse pulmonary function (2/5, 40% correct).

Conclusion: The spine-thorax ratios developed in this study significantly correlated with pulmonary impairment. In patients with Cobb angles between 50-59 degrees, a sagittal chest cage ratio greater than 1.08 was predictive for normal pulmonary function.

Significance: This ratio allows the clinician a method to more directly correlate deformity with pulmonary function, especially in the patient who marginally meets surgical criteria for fusion.

Decreasing Blood Loss in Pediatric Idiopathic Scoliosis Surgery: The Efficacy and Pharmacokinetic Profile of Intravenous Tranexamic Acid

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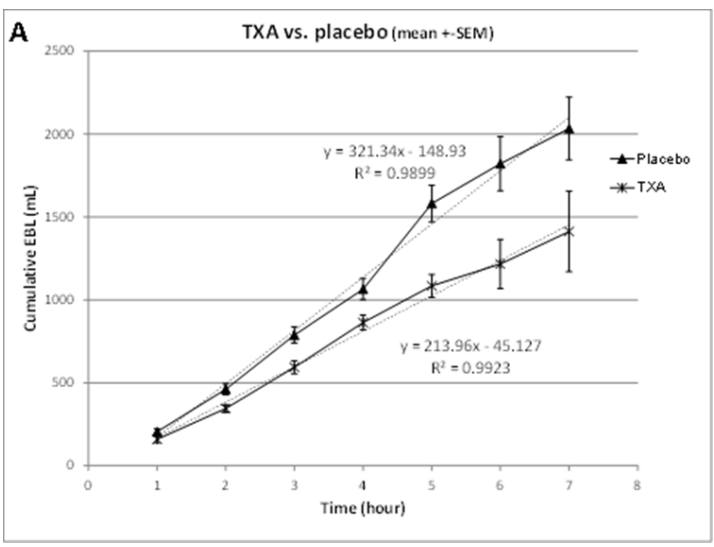
LOE–Therapeutic–Level I

Purpose: Tranexamic acid (TXA) is a potent antifibrinolytic used in surgery to reduce blood loss. The optimal dosing regimen for intraoperative TXA administration in adolescent idiopathic scoliosis (AIS) is not known.
A randomized clinical trial (RCT) of TXA for use in AIS surgery was designed to optimize the dosing regimen, confirm efficacy, and establish a pharmacokinetic (PK) profile.

Methods: This IRB approved prospective double blinded RCT of TXA use in healthy AIS patients used 50 mg/kg loading dose and 10 mg/kg/h infusion for the duration of the surgery. Four plasma sampling schemes were used to maximize data collection of TXA levels in plasma. Blood loss was measured intraoperative every hour and post op for 24 hours. TXA was assayed with a validated high performance liquid chromatography with mass spectrometry (LC/MS).

Results: The 40 patients in the TXA cohort and 40 placebo controls did not differ in age, weight, BMI, gender, Cobb angle, or surgical time. Blood loss increased in linear fashion in both groups with OR time; on average the TXA group compared to placebo had : bleeding rate(L/h) 213 vs. 321; EBL, (mL/level fused) 76 vs. 104, P < 0.001; Intraoperative blood loss (mL ± SEM) 833+/- 72.7 vs 1110+/- 79.8, p = 0.006: EBL in drain at 24 hours (mL): 500 vs. 640, P = 0.008. Four placebo patients and 0 TXA had transfusions. No adverse effects (including seizure s and thromboembolic events) were noted in either group. PK analysis data revealed mean plasma concentration of TXA after loading dose was 214.2 ± 96.3 µg /mL (mean ± SEM) and at end of infusion was 81.5 ± 18.2 µg/mL. Post-infusion the concentrations decayed exponentially with a terminal half-life of 2.1 h (min=1.1; max=2.7). PK models for loading and infusion doses were made to achieve low, moderate, or high plasma levels.



Conclusion: Total cumulative blood loss was significantly reduced in AIS patients given TXA compared to placebo. The rate of blood loss over time, blood loss per fusion level, and transfusion rate were less in the TXA vs placebo group. Plasma concentrations were well above the presumed minimal concentration to block fibrinolysis.

Significance: TXA is efficacious in reducing blood loss in AIS surgery. Our PK data will allow TXA to be administered in as safe and effective a therapeutic concentration.

A Novel Risk Severity Score for Early Onset Scoliosis Predicts SSI Rates Ranging from 5.7% to 79.6%

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LOE–Prognostic–Level III

Purpose: Surgical site infections (SSI) in children with early onset scoliosis (EOS) have a major impact on quality of life, caretaker burden and healthcare expenditure. This study aims to develop a risk severity score (RSS) system to predict SSI in EOS patients undergoing spinal surgery.

Methods: This was a multicenter case-control study identifying risk factors for SSI and developing a RSS for SSI in patients undergoing spinal surgery for EOS. Pediatric patients who underwent surgery in 15 academic institutions, between November 2002 and February 2011, were enrolled. Patients with growing spinal instrumentation and a minimum 5-year follow-up were included. Patient characteristics, preoperative lab values, and clinical data were collected. The Centers for Disease Control's definition of SSI (infection within 90 days of surgery) was used.

Results: In total, 171 patients were identified. The average age at surgery was 4.7 years and 55% of patients were female. EOS etiology consisted of: 76 congenital, 45 neuromuscular, 30 syndromic, and 20 idiopathic. The SSI rate was 22.8%. Regression analysis revealed that syndromic etiology (OR 5.3), pulmonary comorbidity (OR 2.2), Cobb angle >90 (OR 1.7), non-ambulatory status (OR 2.7), high BMI (95th percentile and above) (OR 1.1), and pelvic instrumentation (OR 1.2) were prognostic of SSI. The RSS predicted an infection risk of 5.7% when no risk factors were present and 79.6% when all risk factors were present. The model's predictive ability was 74.0% indicating that it is a good model, accurately identifying true positives while minimizing false positives.

Conclusion: This study revealed a high risk of SSI in patients with EOS (22.8%). The RSS provides a means to predict SSI risk in EOS patients preoperatively. It allows us to provide guidance to patients regarding surgical risks and prepare for high-risk patients. The RSS can facilitate outcome comparisons between hospitals caring for patients with EOS. Variables unable to be measured adequately such as perioperative infection prophylaxis likely contribute to SSI and need further investigation.

Significance: The RSS will serve as a useful tool to quantify the risk of SSI when considering operative intervention in patients with early onset scoliosis. Additionally, it will improve shared decision making with patients and families during preoperative counseling and facilitate optimization of patients at high risk. The RSS will also aid policy makers and administrators in determining reliable and valid risk-adjusted outcome measures.

Successes and Failures Following Spinal Growth Tethering for Scoliosis

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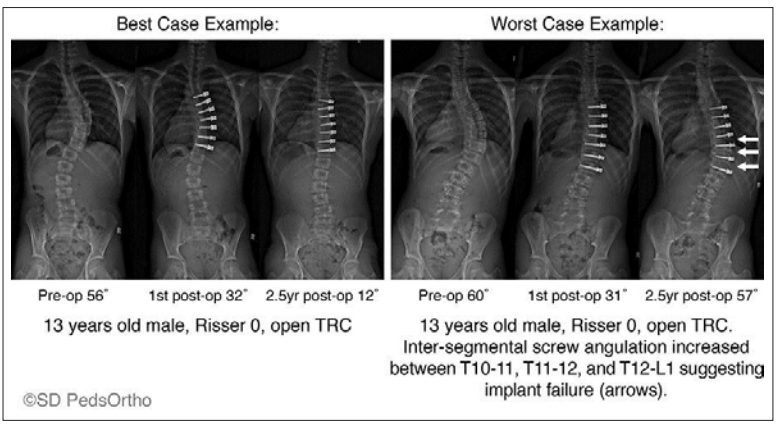
LOE–Therapeutic–Level IV

Purpose: Anterior spinal growth tethering (ASGT) has been shown to alter spinal growth with the potential to correct scoliosis in a non-fusion manner. We began performing this off-label procedure in 2011 and report 2-4 year outcomes.

Methods: From 2011-2013, 17 Risser 0 patients with mean age of 11 (9-14yr) and thoracic scoliosis (40-67º, mean 52º) underwent a thoracoscopic ASGT procedure utilizing HA coated screws and a tensioned polyethylene terephthalate cord. Etiology was idiopathic (13), cardiac (1) and syndromic (3). Clinical success was defined as thoracic Cobb reduction to <35º at most recent follow-up.

Results: Average operative time was 194±35min, EBL of 84±25ml and 6.8±0.5 vertebrae tethered (upper T5-T7, lower T11-L1). The reduction in the Cobb angle at first erect, 6mo, 12mo, and 2yr was 20±8º, 22±10º, 29±14º, and 26±14º. The most recent Cobb angle (prior to tether removal/revision) was 23±23º (-18-57º). The Cobb reduction due to growth modulation averaged 8±17º (36 to -26º), however only 10 were considered a clinical success (<35º) at most recent follow-up. 10 additional surgeries were undertaken/planned in 8 patients: 4 tether removals due to overcorrection, 1 conversion to a posterior fusion with 3 more planned, 1 replaced broken tether, and 1 contralateral lumbar tether added. On critical review of the change in segmental angulation between screws over time, 8/17 had evidence of tether breakage (angulation increase of >6º between screws, 2 confirmed intraop failure) at one or more levels (1-3).



Conclusion: Despite initial reductions in Cobb angle, the 2-4 year postop assessment of ASGT with current technology has resulted in less than ideal outcomes for ~40%, partially explained by tether breakage in ~50%. The tether clearly affects spinal growth, and avoided spinal fusion in 13 of 17 patients at current follow-up.

Significance: The outcome of spinal growth tethering with current technology has resulted initial correction, but inconsistent midterm outcomes with revision surgery required for ~50%. Understanding the variables leading to success/failure will be critical in advancing a reliable definitive non-fusion treatment for progressive scoliosis.

Does Delay to Surgery in Type III Supracondylar Humerus Fractures Lead to Longer Surgical Times and More Difficult Reductions?

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LOE–Therapeutic–Level III

Purpose: As numerous studies have shown that delay in reduction of pediatric supracondylar humerus fractures (SCHFx) does not affect clinical outcomes, and as many hospitals adopt dedicated daytime trauma operative time, more type III SCHFx are being pinned non-emergently after hospital admission. We sought to determine if delay in surgical treatment of type III SCHFx would affect the length of operative time.

Methods: This is an IRB-approved, retrospective review of a series of 317 modified Gartland type III supracondylar fractures treated operatively at a tertiary referral center from 2011 to 2013. Mean patient age was 5.4 years (range, 2-10y). To balance the study design, 15 hours was selected as the cut-off between early and delayed treatment. A total of 53.6% (170/317) fractures were treated early, and 46.4% (147/317) were delayed. Surgical time was defined as "incision start" to "incision close". Fluoroscopy time was use as a surrogate for difficulty of reduction.

Results: Time from injury to OR was shorter for high-energy fractures (fractures with soft tissue or neurovascular injury) versus low energy fractures (12.9 vs. 15.2 hours, $p < 0.0001$); however, surgical time (37.3 vs. 31.9 minutes, $p = 0.005$) and fluoroscopy time (54.4 vs. 48.4 sec, $p = 0.032$) were longer in high-energy fractures vs. low-energy fractures. Among low energy fractures, no significant difference was detected in surgical time between the early and delayed treatment groups (32.0 vs. 31.9 minutes, $p = 0.284$) or in the fluoroscopy time (50.6 vs. 46.5 seconds, $p = 0.778$). Additionally, there was no statistically significant difference found in surgical or fluoroscopy time with the presence of a surgical assistant. Mean surgical time when the attending surgeon was alone was 29.3 minutes, compared to 38.6 min with a fellow, 33.5 min with a resident, 34.8 min with a mid-level practitioner, and 40.9 min with both a fellow and resident ($p=0.065$). Mean fluoroscopy time when the surgeon was alone was 42 seconds, compared to 58.3 sec with a fellow, 51 sec with a resident, 47.6 sec with a mid-level practitioner, and 53.4 sec with multiple trainees ($p=0.102$).

Conclusion: Delay in surgery did not result in a longer surgical time or more difficult reduction for type III SCHFx. Patients with low energy fractures still underwent a shorter operative time even with delay from injury to surgery.

Significance: When excluding high-energy injuries, surgical treatment of Gartland type III SCHFxs may be delayed without increasing surgical time or difficulty of reduction.

What is an "Acceptable Reduction" for Supracondylar Humerus Fractures in Children?

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LOE–Therapeutic–Level II

Purpose: Following reduction and percutaneous fixation of humeral supracondylar fractures what is the magnitude of allowable residual displacement compatible with a good clinical outcome?

Methods: 95 children, mean (SD) age 6.7 yrs (2.3), who underwent closed reduction and percutaneous wire fixation of supracondylar humerus fractures were prospectively enrolled at a tertiary pediatric hospital over a 1 year period. Intra-operative AP and lateral radiographs were analyzed to determine residual displacement after fixation. At 3 months, patient/parent reported outcomes were measured using the Quick DASH, the PROOF, in addition to elbow range of motion and standardized photographs of both upper limbs to record carrying angle.

Results: Range of residual displacement was from 4 mm (15%) lateral to 7.0 mm (30%) medial; 5 mm (37%) posterior to 4 mm (24%) anterior. Baumann's angle ranged from 59° to 83° (Ave 70°). The anterior humeral line crossed at or behind the anterior 1/3 of the capitellum in 94/95. At 3 months, no patient had or reported a cubitus varus deformity. The average (SD) arc of motion was 137° (14°) compared with 140° (8°) on the uninjured side. The mean (SD) Quick DASH score was 2.06 (6.9). The mean (SD) PROOF score was 0.93 (1.57). The one outlier who scored 7 was the child whose anterior humeral line passed anterior to the capitellum and lacked 40° of elbow flexion compared to the other side. Within the range of displacements, there was no correlation between the amount of fracture displacement and clinical or patient reported outcome measures.

Conclusion: In this prospective cohort of children with supracondylar humerus fractures treated by closed reduction and percutaneous wiring fixation, up to a displacement of 30% medial to 15% lateral in the AP plane and 25% anterior to 37% posterior in the sagittal plane, a Baumann's angle between 59 and 83 degrees and an anterior humeral line that crosses posterior to the anterior 1/3 of the ossified cappitellum is completely compatible with an excellent outcome based on physical appearance (carrying angle), range of motion, function and patient reported outcomes.

Significance: Within the parameters described, the surgeon does not need to revise or improve upon the reduction of a SCH fracture treated with closed reduction and pinning to obtain an excellent clinical outcome. If replicated in a larger cohort, this might result in fewer open reductions, and less time to achieve a satisfactory closed reduction.

Flexion–extension Cross Pinning of Supracondylar Humeral Fractures in Children: Does It Really Increase Stability and Prevent Ulnar Nerve Injury?

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LOE–Therapeutic–Level IV

Purpose: Supracondylar fractures of the distal humerus are the most frequent elbow fractures in children, prone to serious complications when treated improperly. There is no consensus in the literature regarding proper configuration of wire pinning. The standard treatment protocol after reduction of a displaced supracondylar fracture in our hospital is insertion of two lateral Kirschner wires in full flexion and insertion of a medial wire in full extension in order to prevent injury of the ulnar nerve. The purpose of this study was to evaluate stability and incidence of ulnar nerve injury of this flexion-extension technique.

Methods: From October 2001 to January 2016, we operated on 305 children using the flexion-extension cross-pinning technique. All patients had Gartland type 3 extension type fractures. We reviewed all patient files, including x-rays and neurological status, before and after surgery. Bauman angle was evaluated before and three weeks after surgery.

Results: One patient has ulnar nerve palsy postoperatively; on review of the intraoperative x-rays, the K-wire was inserted significantly below the medial epicondyle. The mean change of the Bauman angle was 2.1° three weeks after surgery and showed no statistical or clinical significance. There were no cubitus varus complications.

Conclusion: Flexion-extension cross-pinning provides excellent mechanical stability and, when done properly, prevents ulnar nerve palsy. Insertion of the medial wire must be done in extension through the medial epicondyle, using fluoroscopic verification of the wire position.

Significance: A well-known fact is that cross-pinning provides maximal mechanical stability, but experience showed greater chances of iatrogenic ulnar nerve injury using the standard cross-pinning technique.
In our experience, flexion-extension **cross-pinning** technique, in which the lateral KWs are inserted in full flexion, and the medial KW inserted in full extension (where the aponeurosis over the ulnar nerve does not stretch the nerve) is safe, it provide good mechanical stability and easily handled by orthopedic surgeon expert and resident as one.

Complications Associated with Lateral Humeral Condylar Fractures in Children

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LOE–Therapeutic–Level III

Purpose: The aim of the study is to determine the incidence of complications after sustaining a lateral humeral condylar fracture in children and to investigate predictors of its occurrence.

Methods: 154 children with a lateral humeral condylar fracture were reviewed after an average of 16.8 years (1.6 – 38). Data regarding age at the time of fracture, sex, side involved, mechanism of injury, type of treatment, duration of surgery, type of reduction, time of immobilization, and complications were recorded. Fractures were classified according to Jakob's classification. Statistical analysis was performed looking for predictors of complications.

Results: Mean age at the time of fracture was 6.2 years (SD 2.9). Fractures were more common in males (70%) and in the left elbow (60%). A ground-level fall was the commonest mechanism of injury (83%). According to Jakob classification, fractures were as follow: 32.5% Jakob type I, 18% Jakob type II and 49.5% Jakob type III. Type of fracture was not related to sex (p=0.848), side (p=0.513) or age (p=0.409). Surgery was performed in 68.5% of the patients: open reduction in 83% and k-wires in 94% (screws in 6%). Mean duration of surgery was 56 minutes (15-105). Average delay to surgery was 2.8 days (median 1). K-wires were removed after an average of 25 days (median 32). Average time of cast immobilization was 36 days (SD 10). Complications were present in 22% of patients: elbow stiffness 7%, nonunion 1.5%, prominence of the lateral epicondyle 10%, osteonecrosis 0.5%, and cubitus varus 1.5%. Surgery for complications was needed in four patients (2.5%). Incidence of complications was significantly higher when the fracture was a Jakob's type 2 fracture (p=0.024), when fracture was treated surgically (p=0.009), when surgery was delayed (p=0.029), when closed reduction was performed instead of open reduction (p=0.088), when configuration of k-wires was convergent (p=0.072), and when immobilization was prolonged (p=0.080). Specifically, prominence of the lateral epicondyle was statistically related to displacement of the fracture (p=0.052), surgical treatment (p=0.011), and younger age (p=0.009).

Conclusion: The incidence of complications was 22%, although the majority of them did not need surgical treatment. Complications were more common in Jakob's type 2 fractures, when the fracture was treated surgically, surgery was delayed, a closed reduction was performed, and when immobilization was prolonged.

Significance: Although incidence of complications after sustaining a lateral humeral condylar fracture in children are high (22%), the majority of them are not relevant.

No Difference in Time to Full ROM, Union or Incidence of Complications in a Matched Cohort of Operative versus Non-Operatively Treated Displaced Medial Epicondyle Fractures

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LOE–Therapeutic–Level III

Purpose: There is a lack of consensus regarding the management of uncomplicated, displaced medial epicondyle fractures. The purpose of this matched cohort study was to compare treatment outcomes among operative versus non-operatively treated medial epicondyle fractures.

Methods: A retrospective chart review was used to collect demographic, clinical, and radiographic data from all pediatric patients that were treated for an acute, displaced medial epicondyle fracture between 2005 and 2015. Propensity scores (probability of receiving operative treatment) were used to match operatively managed fractures to non-operatively treated fractures on the basis of fracture displacement, age, gender, limb dominance, mechanism of injury, date of injury, and presence of an incarcerated fracture, elbow dislocation, nerve injury and/or an additional fracture. Generalized logistic regression analyses were used to compare incidence complications (malunion, non-union, loss of reduction, or stiffness) in the two groups. Cox-proportional hazards regression analyses were used to compare time to full range of motion. Correlation due to the 1:1 matching was accounted for in the statistical models.

Results: Of the eligible subjects with follow up until union and final range of motion were determined, (operative N = 43, non-operative N = 69), 22 subjects in the operative group were matched to 22 subjects in the non-operative group. Median displacement was similar in non-operative and operative groups, (7.3 mm, IQR 4.5 - 11.7 vs 7.4 mm, IQR 5.3 - 12.3). Complications in the non-operative group included: stiffness (N=1), non-union (N=2), and malunion (N=1). Complications in the operative group included revision surgery (N=1). There was no difference in the cumulative incidence of complications in the operative versus the non-operative group [Odds Ratio: 6.2, 95% CI: 0.6 to 64.3, p = 0.1278]. Time to full flexion/extension was similar in the operative (median time = 131 days) versus the non-operative (median time = 170 days) group [p=0.0625]. There was also no difference in median time to full pronation/supination in the operative (median time =118 days) versus the non-operative (median time = 104 days) [p=0.8269].

Table 1: Displacement of Medial Epicondyle Fractures by Group

Displacement	Non-Operative		Operative	
0-5 mm	6	27.3%	3	13.6%
5-10 mm	7	31.8%	10	45.5%
≥ 10 mm	9	40.9%	9	40.9%

Conclusion: Between non operative and operatively treated groups matched for the propensity for treatment in either group, the incidence of complications and the time to full range of motion was similar between groups.

Significance: In these matched groups of medial epicondyle fractures, outcomes of union, range of motion, and complications were similar with non-operative and operative treatment. This suggests that in uncomplicated medial epicondyle fractures with mild to moderate displacement, non-operative treatment may be warranted.

To Fix or Not to Fix: Fracture Type and Outcomes of Operative vs Nonoperative Management of Pediatric Humeral Shaft Fractures

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LOE–Therapeutic–Level IV

Purpose: Humeral shaft fractures are uncommon in the pediatric population and are generally treated nonoperatively. Current literature does not adequately outline the optimal patient for which operative management is the preferred surgical technique. This study evaluates current indications for and results of operative management of pediatric humeral shaft fractures.

Methods: IRB-approved retrospective study of all pediatric patients treated for humeral fracture between 1996-2016 was completed. At latest follow up, data including fracture characteristics, operative vs nonoperative management, complications and outcomes were recorded.

Results: 522 pediatric patients with diagnosis of "humerus fracture" were treated; location included proximal (44%), humeral shaft (19%) and distal humerus (37%).
100 patients sustained humeral shaft fracture (32 female, 68 male) with average age at injury of 10 (range 0-17). Follow-up averaged 34 months (range 2-181) excluding 7 deceased from inciting trauma. Fractures included 65 type AO 12A, 13 type 12B and 2 12C. Location was proximal (6), middle (72), middle/distal junction (6) and distal third (16). Final management consisted of nonoperative (70) and operative (30). Of operative patients, 11 were treated acutely due to open fracture or unacceptable displacement. Nineteen were initially treated conservatively but subsequently underwent fixation due to fracture displacement or refracture. Operative treatment included open reduction internal fixation (18), flexible intramedullary nailing (10) and external fixator (2).
Average immobilization was 6 vs 2 weeks (nonoperative vs operative). Average time to healing was 12 vs 16 weeks (nonoperative vs operative).
Complications included refracture in 3 patients (2 nonoperative, 1 operative). In the operative cohort, patients were noted to have infection (1), reduced motion requiring therapy (1) and return to OR for planned removal of flexible nail (4).

Fracture characteristics were worse in operative group with initial angulation 21 degrees vs 13 degrees. A significant finding was that operative fractures were disproportionately in the middle 1/3 of the humerus with no proximal location and only 1/16 in the distal location undergoing surgery.

Conclusion: Humeral shaft fractures are uncommon in the pediatric population representing only 19% of humerus fractures and are largely treated non-operatively (70/100) with good outcomes. When indicated, operative fixation is a safe alternative with similar clinical outcomes, less immobilization and slightly improved final alignment. In this series, operative fractures were largely middle third and in older children.

Significance: Study reviews the management of pediatric humeral shaft fractures, noting that the majority are treated nonoperatively (70%) with good outcomes. When indicated, surgical management provides a safe reliable alternative.

Effect of NSAID Use In the Acute Phase of Skeletally Immature Bone Healing: A Prospective, Randomized, Blinded, Controlled Trial

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LOE–Therapeutic–Level I

Purpose: Non-steroidal anti-inflammatory drugs (NSAIDs) are effective in controlling pain associated with orthopaedic injuries and treatment, particularly in the pediatric population, and can minimize the need for narcotic pain medications. There are little data regarding the effects these medications have on long bone fracture healing in skeletally immature patients.

Methods: In this prospective, randomized, blinded, controlled study, skeletally immature patients with a long bone fracture were randomized to one of two groups for their post-fracture pain management: one group received acetaminophen (Control Group) and the other received ibuprofen (NSAID group). Both groups received oxycodone for breakthrough pain. The patients were followed clinically for fracture healing and were evaluated with physical exam, visual analog pain score and radiographs.

Results: Eighty-one skeletally immature patients with long bone fractures were enrolled. Three were lost to follow-up. Seventy-eight completed 6 months of follow-up (45 in the Control group and 33 in the NSAID group). The groups were similar in regards to age, gender, height, weight and BMI (Table 1). None of the patients achieved healing by the 1-2 week follow-up. By six weeks, 74% of the Control patients had healed fractures and 89% of the NSAID patients had healed fractures (p = 0.1). At the 10-12 week follow-up, 97% of the Control group fractures were healed and 100% of the NSAID group fractures were healed. All fractures were healed in both groups by 6 months. Healing was documented at a mean of 44 days in the Control group and 42 days in the NSAID group (p = 0.58; power = 0.8). The mean number of days breakthrough oxycodone was used was 2.5 days in the Control group and 2 days in the NSAID group. No statistically significant differences in pain scores were found between groups at any time point.

Table 1

	Control group Mean (range)	NSAID group Mean (range)	*p value*	Power
Age	7.8 years (2-16)	7.6 years (1.5-16)	0.6	0.81
Male:Female	28:19	25:22		
Height	130 cm (88-175)	126 cm (80-176)	0.3	0.64
Weight	33.3 kg (13.5-76)	28.6 kg (10.9-70.3)	0.2	0.4
BMI	18 (12-27)	17 (13-27)	0.4	0.55

Conclusion: The results of this study provide evidence that NSAID use in the acute phase of fracture healing does not impair long bone fracture healing in skeletally immature patients.

Significance: This study supports the use of NSAIDs as a useful alternative for pain control in the setting of acute long bone fractures in skeletally immature patients.

Risk of Fracture and 25-OH Vitamin D Level in Pediatric Population

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LOE–Diagnostic–Level II

Purpose: Recent publications have shown a high rate of hypovitaminosis D among children with fractures. Our goal was to compare the levels of 25-OH Vitamin D and lifestyle characteristics in a pediatric population (fracture group) with a control group (who had not suffered a fracture) in our environment (Mediterranean climate) and establish risk of fracture related to 25-OH Vitamin D level.

Methods: Prospective case-control IRB approved study. Patients were included in Group 1 (with fracture) or in Group 2 (control group) during a 12-month study period. Age included from 6 months to 14 years. At the time of the first clinic appointment within 1 week after the initial presentation the following parameters were measured: serum 25 OH Vitamin D, serum calcium, and bone alkaline phosphatase. Age, height, weight, body mass index, race and fracture pattern were collected from medical records. Estimated weekly hours of exercise, sun exposure hours, carbonated beverage consumption and associated conditions were collected through a self-reported survey. Vitamin D levels were categorized as low or deficient (<50 nmol/L), average (50-150 nmol/L) and high or optimal (>150 nmol/L). The study population and subgroups were analyzed using parametric and non-parametric tests and correlation analysis to compare levels of Vitamin D with age, BMI, seasonality and type of fracture. Binary logistic regression analysis was used to assess the risk of fracture related to 25-OH Vitamin D level. In all cases statistical significance of 5% ($p < 0.05$) was established.

Results: One hundred and thirty-three patients were recruited, 74 in Group 1 and 59 in Group 2. Mean age was 84.3 months (6.75-167.0). Most fractures were located in the upper limb (53 radius and ulna and 17 humerus). Mean 25-OH Vitamin D in Group 1 was 79.67 nmol/L and 91.63 nmol/L in Group 2. This difference was statistically significant ($p=0.012$). Six patients in Group 1 had deficient levels of 25-OH Vitamin D whereas only 1 in Group 2 did. Vitamin D levels lower than 95.05 nmol/L significantly increased the risk of fracture (sensitivity 79.73 and specificity 49.15).

Conclusion: Lower levels of 25-OH Vitamin D were detected in children with fractures. The risk of suffering a fracture increases significantly with 25-OH Vitamin D levels lower than 95.05 nmol/L.

Significance: Patients with low levels of 25-OH Vitamin D are at increased risk for fractures. 25-hydroxyvitamin D level may be used as screening tool to predict risk of fracture and implement specific nutritional programs for children.

Pediatric Supracondylar Humerus Fractures: Does After-hours Treatment Influence Outcomes?

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LOE–Not Applicable-III

Purpose: Surgery for pediatric supracondylar humerus fractures frequently occurs outside of normal operating hours. This may be suboptimal due to surgeon fatigue, limited resources, and variations in comfort with pediatric fracture care. This study compared the outcomes of pediatric supracondylar humerus fractures treated during daytime hours to those treated after-hours.

Methods: We retrospectively reviewed the charts of 263 pediatric patients treated with surgical reduction and pinning of closed supracondylar fractures at one institution. Seventy-seven patients underwent surgery during daytime hours. One hundred and eighty-six patients underwent surgery after-hours. Demographics, surgeon subspecialty, operative times, and outcomes were extracted from the patient medical records. Statistical analysis was performed using Chi-square, Fisher's exact test, Student t-test and logistic regression.

Results: There were no demographic differences between the daytime hours and after-hours groups. Daytime surgery was more likely to be performed by a pediatric orthopaedic surgeon than after-hours surgery (94% vs. 49% $p<0.01$). Fractures treated after-hours had more severe injury patterns with 73% classified as Gartland Type III compared to 57% in the daytime group ($p=0.01$). After controlling for injury pattern and surgeon fellowship training, after-hours surgery was not independently associated with rate of open reduction, complications, range of motion, radiographic alignment or operative times. After controlling for surgeon fellowship training, late night operations were associated with increased odds of malreduction (OR 18, 95% CI 1-311, $p = 0.047$).

Conclusion: There is no difference in the operative times or outcomes following surgical treatment of pediatric supracondylar humerus fractures performed after-hours when compared to daytime surgery. Late night surgery is associated with higher rate of malreduction.

Significance: Supracondylar humerus fractures can be treated by the on-call surgeon after hours without increased risk. However, late night surgery results in an increased rate of malreduction. These data can better inform surgeons who must decide how and when to treat supracondylar humerus fractures in children.

Descriptive Epidemiology of Adolescent Clavicle Fractures: Early Results from the FACTS (Function After Adolescent Clavicle Trauma and Surgery) Prospective, Multi-Center Cohort Study

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LOE–Therapeutic–Level IV

Purpose: To provide a comprehensive description of the epidemiology of adolescent, diaphyseal clavicle fractures in the United States and to establish the study population for an observational, prospective, multi-center cohort study (FACTS) investigating operative versus non-operative treatment outcomes for these fractures.

Methods: All patients 10-18 years old treated for a clavicle shaft fracture between August 2013 and February 2016 at one of 8 geographically diverse, high-volume, tertiary-care pediatric centers were screened. Age, gender, race, ethnicity, fracture laterality, hand dominance, mechanism of injury, athletic participation, injury activity, and treatment decision were recorded in those who consented to enroll. Fracture characteristics, including pattern, displacement, shortening, and comminution, were analyzed.

Results: Of 852 patients screened, 550 (65%) met inclusion/exclusion criteria and agreed to participate. The mean age of the study population was 14.1 years (SD ±2.1, range 10-18) (Figure 1), and 79% were male. The most common race category affected, according to NIH categories, was 'White' (71%), followed by 'Black/African-American'. Fractures occurred more frequently on the non-dominant side (56%). Sport was the predominant activity during which injury occurred (66%), followed by "horseplay" (12%) and "biking" (6%). The primary mechanism of injury was a direct blow/hit to shoulder (60%), followed by a direct blow to collar bone/chest (24%), and fall onto outstretched hand (11%). 13% were non/minimally-displaced fractures, 33% were mildly displaced/angulated fractures, and 54% were completely displaced fractures with no cortical contact between fragments. 82% were two-part fractures, while 18% were comminuted. Mean shortening within the completely displaced group was 21.9mm when measuring the distance between fragment ends and 12.4mm when measuring distance between fragment end to its corresponding site on the other fragment (i.e. 'true shortening'). 83% of all clavicle fractures were treated non-operatively, while 32% of completely displaced fractures underwent ORIF.

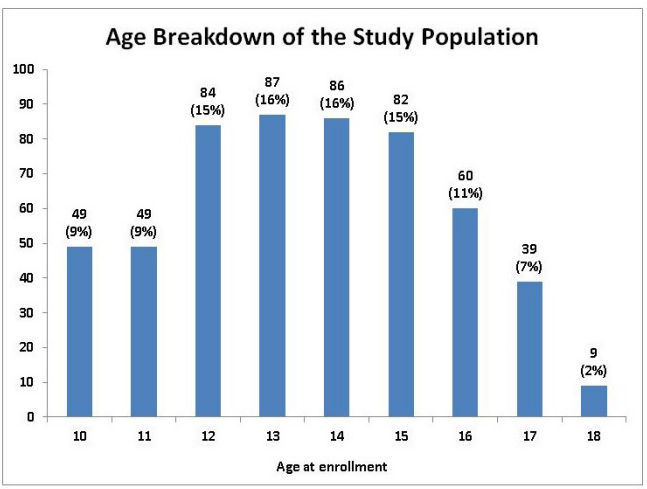

Figure 1. Breakdown of the ages of the study subjects at enrollment.

Conclusion: Treatment of midshaft clavicle fractures has become significantly controversial in orthopaedics. These data show that adolescent clavicle fractures predominantly occur during sports, are most commonly secondary to a direct blow, and occur more frequently on the non-dominant side. The majority of these fractures (54%) are completely displaced, and almost 1/5th (19%) are comminuted. At eight large pediatric centers with many surgeons making independent treatment decisions, 32% of patients with completely displaced fractures underwent surgery.

Significance: These data establish the most comprehensive descriptive epidemiologic assessment, to date, of clavicle fractures in adolescents, the population most affected by this condition, and provide a foundation for much needed prospective comparative clinical studies.

To Nail or Plate Forearm Fractures in the Adolescent: Using Bone Age as Guide

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LOE–Therapeutic–Level III

Purpose: The aim of this study is to evaluate and compare the functional, radiological and surgical factors in the surgical management of forearm fractures in adolescent children using flexible intramedullary nails versus plates and screws with Sauvegrain method of bone age measurement as a guide.

Methods: A 5-year retrospective single institution review of 168 children with displaced paediatric forearm fractures from the adolescent age group of 10 to 16 years was conducted. The surgical notes and the radiographs of these patients were reviewed. The treatment outcomes studied were operating time, rate of union and presence of complications. Operating time was defined as the interval from skin incision to skin closure. The rate of union was defined according to the number of weeks for fracture union to occur whilst the rate of complication was defined as the rate of non-union, malunion, delayed union, limited range of motion and functional disability.

Results: There was no statistically significant difference in the rate of union ($p = 0.31$) and complications seen ($p = 0.99$) when comparing between flexible intramedullary nailing and plating. This lack of significance was confirmed even after accounting for bone age. Other factors such as gender, number of forearm bones involved, impact of initial injury and presence of associated injuries also did not show any statistical significance. The mean operating time for intramedullary nailing, however, was significantly less ($p<0.01$) compared to that of plating which was 62.61 minutes and 126.25 minutes respectively.

Conclusion: Surgical management has been increasingly used for adolescent forearm fractures. This study shows that both intramedullary nailing and plating have comparable outcomes in terms of rate of union and complications, regardless of chronological or bone age. However in view of it being less invasive and more biological with reduced operating time, intramedullary nailing is recommended for forearm fractures even in older adolescents.

Significance: Forearm fractures are common injuries among children. While closed reduction and cast immobilization is useful in the younger children, as they approach adolescence these fractures become increasingly unstable and require surgical fixation. Current literature has not established the superiority of one surgical method over the other. This study debunks the idea that plates and screws are better for the older adolescents even when bone age is taken into account. Intramedullary nailing is less invasive with reduced operating time thus preferred and recommended

Pediatric Forearm Fractures Are Effectively Immobilized with a Sugar-Tong Splint Following Closed Reduction

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LOE–Therapeutic–Level IV

Purpose: Following closed reduction and initial casting of pediatric forearm fractures, loss of reduction (LOR) occurs in approximately 40% of fractures. Sugar-tong splinting has been shown to maintain acceptable reduction in pediatric distal radius fractures. However, there remains a gap in the literature regarding the effectiveness of sugar-tong splints in midshaft and proximal forearm fractures. We hypothesized that the sugar-tong splint would be an acceptable method for initial immobilization to prevent LOR in distal, midshaft, and proximal pediatric forearm fractures.

Methods: This is an IRB-approved, retrospective study. Patients age 4-16 years old, open growth plates, with a displaced, extraphyseal forearm fracture that underwent closed reduction were included. The clinical protocol involved closed reduction and application of a sugar-tong splint by an orthopaedic resident in the emergency department. Patients were then followed at 1, 2, 4, and 6-week intervals with a long-arm cast overwrap applied at the initial clinic visit. Primary outcome was radiographic LOR (>10 degrees of angulation on AP/LAT projections) from initial post reduction radiograph or previous follow-up radiograph. The secondary outcome was the need for further intervention.

Results: There were 168 patients that met inclusion criteria – 125 both bone forearm fracture (BBFF) patients, 3 isolated ulna fractures, and 40 isolated radius fractures. Overall, 64 (38%) patients demonstrated radiographic LOR with 90% of LOR occurring in the first two weeks. LOR was significantly more common in distal radius fractures (48/110 (44%)) than with either proximal (2/14 (14%), $p = 0.04$) or midshaft radius fractures (7/41 (17%), $p = 0.004$). There was no difference in LOR by location for ulna fractures (proximal = 2/13 (15%), middle = 4/38 (11%), distal = 20/77 (26%), $p > 0.08$). Additionally, there was no difference in radial LOR in patients with isolated radius fractures compared to BBFF (17/40 vs. 40/125, $p = 0.22$), or ulnar LOR between isolated ulna and BBFF (0/3 vs. 26/125, $p > 0.99$). 22 patients (17.8%) required an additional intervention.

Conclusion: The sugar-tong splint is effective at maintaining reduction of pediatric forearm fractures similar to published rates for casting. While effective at all levels of the forearm, the sugar-tong splint performed best in proximal and midshaft forearm fractures.

Significance: This is the first study to demonstrate success of the sugar-tong splint in maintaining alignment following closed reduction of BBFF, particularly in the midshaft and proximal forearm. Therefore, sugar-tong splinting is a viable alternative to primary placement of a long-arm cast.

Significant Reductions in Surgical Site Infection (SSI) In Spinal Fusion Patients Using a Bundled Intervention Approach

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LOE–Not Applicable–Level III

Purpose: Surgical site infection (SSI) following clean spinal fusion surgery leads to high morbidity and cost to the patient. The Center for Disease Control and Prevention cites that adoption and implementation of evidenced-based practices, such as bundled interventions, can significantly decreased SSI rates . Wide clinical care variations likely contributed to the spine infection rates at our institution. The purpose of this quality value safety initiative (QVSI) was to reduce spine SSI meeting acute hospital acquired infection (HAI) criteria by 50% by the end of 2016.

Methods: In 2016, a our institution created a multidisciplinary SSI executive committee that included representation from a Physician Champion, Nursing, Administration, and Infection Prevention and Quality. A literature review was performed and evidenced based bundled interventions were implemented. Sequential Plan-Do-Study-Act cycles were implemented. The executive committee reviewed the data for all spine infections during 2 distinct study periods. Study Period #1: (7/1/2014 – 6/30/15) and Study Period #2: (7/1/2015 – 6/30/2016). Rapid cycle improvement strategies were initiated (as seen below).

2015
Cycle #1 – Increased Ancef dosing from 25 mg/kg to 30mg/kg on all spine procedures
Cycle #2 – Vancomycin and Gentamycin placed in the bone graft for neuromuscular/ syndromic spine procedures
Cycle #3 – Timing of pre-incisional iv antibiotics within 60 minutes of incision

2016
Cycle #1 – Implemented a pre-operative Chlorhexidine (CHG) skin cleansing protocol
Cycle #2 – Aligned timing of pre-incisonal iv antibiotics to co-inside with intra-op sterile CHG site prep
Cycle #3 – Re-dosing of Ancef every 3 hours
Cycle #4 – 24" Sterile Safe Zone around the OR table
Cycle #5 – Limit OR traffic

Root Cause Analysis was performed for infections meeting HAI criteria, and infection rates were calculated using rolling 6 months averages.

Results: SSI rates for spinal fusion patients were effectively reduced from 11/304 = 3.61/100 in study period #1 to 5/322 = 1.50/100 in study period #2, with an overall 58% improvement, as well as a 40% reduction in direct cost to the patient.

Conclusion: We achieved our aims through the utilization of a multidisciplinary team, standardized bundle interventions, patient and family education and root cause analysis methodology. We are planning to implement a standardized surgical/clinical pathway

for the neuromuscular/syndromic spine population(s) by the end of 2016, hoping to achieve an SSI rate of zero in 2017.

Significance: The utilization of an evidence based bundled intervention approach significantly reduced our spine infection rate by 58% and direct costs by 40%.

Bundles, Surveillance and Committees: Results of an All-Out Assault on Spinal Fusion Surgical Site Infection

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LOE–Therapeutic–Level III

Purpose: Recently, there has been a strong push to make surgical site infection (SSI) in Posterior Spinal Fusion (PSF) a "never event." In the past 5 years, our large pediatric spine center has implemented many measures (bundles, practice changes, surveillance, committees) to drive down SSI rates. The purpose of this study was to audit more than a decade of cases and interventions to determine the return on our investment to reduce SSI for PSF.

Methods: We reviewed a consecutive series of 1,181 PSFs at our institution over a 10.5 year period, identifying all cases that returned to the OR for surgical debridement within 90 days of PSF. Yearly SSI rates for Idiopathic (I), Syndromic(S), Neuromuscular (NM) SSIs were related to the dates of SSI prevention interventions (Figure 1).

Results: At our institution from 1/1/2005 to 6/30/2015, 22/1, 181 cases met the CDC criteria for acute SSI (1.9%). The overall 10 year SSI rate was I=0.6%, NM=6.5%, S=2.0%. From 2005-2010, the SSI rate was 10/593 1.7% overall; 2/407 I 0.5%, 7/111 NM 6.3%, 1/75 S 1.3%. After implementation of multiple prevention measures (Figure 1), the SSI rate 2011-6/2015 was 12/588 (2.0% overall SSI; 3/409 I 0.7%, 7/105 NM 6.7%, 2/74 S 2.7%). There was no significant difference after the interventions (p =0.5). However, since topical Vancomycin and Betadine wash were introduced, overall SSI is 1.1%, I=0.4% and combined NM/S = 4.0%, our best results ever measured.

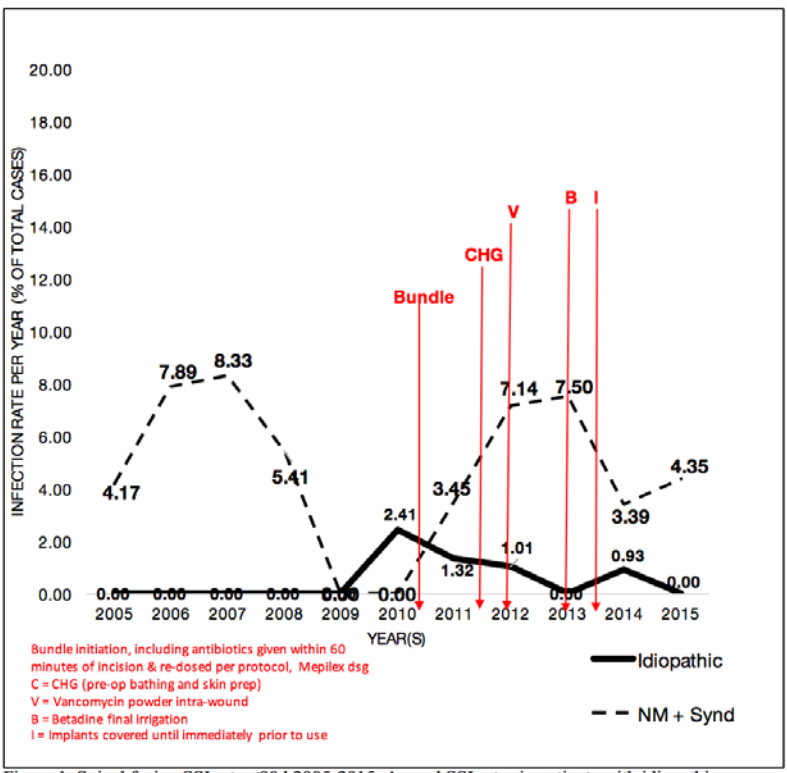

Figure 1. Spinal fusion SSI rate <90d 2005-2015. Annual SSI rates in patients with idiopathic scoliosis are shown in comparison to SSI rates in neuromuscular and syndromic patients combined. The approximate timing of interventions are shown with corresponding labels as delineated in the figure.

Conclusion: Extensive investment, practice change and surveillance have not yet produced a significant reduction in PSF SSI rate at our large pediatric spine surgery center. Pediatric spine wounds are known to become progressively more contaminated during the course of the operation. Measures introduced since 2012 at the end of the operation (topical Vancomycin powder and Betadine irrigation) have produced the best SSI results we've ever measured, although we will need a few more years to determine if this very positive trend is statistically significant.

Significance: Analyzing a consecutive series of 1,181 PSFs at our pediatric spine center over a 10 year period, we calculated SSI rates for Idiopathic, Neuromuscular and Syndromic scoliosis fusions before and after implementation of multiple SSI prevention measures. Although there were no significant change in the rates before and after interventions (1.7% vs. 2.0%, p =0.5), measures taken at the end of the operation (topical Vancomycin powder and Betadine wash) are now delivering the lowest PSF SSI rates we've ever measured.

Development of Consensus-based Best Practice Guidelines (BPG) for Postoperative Care following Posterior Spinal Fusion for AIS

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LOE–Not Applicable–Level V

Purpose: Significant variability exists in post operative care following PSF for AIS, despite a relatively healthy patient population and continuously improving operative techniques. We hypothesized that use of the Delphi method based on expert opinion would result in consensus surrounding various aspects of postoperative care following PSF for AIS.

Methods: An expert panel composed of 26 pediatric spine surgeons was selected. Using the Delphi process and iterative rounds using a nominal group technique, participants were presented with a literature review and asked to voice opinion collectively. Voting for consensus comprised three rounds (one electronic and two face-to-face). Agreement >80% was considered consensus. Interventions without consensus were discussed and revised, if feasible.

Results: Consensus was reached to support 14 BPG measures for post operative care including:
1) Patients may be admitted to a general floor rather than the PICU
2) A PCA pump should be used
3) An epidural is not necessary
4) Primary transtion to oral narcotics should occur on a target date (i.e. POD#1) rather than based on clinical thresholds
5) Muscle spasm medications, Gabapentin, and Ketorolac should be used to minimize narcotic needs
6) PT should help with mobilization 1-2 times daily
7) Clear liquids can be started immediately post operatively and a regular diet may be provided once tolerating clears
8) A bowel regimen should be used
9) Antiemetics should be given post operatively
10) Chewing gum may be used to increase gastric motilit
11) Intraoperative, without post operative radiographs, may suffice to evaluate implant placement and location
12) Patients may be discharged prior to having a bowel movement
13) Discharge on POD 2 or 3 is acceptable
14) The patient should be contacted about their progress in the first week after surgery.

Conclusion: We present a consensus-based BPG consisting of 14 recommendations for the post operative management of patients following PSF for AIS.

Significance: These recommendations can serve to reduce variability in practice in this area, help develop specific protocols, and guide research.

Cost Effectiveness Analysis of Operative versus Non-Operative Treatment for Adolescent Idiopathic Scoliosis

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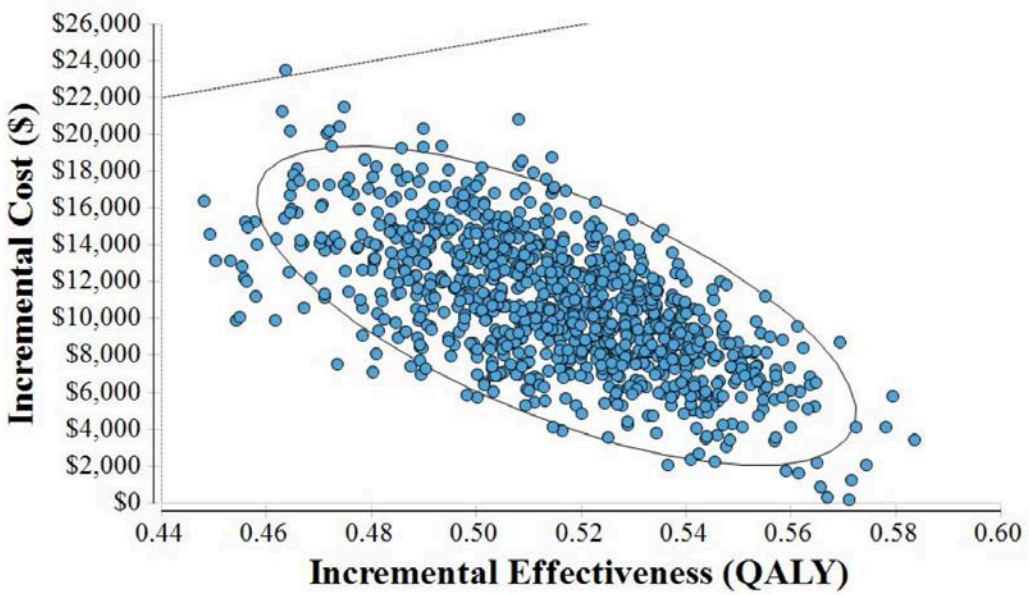
LOE–Economic and Decision Analyses–Level II

Purpose: The aim of our study was to perform cost effectiveness analysis of adolescent idiopathic scoliosis (AIS). We hypothesized that surgical treatment of AIS is cost effective, and key drivers of cost effectiveness can be identified.

Methods: A decision tree model was developed for a hypothetical 15-year old skeletally mature child with 50° right thoracic curve who would live through age 79. A comprehensive review of the AIS literature was performed to estimate the probability and health utility at each node. Quality adjusted life years (QALYs) were estimated from multiplying utility by years presumed in a given health state. For a very conservative model, we assumed that the health utility in AIS patients was same as the U.S. population average for a given age, and that surgery did not result in any QALYs gained. All potential benefits of surgery were assumed to derive from its preventative aspects. Costs were inflation-adjusted at 3.22%/yr to 2015 USD, and costs and benefits were discounted at 3%. Sensitivity analysis was performed by varying the cost and QALY estimates by ±50%, and varying the probability estimates from 50% to 200%.

Figure 1. Scatter plot of incremental cost vs. incremental effectiveness of operative compared to non-operative treatment for 1000 hypothetical patients (blue dots). Ellipse represents 95% confidence interval. The dotted line represents the $50,000/QALY willingness to pay threshold.



Results: Monte Carlo simulation performed for a 1000 hypothetical patients revealed that the mean net cost with operative strategy was $78,799 ± $2,663, and the mean net cost with the non-operative strategy was $68,260 ± $2,512. The net lifetime QALYs with the operative strategy were 22.83 ± 0.01, and with the non-operative strategy were 22.31 ± 0.02. The analysis revealed that the operative strategy was favored with incremental cost-effectiveness ratio (ICER) at $20,559 per QALY gained (Fig 1). Deterministic sensitivity analysis revealed that the top 3 drivers of increasing ICER were: 1) health utility associated with chronic dyspnea, 2) cost of uncomplicated surgical treatment, and 3) probability of spinal deformity surgery as an adult.

Conclusion: Surgical treatment of AIS is below the $50,000/QALY threshold.

Significance: Future research is warranted to reduce the uncertainty in cost, QALY and probability estimates to help better define the cost effectiveness of surgical treatment.

Decreasing Unexpected Returns to Orthopaedic Hand Clinic: Improving Efficiency of Health Care Delivery While Decreasing Medical and Non-Medical Costs

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LOE–Economic and Decision Analyses–Level II

Purpose: An unexpected return to clinic (URTC) visit, defined as a return to clinic prior to the next scheduled appointment, or a return within 30 days of discharge from clinic, can place a significant financial burden on the patient and family while stressing the healthcare system. Our SMART aim was to decrease the rate of unexpected patient return visits from 1.8 per 100 patient follow-up visits by 50% using Quality Improvement (QI) methodology.

Methods: The rate of URTC visits was tracked at our tertiary care pediatric hospital from February 1, 2014 to May 31, 2015 using a control chart (weekly P-chart), and interventions were studied from January 1 to May 31, 2015. Pareto charts were utilized to determine the most common causes of URTC visits, and interventions were studied using Plan-Do-Study-Act (PDSA) cycles. The medical charges for all URTC patient visits were collected and patient/families were given a cost survey to determine non-medical costs associated with the clinic visits.

Results: The rate of URTC visits dropped from 1.8 to 0.7 (62% decrease) per 100 follow-up visits during the study period, signified by a change in the centerline on the P-chart ($p<0.003$). The most common reasons for URTC were cast issues (50.5%), new symptom/complaints (29.5%) and persistent/worse symptoms (15.2%). Cast issues were decreased by transitioning from casts to removable splints for distal radius buckle fractures and stable hand fractures. This transition additionally decreased the need for scheduled return clinic visits. Similarly, post-operative patients were placed into splints instead of casts when feasible. Physicians, Physician Assitants, Nurses and Orthopaedic Technologists provided standardized patient education in clinic, with diagnosis-specific pamphlets and/or templated discharge summaries given to all clinic patients. The average URTC resulted in $350 of charges ($47.14 in professional fees, $303.24 in hospital fees, radiology fees and supplies). The average URTC cost $70 for families including ½ day of lost wages and travel expenses, not to mention the value of lost time in school for children.

Conclusion: Applying QI methodology to URTC visits by standardizing patient care resulted in a substantial decrease in the number of patients returning to clinic, both scheduled and unexpectedly. This improvement resulted in a savings of more than $420 per visit saved, including medical and non-medical costs.

Significance: Improving the efficiency and cost-effectiveness of health care delivery will become more important as medical care is transitioned from fee-for-service to value-based reimbursement models and/or Accountable Care Organizations.

Implementation of a Dedicated Clubfoot Clinic Significantly Decreases the Occurrence of Major Unplanned Clubfoot Surgery: A Quality Improvement Initiative

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LOE–Therapeutic–Level III

Purpose: In response to an initial study which identified an unacceptably high rate of major surgical correction in patients treated for clubfoot, a quality improvement (QI) intervention was implemented to address the failure flags identified as increasing the risk for major surgery. The QI intervention established a dedicated clubfoot program to decrease the number of casts, providers applying casts, and cast related complications. The purpose of this study was to compare the occurrence of major surgery before and after the QI intervention.

Methods: Data were retrospectively collected from isolated clubfeet that underwent treatment before (2003-2007) and after (2012-2014) implementation of a dedicated clubfoot program. Variables included treatment patterns (total number of casts during the initial casting period, TAL procedures, number of different providers that performed castings, and cast related complications), demographics, and the occurrence of major surgery within the first 2 years of treatment. A generalized logistic regression analysis was used to test the null hypothesis of no difference in the occurrence of major surgery between the two time periods. Generalized estimating equations were used to account for correlation due to the inclusion of multiple feet per patient.

Results: The pre- (N=91 patients, 131 limbs) and post-clubfoot (N=51 patients, 71 feet) cohorts were similar with respect to gender, primary language, positive family history, occurrence of perinatal complications, and average birth weight. The occurrence of major surgery was decreased in the post- (1.2%) versus the pre-clubfoot program (33.6%, OR: 0.02, 95% CI: 0.01-0.17, p=0.0002) time periods. There was also a decrease in the number of casts per foot (8 vs. 5.8, p<0.0001), proportion of feet treated by multiple providers (27% vs. 8%, p=0.0179), and the proportion of feet that underwent TAL (66% vs. 86%, p=0.0122). There was no difference in reported bracing non-compliance (37% vs. 47%, p=0.1331), the occurrence of cast related complications (37% vs. 15%, p = 0.2960), or average number of days between cast visits (8 days vs. 5.6 days, p = 0.1898) in the pre- vs. post-clubfoot groups.

Conclusion: The implementation of a dedicated clubfoot program was associated with a decrease in major clubfoot surgery, the number of providers involved in a patient's care, and the average number of casts. Additional intervention is being explored to improve brace compliance.

Significance: The implementation of quality improvement processes in health care is essential to our commitment to improve the outcomes, quality of care and safety of our patients.

Training Effect of Using A Mobile App-Based Simulation for the Treatment of Pediatric Septic Arthritis – A Pilot Study

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LOE–Not Applicable–Level IV

Purpose: Simulation training allows for deliberate acquisition of medical knowledge and iterative practice of technical skills, without the risk of patient harm. Recently the American Board of Orthopaedic Surgery and the Accreditation Council of Graduate Medical Education (ACGME) has identified the treatment of pediatric septic hip arthritis as a milestone skill for all U.S. orthopaedic residents. However, septic arthritis of the hip remains an uncommon condition, with which trainees often have little experience. The purpose of this study was to test the training effect of orthopedic trainees using the Touch Surgery™ training module for the treatment of pediatric septic hip arthritis. Our hypothesis is that simulation training may improve recognition, diagnosis, and surgical management of pediatric septic hip arthritis.

Methods: A four-part simulation model on the surgical decision-making associated with the treatment of pediatric septic arthritis was developed through expert consensus. Orthopedic trainees participating in the "Top Gun" program of the 2015 International Pediatric Orthopaedic Symposium were recruited to participate in this pilot study. Trainees completed the simulation on diagnosis, arthrocentesis, and surgical irrigation and debridement on a pediatric patient presenting with septic hip arthritis. In addition, trainees competed a pre- and post-test quiz to assess pre-training knowledge gaps and post-training performance. Pre- and post-test scores were compared using Pearson correlation, where significance was set as a 2-tailed p value <0.05. Trainees also completed a satisfaction survey at the completion of the simulation.

Results: A total of 16 orthopedic residents and fellows participated in the simulation. Pre-test scores were 84 (range 64-97) and mean post-test scores were 96.7 (87-100). On average, trainees spent 23.68 minutes learning the didactic content and performing the simulation. Trainees significantly improved their score results during the simulation experience ($r=0.71$, $p=0.0001$). The majority of respondents agreed that the simulation model for the septic hip had graphics, simulated environment, and procedural steps, which were realistic, and only 2 respondents felt the simulation was poor.

Conclusion: This proof of concept study demonstrates the ability for orthopedic trainees to acquire critical cognitive competencies surrounding the management of pediatric septic arthritis. Further studies testing knowledge retention and application to real operative scenarios are necessary to identify the optimal balance between simulation and real-time experience.

Significance: In the current environment for orthopedic trainees of decreased work hours and patient exposure, virtual simulation has the potential to safely aid in education and training for orthopaedic residents and fellows.

A Coordinated Discharge Pathway Following Posterior Spinal Fusion for Neuromuscular Scoliosis Associated with GMFCS 4/5 Cerebral Palsy Resulted in a 50% Decrease in Complications and a 25% Shorter Length of Stay

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LOE–Therapeutic–Level III

Purpose: Implementation of a coordinated multidisciplinary post operative pathway has been shown to reduce length of stay following posterior spinal fusion (PSF). This study sought to compare the outcomes of patients treated with PSF for neuromuscular scoliosis (NMS) and cared for using an optimized discharge pathway with those using a more traditional non optimized discharge pathway.

Methods: 72 patients with GMFCS 4/5 cerebral palsy undergoing PSF for NMS were reviewed. 30 patients were cared for using a non optimized discharge (NOD) pathway where patients were mobilized gradually, fed after bowel sounds returned, and remained on intravenous pain management for 48 hours post operatively. 42 patients were subsequently treated using an optimized discharge pathway (OD) and were mobilized more quickly and had enteral feeding and narcotics started on POD#1. The cohorts were then evaluated for post operative complications and length of stay. Length of follow up was 2 years.

Results: Length of stay was 25% shorter in patients managed with the OD pathway (OD 3.7 days (95% CI 2.9-4.5) vs NOD 4.9 days (95%CI 4.0-5.9), p=0.006). There was no difference between groups with respect to age at surgery, GMFCS class, preoperative curve magnitude (NOD 65.9° vs OD 63.5°, p=0.5) pelvic obliquity, kyphosis, post operative curve correction, fusion to the pelvis, or length of fusion between groups. No difference existed in preoperative comorbidities including seizures, cardiac history, need for a gastrostomy tube, and ventilator dependence. Regression analysis showed no significant impact on length of stay of either EBL (p=0.18) or length of surgery (p=0.45). Complications were significantly different in the OD group (31% OD vs 60% NOD, p=0.01) with a notable decrease in pulmonary complications (14% OD vs 31% NOD, p=0.03). There was no difference in wound complications, return to the operating room, or medical readmissions between groups. Length of stay correlated with time to initiation of feeds (p<0.0001), foley removal (p<0.0001), mobilization to a chair (p=0.001), time to starting enteral narcotics (p=0.001), and need for ICU (p=0.04).

Conclusion: Adoption of a standardized post operative pathway resulted in a 25% decrease in length of stay in patients with PSF for NMS and a 50% lower complication rate.

Significance: A generalized coordinated postoperative pathway appears to be helpful in this challenging patient population. While the OD pathway may not be appropriate for all patients with NMS, the utility of the OD pathway in optimizing care for more routine PSF for NMS appears to be significant.

Complications of Peripheral Nerve Blocks following Pediatric Knee Surgery

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LOE–Therapeutic–Level IV

Purpose: Peripheral nerve blocks (PNBs) are quickly becoming a mainstay of pain control in orthopaedic procedures because of the decreased requirement for systemic analgesics and excellent pain control. Moreover, PNBs in knee surgeries have been shown to improve time to ambulation and shorten post-operative length of stay. While most existing studies show that PNBs are rarely associated with complications, a few studies have reported higher than expected neuropathic complications in the early post-operative period in adults and a delay to muscle strength recovery. Our study aims to investigate the complications associated with the use of PNBs in pediatric knee surgery.

Methods: We retrospectively reviewed the records of all surgical patients of a single orthopaedic surgeon between October 2014 and September 2016. During the study period, 120 patients had knee surgery, of which, 100 (83%) had accompanying PNBs. The primary outcome was post-operative neuropathic symptoms reported at follow-up visits. Other study parameters included patient demographics, surgical details, tourniquet time, nerve block method and location, training level of nerve block performer, and complications of PNB procedure. Data were analyzed using student's t-test with significance set to $p<0.05$.

Results: Of the 100 patients, 23 patients had some type of persistent lower extremity paresthesia following surgery. Most could be explained with the surgical incision(s), however, 6 patients (Table 1) had paresthesias and other nerve related symptoms proximal to the knee in the dermatomal pattern consistent with their PNB at their first follow-up ($M=1.6\pm0.4$ weeks), and 4 of these were unresolved after their last follow-up ($M=8.5\pm3.2$ weeks). Compared to patients without suspected PNB associated nerve symptoms, these 6 patients had a significantly higher BMI ($M=31.39\pm5.47$ kg/m^2) while showing no significant difference in age, surgery duration, or duration of tourniquet usage. No complications were reported during the PNB procedures.

Conclusion: Compared to prior studies, we demonstrate a higher (6%) rate of nerve related symptoms after PNB for pediatric orthopaedic knee surgery. Increased BMI was found to be associated with persistent effects of the block.

Significance: PNBs may be more commonly associated with neuropathic complications than previously thought in the pediatric population. This delay in return of normal sensation, along with the known delays muscle strength recovery, should better equip surgeons when considering PNBs and counseling their patients. Continued prospective investigation is necessary to examine the factors surrounding this procedure and its impact on post-operative patient recovery.

Table 1. Characteristics of 6 pediatric patients with PNB-related paresthesia following knee surgeries 2014 to 2016

	Injury	Procedure	Tourniquet Time (Min)	# of PNBs	Anesthetic	Level of Performer	Location	Method	Location of Paresthesia
1	Lateral dislocation of right patella Osteochondral Lesion	Repair of medial patella femoral ligament Arthroscopic lateral release Drilling and fixation of Osteochondral Lesion	48	2	Ropivacaine 0.2% Ropivacaine 0.2%	Fellow Fellow	Popliteal Femoral	Ultrasound Ultrasound	Proximal medial thigh
2	ACL Tear Complex tear, lateral meniscus	ACL reconstruction with hamstring autograft Partial menisectomy lateral meniscus	131	1	Ropivacaine 0.2%	Fellow	Sciatic	Nerve stimulator, ultrasound	Lateral lower leg and distal medial thigh
3	ACL Tear	ACL reconstruction with hamstring autograft	121	1	Ropivacaine 0.2%	Resident	Femoral	Ultrasound, hydro-dissection	Lower leg and thigh down to foot
4	Lateral dislocation of right patella, Chondromalacia patellae	MPFL reconstruction with allograft hamstring Arthroscopic chondroplasty	119	1	Ropivacaine 0.5%	Resident	Femoral	Ultrasound	Shooting pain down distal leg with deep palpation of anterolateral thigh
5	Patellar Instability Chondromalacia patellae Loose body in knee	Tibial tubercle osteotomy and transfer Medial patellofemoral ligament imbrication Lateral release Arthroscopic removal of loose bodies	132	2	Ropivacaine 0.2% Ropivacaine 0.2%	Attending Attending	Femoral Sciatic	Ultrasound Ultrasound	Lateral distal thigh, lateral knee, and proximal lateral lower leg
6	Medial meniscal tear with prior repair	Knee arthroscopy Meniscus repair	77	2	Ropivacaine 0.2% Ropivacaine 0.2%	Resident Attending	Femoral Popliteal	Ultrasound Nerve-stimulator, ultrasound	Proximal Medial thigh

Abbreviations: ACL – anterior cruciate ligament; Min – minutes; MPFL – Medial Patellofemoral Ligament; s/p – status post

Utilization of a Wide Array of Non-Validated Outcome Scales in Pediatric Orthopedic Publications: Can't We All Measure the Same Thing?

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LOE–Not Applicable–Level II

Purpose: Clinical changes after intervention or during the course of a disease are best evaluated with standardized, validated outcome measures, including patient and clinician reported outcome scales. The purpose of this study was to describe the spectrum of outcome measures used in pediatric orthopedic publications over the past 10 years and to determine the proportion that are age-appropriate, validated, and appropriately applied.

Methods: Journal of Bone and Joint Surgery, the Bone and Joint Journal, Journal of Pediatric Orthopedics A and B, and Journal of Children's Orthopedics were systematically searched for studies on children aged <= 18, from January 2005 to December 2014 inclusive. Economic evaluations, letters, editorials, review articles, and clinical guidelines were excluded. Descriptive statistics were performed.

Results: A total of 4097 articles were identified, of which 954 met inclusion and exclusion criteria. 38.8% used a patient or clinician-reported outcome scale/questionnaire. 53.2% of studies reported imaging outcomes. The most frequently reported clinical outcome was complication rate. Fifty different outcome scales were identified; 29 were patient reported and 21 were clinician reported. The most commonly used patient and clinician reported outcomes were the Pediatric Outcomes Data Collection Instrument (PODCI) and the Pirani score. Only 42% of outcome scales were validated in an age and disease-appropriate demographic.

Conclusion: Within the field of pediatric orthopedics, a wide variety of outcome scales are used, many of which have not been validated in children. Improved uniformity in reporting of outcomes and use of disease and age-validated outcomes scales are essential to improving the quality of research and comparisons of treatment modalities in our field.

Significance: Recognition of variations in outcome scale utilization and the practice of using invalid outcome scales in pediatric orthopedics may help our community come to consensus on appropriate validated outcome scales for various pediatric anatomic locations and conditions. This may ultimately improve our ability to compare and collaborate amongst sites and find the optimal care pathways for our patients.

Clinical Assessment of Generalized Ligamentous Laxity Using a Single Test: Is Thumb-to-Forearm Flexion Enough?

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LOE– Diagnostic–Level II

Purpose: Identification of physical examination maneuvers that are quickly performed, easy to reproduce, and yield reliable information is increasingly desirable. However, simplifying the musculoskeletal examination may introduce diagnostic error. The complete Beighton criteria used to establish the diagnosis of generalized ligamentous laxity (GLL) consist of examination of bilateral knees, elbows, thumbs, small fingers and the trunk, yet it is common for busy examiners to perform only a single maneuver (e.g., passive flexion of the thumb to the forearm) as a rapid method of assessment. We hypothesize that the use of a single joint hypermobility test does not reliably identify the presence of GLL.

Methods: After obtaining IRB approval, all patients 2-18 years old presenting to a general pediatric orthopaedic clinic were screened for study participation. Exclusion criteria included the presence of a systemic illness (including connective tissue disorders), neuromuscular disease, and inability to complete the examination. Once informed parental consent was given, each subject was assessed for GLL according to the widely accepted Beighton criteria, using a cutoff score of 5. Positive predictive value (PPV), negative predictive value (NPV), and likelihood ratio (LR) were calculated for each of the three individual upper extremity Beighton tests, with the composite Beighton score used as the gold standard.

Results: Two hundred and four patients were included in the study, 111 females and 93 males, with an average age of 10.7 years. The prevalence of GLL in this population was 13%. When (1) small finger flexion greater than 90º; (2) thumb-to-forearm flexion; and (3) elbow hyperextension >10º were considered in isolation unilaterally, the PPVs were poor: 0.40, 0.34 and 0.41, respectively. Conversely, the NPVs of each test were quite good: 0.95, 0.99, and 0.92. The LRs were 4.4, 3.3 and 4.7, respectively. Performing each test bilaterally did not change the test's utility. Results are presented in **Table 1**.

Conclusion: When performed in isolation, commonly used tests for GLL have poor PPVs, excellent NPVs, and modest LRs. While single tests may be helpful for "ruling out" GLL, they are less reliable at identifying it, with a positive result for each test increasing the likelihood of GLL by <30%. As a result, they may be inadequate for detecting joint hypermobility.

Table 1. Descriptive statistics for each clinical test of ligamentous laxity. *(PPV = positive predictive value; NPV= negative predictive value; LR= likelihood ratio)*

Clinical Laxity Test	PPV	NPV	LR
Small finger flexion >90°			
Unilateral	0.40	0.95	4.4
Bilateral	0.45	0.94	5.3
Thumb-to-forearm flexion			
Unilateral	0.34	0.99	3.3
Bilateral	0.37	0.99	3.8
Elbow hyperextension >10°			
Unilateral	0.41	0.92	4.7
Bilateral	0.43	0.90	4.8

Significance: Single tests of joint hypermobility may not accurately detect GLL. When single tests are used in either clinical or research settings, the results should be interpreted with caution.

Why is SCFE Decreasing While Obesity is Increasing?

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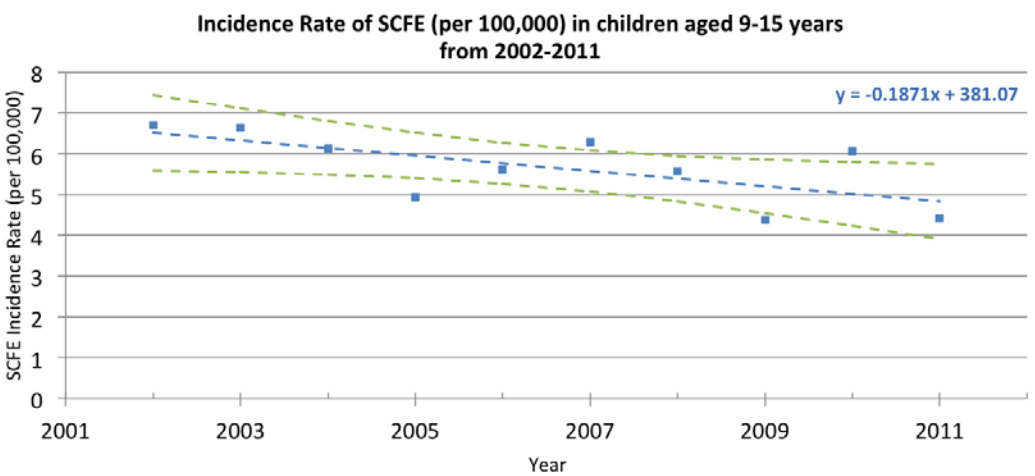
LOE–Not Applicable–Level III

Purpose: Slipped Capital Femoral Epiphysis (SCFE) is a common disorder of the hip seen in adolescent patients. The etiology includes both biomechanical factors and endocrine factors, and SCFE is commonly considered a disease of obesity. According to Statistics Canada, 23.4% of Canadian children aged 2-17 were overweight or obese in 2013, up from 18.7% in 2007. Few true population based studies of SCFE exist, and incidence estimates vary widely from 0.2 to 81 per 100,000. The goal of our study was to evaluate the population - based epidemiology of SCFE in a province with increasing child and adolescent obesity.

Methods: We searched the Institute for Clinical and Evaluative Sciences (ICES) databases for recorded cases of SCFE between April 1, 2002 and March 31, 2011. ICES databases cover the entire child population of Ontario and we identified SCFE cases both from discharge diagnosis codes as well as from procedure codes. We analyzed the incidence of new cases by year with reference population data. We obtained the demographic information for each subject including age at diagnosis, sex, his or her respective Local Health Integrated Network (LHIN), and socioeconomic status. We modeled the changing incidence of SCFE using linear regression.

Results: Over a ten-year period, there were 648 cases of SCFE in Ontario. The overall annual incidence rate (IR) of SCFE ranged from 1.4322 to 10.0184 cases per 100,000, peaking in the 12-year-old group. A statistically significant decrease in the annual incidence of SCFE occurred across the study period with 34% fewer SCFE cases in 2011 compared with 2002.



Conclusion: We were surprised to see an important decline in SCFE incidence given increasing obesity. UK data (unpublished) show similar trends. The result is population based and robust.

Significance: This questions our assumptions that more obesity will mean more SCFE and raises an intriguing hypothesis that earlier onset of obesity may be protective through acquisition of skeletal strength or through earlier or more rapid maturation.

Hip Surveillance for Children with Cerebral Palsy: A Survey of the POSNA Membership

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LOE–Not Applicable–Level V

Purpose: Currently, hip surveillance programs for children with cerebral palsy exist in Europe, Australasia and parts of Canada, but a neuromuscular hip surveillance program has yet to be adopted in the United States. The purpose of this study was to report the current orthopaedic practice of hip surveillance in children with cerebral palsy, identify areas of practice variation and suggest steps moving forward to generate guidelines for national neuromuscular hip surveillance.

Methods: The entire membership of the Pediatric Orthopaedic Society of North America (POSNA) was surveyed in 2016 for information regarding their practice for hip surveillance in children with cerebral palsy. Detailed information regarding timing, frequency and practice of hip surveillance was obtained in answers to 26 different questions.

Results: A survey response rate of 27% was obtained (350/1300 members) during the study period. The majority of respondents treated pediatric patients exclusively (97%), worked in an academic practice (70%) and was affiliated with a university (76%). 18% (69/350) of respondents followed a regular neuromuscular hip surveillance program, about half of whom (44%, 30/69) had adopted the Australian guidelines. Respondents agreed that a dislocated hip in a child with cerebral palsy was painful (90% agreement) and should be prevented by hip surveillance (93% agreement). Furthermore, 93% of respondents indicated they would follow a national surveillance program if one was in place. Age (79%), GMFCS (81%) and Migration percentage (78%) were all identified as critical elements to a hip surveillance program. The majority of respondents felt that a hip "at risk" for hip displacement had a MP between 20-30% (57% of respondents), while surgery should be utilized once the MP exceeded 40% (50% of respondents).

Conclusion: Results from this POSNA wide survey demonstrate that there is significant practice variation associated with the initiation and screening of neuromuscular hips.

Significance: At a societal level, we have the ability to standardize neuromuscular hip surveillance, thereby decreasing practice variation and improving the quality of care we deliver to this vulnerable patient population.

Is There a Consensus in Diagnosing and Preventing Hip Dislocation in CP Patients?

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LOE–Economic and Decision Analyses–Level V

Purpose: Hip dislocation is a major problem in CP patients - especially in the severely handicapped like GMFCS level 4 and 5. Therefore some countries already have implemented a screening program. The objective of this study was to find out how much agreement exists between orthopaedic surgeons and neuropaediatricians concerning diagnosing and preventing hip dislocation in this patient group. The idea is to implement a hip surveillance-program which is widely accepted by both faculties.

Methods: 37 European orthopaedic surgeons (n=20) and neuropaediatricians (n=17) especially known for there expertise in treating CP-patients agreed to participate in a Delphi consensus process. The questionnaire was developed by two orthopaedic surgeons and two neuropaediatricians and covered questions related to the mentioned subjects. All participants responded to the first round.

Results: There is a high degree of consent that surveillance of the hip needs a x-ray image of the pelvis which is performed in a standard neutral position of the pelvis (89% acceptance). The migration index is the most important parameter (100% acceptance) to evaluate the hip condition, followed by the Shenton-Menard-line (94%), the acetabular index and center-edge-angle (82%); the projected CCD-angle (70%) and the femoral antetorsion (67%) were of minor relevance. Most participants agreed that a hip surveillance program should consider the parameters age, GMFCS-level, migration index and progression of hip migration (94%). The German signal-light-concept was not well accepted (71%). For preventing hip migration 78% agreed that botulinum toxin is an option although the evidence is bad (53%). Especially the adductors and the medial hamstrings should be injected (58%).

Conclusion: There is a high level of agreement among orthopaedic and neuropaediatric specialists that hip surveillance in CP-patients should be performed and parameters like age, GMFCS-level and radiologic indices should be considered. Botulinumtoxin plays an important role in daily practice for preventing hip migration although its effectivity is insufficiently evaluated.

Significance: This survey marks a baseline for developing a surveillance program which can be accepted by orthopaedics and neuropaediatricians

Radiation Prophylaxis for Hip Salvage Surgery in Cerebral Palsy – Can We Reduce the Incidence of Heterotopic Ossification?

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LOE–Therapeutic–Level III

Purpose: Heterotopic ossification (HO) is a well-recognized complication of proximal femoral head resection (PFHR) surgery in cerebral palsy. While single-dose radiation prophylaxis (SDRP) has been shown to be effective at lowering the rates of HO following total hip arthroplasties; there has been limited study examining the efficacy of SDRP for HO prevention in patients undergoing PFHR. The purpose of this study was to assess the efficacy of SDRP in patients with cerebral palsy undergoing PFHR.

Methods: This retrospective case control series identified all patients from one tertiary children's hospital undergoing PFHR (Caste or McHale). Patients were dichotomized into (1) SDRP group and (2) Non-SDRP group. Radiation was delivered preoperatively or within 72 hours' post-op at a dose of 7.5 Gy utilizing a 6 MV photon beam. Patients with less than 3 months of clinical follow-up were excluded. The incidence of HO in the radiated cohort was compared to historic data using binomial testing. The size of HO lesions in the two cohorts was compared using Wilcoxon test. McCarthy, Booker and Anatomic Classifications of HO were compared using Likelihood ratios.

Results: Seventeen patients (mean age 15.4) and 25 hips (17 SDRP, 8 Non-SDRP) were included in the analysis. There were 12 females and 5 males in the cohort and all patients carried a diagnosis of cerebral palsy with the majority classified as GMFCS V 15/17 (88%). The majority of patients underwent the Castle procedure (56%, 14/25) with the remainder undergoing the McHale. HO was seen in 6 of the SDRP hips (6/17, 35%) and 5 of the non-SDRP hips (5/8, 63%). Our rate of HO was lower than the historic rate of 64% ($p < .05$). The average size of HO at maturity was 272.7 mm^2 in the SDRP group compared to 1520.4 mm^2 in the Non-SDRP group ($p < .05$). Bilateral surgery was associated with a 1.8 odds ratio of HO development ($p < .05$). Radiation treatment is associated with a 1280mm^2 *decrease* in HO size at maturity ($p < .05$). There were no differences in infection rates between the two cohorts and there were no radiation-associated complications.

Conclusion: Single-dose radiation prophylaxis is a safe and efficacious intervention in decreasing the incidence and size of heterotopic ossification in children with cerebral palsy undergoing proximal femoral head resection.

Significance: Single-dose radiation prophylaxis should be considered when performing proximal femoral head resection to reduce the incidence of heterotopic ossification.

Trochanteric Sparing Proximal Femoral Resection for Spastic Hip Arthritis

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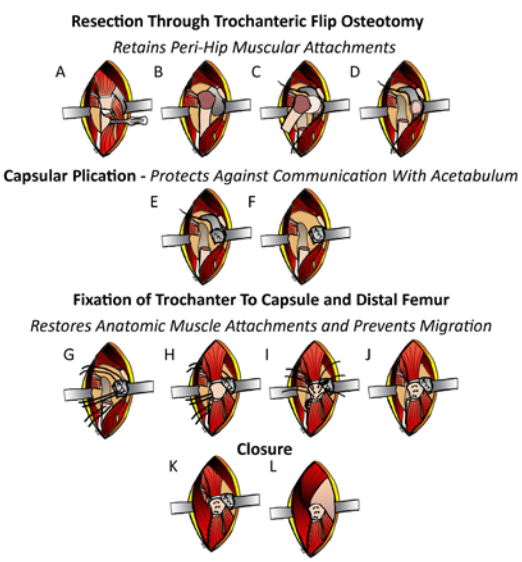
LOE–Therapeutic–Level III

Purpose: A spastic arthritic hip is a significant cause of morbidity to the patient and burden to the caretaker. Several salvage operations exist including proximal femoral resection as described by Castle. Although this procedure is successful in some, surgeon and caretaker enthusiasm is limited by the need for post-operative traction and reported persistent pain, proximal femoral migration, heterotopic ossification, and high revision rates. Utilizing technical advances recently developed for surgical hip dislocations described by Ganz, we postulated that securing a retained greater trochanter with its gluteal and vastus musculature to the capsular arthroplasty and remnant femoral shaft would preclude the need for post-operative traction by compartmentalizing the proximal femur, thereby reducing the rate of femoral proximal migration (See Figure). Furthermore, because muscle is the nidus of heterotopic ossification, by maintaining origins and insertions of muscles that cross the hip, we anticipated this technique would minimize Brooker 3-4 HO. The purpose of this study is to describe the results of the trochanteric sparing proximal femoral resection from two institutions.

Methods: A retrospective review of patients treated at two institutions identified those who underwent the trochanteric sparing proximal femoral resection for arthritic spastic hip (See Figure). Data collected included presenting complaints, peri-operative course, and radiologic evaluation for migration and heterotopic ossification. Caretakers completed a survey for pain relief, sitting tolerance, and perineal hygiene. Data was compared to prior published surgical techniques.

Results: Twenty-hips in 15-patients were treated without post-operative traction. All patients experienced significantly improved pain, function and caretaking survey scores. Thirteen of 15-patients experienced complete pain relief, and all had improved sitting tolerance and perineal care. One patient underwent revision for migration from failed soft tissue envelope.

Conclusion: The trochanteric sparing proximal femoral resection predictably provides notable relief and improved ease of care and function in activities of daily living of what has typically been incapacitating neuromuscular instigated hip pain. These improvements notably increased caretaker satisfaction as compared to other surgical options.



Significance: These results represent a significant improvement from prior salvage operations, without increase in clinically significant blood loss, length of stay, proximal femoral migration, or HO. The structured compartmentalization of the remnant femoral shaft resolves the need for traction without leading to increased migration. Maintaining gluteal and vastus attachments in anatomic locations attached to the trochanteric fragment and periosteal sleeve reduces muscle necrosis, an instigator of HO.

San Diego Pelvic Osteotomy in Patients with Closed Triradiate Cartilage

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LOE–Therapeutic–Level III

Purpose: A San Diego-type incomplete, reshaping, trans-iliac osteotomy, classically described in patients with open triradiate cartilage, is frequently used as part of the surgical treatment of neuromuscular patients with hip displacement. The aim of this study was to assess the effectiveness of this osteotomy in patients with closed triradiate cartilage compared to patients with open triradiate cartilage.

Methods: Retrospective review of 43 patients (44 hips) with neuromuscular hip disease who underwent a San Diego pelvic osteotomy ± concomitant surgical procedures to correct hip displacement. 24 hips had open triradiate cartilage at the time of surgery and 20 hips had closed triradiate cartilage. Mean follow-up was 23 months. Center edge angle (CEA), acetabular angle (AA), and Reimer's index (RI) were recorded from preoperative, immediate postoperative, and the latest follow-up radiographs. Statistical analysis was performed using the paired t-test within the individual groups and the unpaired t-test between the open and closed groups.

Results: CEA improved by 39° (range 7-69) in the open group and 30° (range 9-80) in the closed group from preoperative radiographs to immediate postoperative, with no significant difference in improvement between groups (p=0.084). There was also no significant difference between improvement in AA between the open (improved by 11° (range 3-23)) and closed (improved by 10° (range 4-21)) groups (p=0.65). RI improved from 61% to 11% in the open group and 51% to 12% in the closed group. There was no statistically significant difference between groups for RI at preoperative, immediate postoperative, and final follow-up radiographs. At latest follow-up, CEA, AA, and RI all remained relatively stable in both groups.

Conclusion: San Diego pelvic osteotomy, classically described for patients with open triradiate cartilage, is equally effective in improving radiographic parameters in neuromuscular patients with open and closed triradiate cartilage.

Significance: This study challenges the notion that closed triradiate cartilage is a contraindication to performing a San Diego-type reshaping osteotomy. This knowledge provides another option for the treatment of neuromuscular hip disease in patients with closed triradiate besides the more technically challenging periacetabular osteotomy or a salvage type procedure.

Long-term Outcome of Hip Instability Following Non-surgical and Surgical Interventions in Children with Cerebral Palsy

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LOE–Therapeutic–Level III

Purpose: This study compares the 20-years-long-term outcome of hip instability following single-event multi-level surgery with a botulinum toxine treatment program.

Methods: A retrospective study of two groups was undertaken. The first group included 68 adults with bilateral spastic cerebral palsy GMFCS III-V who had infant hip instability of MI 32% treated by multi-level soft tissue surgery at a mean age of three years and two months (2.0 to 5.8) in the years of 1993-1998. The second group included 72 adults with bilateral spastic cerebral palsy GMFCS III-V who had infant hip instability of MI 28% treated by a botulinum toxine (BoNT) program starting at a mean age of two years and ten months (2.2 to 3.8) in the years of 1998-2003. Both groups underwent examination in early adulthood, the first/surgery group at a mean age of 21.3 years, the second/BoNT group at a mean age of 16.8 years. ROM, hip CE angle, acetabular index, pain by visual analog scale, isometric muscle strength and gross motor function were assessed. Additional surgical interventions were notified.

Results: The first/surgery group had significantly better ROM, and hip CE angle, and acetabular index, a tendency to less pain, improved muscle strength, and gross motor function. They underwent additional soft tissue surgery in 7% and additional hip reconstructive surgery by osteotomies in 18%. 6% of hips were dislocated at follow-up. The second/BoNT group had significantly reduced ROM, and hip CE angle, and acetabular index, a tendency to more pain, reduced muscle strength, and gross motor function. They underwent additional soft tissue surgery in 36% and additional hip reconstructive surgery by osteotomies in 28%. 17% of hips were dislocated at follow-up. There was one re-dislocation, and no complications intraoperatively or during rehabilitation in either group. There were two cases of osteonecrosis of femur and acetabulum in each group.

Conclusion: We consider that physiologic hip function in young adults may be achieved effectively and safely more often by early surgical soft tissue interventions with significant advantages over a BoNT program in children and young adults with bilateral cerebral palsy and infant hip instability MI >28%.

Significance: high significance of measured parameters

Is Percutaneous Myofascial Lengthening of Medial Hamstrings as Effective and Safe as the Open Procedure?

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LOE–Therapeutic–Level III

Purpose: Medial hamstring fractional lengthening is commonly performed in children with cerebral palsy (CP). Percutaneous procedures are gaining more and more popularity even in the pediatric population, with equivocal results. The aim was to determine the efficacy and safety of percutaneous medial hamstring myofascial lengthening (PHL).

Methods: This is a cross-over randomized controlled trial including 31 consecutive knees from 18 patients with cerebral palsy (CP) scheduled for medial hamstring tenotomy in the setting of multilevel tendon lengthening procedures. A first pediatric orthopedic surgeon executes the PHL at one level. Another surgeon opens and extends the wound to explore what had been cut during the PHL, and completes fractional lengthening (OHL) of both semi-membranosus and semi-tendinosus when possible. Popliteal angle (PA) was assessed by a third surgeon immediately before PHL, after PHL, and then after OHL, using a goniometer. All 3 surgeons were blinded to the others' findings. Primary endpoints included easiness to perform PHL, the percentage of tendon-fascia/muscle portion sectioned percutaneously, and improvement of PA. Comparison between PA after PHL and OHL was done using a paired t-test.

Results: The first surgeon was at ease in palpating and identifying through the skin both medial hamstrings before PHL in 10 cases. PHL led to undesirable cut of the semi-membranosus muscle fibers to more than 50% of the muscle section area in 30 cases (<50% in 23 cases and <75% in 7 cases), and of the semi-tendinosus muscle fibers to >50% in all cases (complete rupture in 6 cases, >75% in 8 cases, and ≈50% in 17 cases). Mean PA measured 52° preoperatively and decreased to 40° after PHL. After OHL, PA averaged 22°. There was a significant difference between the PA after PHL (40.4±11.8°), and the PA angle after OHL (22.5±8.7°), $p<0.001$. The gain in PA did not correlate with the extent of semi-membranosus muscle divided ($p=0.38$) nor with the extent of semi-tendinosus muscle divided ($p=0.35$).

Conclusion: This is the first prospective study concerning the anatomic effects of PHL. Although it is a quick procedure, it is often associated with difficulty by the surgeon to identify and evaluate what should be cut percutaneously, leading to abusive injury of the muscle itself rather than the fascia alone. The lesser gain in PA following PHL compared to OHL may be due to the multiple fascial cuts (fractional lengthening) usually performed in OHL.

Significance: PHL leads to undesirable muscle injuries without improvement in PA postoperatively.

Minimal Invasive Multi-level Surgery Allows Early Mobilisation by Locomotion Therapy in Children and Young Adults with Cerebral Palsy

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LOE–Therapeutic–Level III

Purpose: This study compares the outcomes of locomotion therapy following minimally invasive single-event multi-level surgery with conventional mobilisation following conventional single-event multi-level surgery. Our aim was to evaluate the functional outcome of intervention techniques using the combination of recent surgical, orthetic, and therapeutic achievements.

Methods: A retrospective study of two groups was undertaken. 32 children and young adults with bilateral spastic cerebral palsy GMFCS II-IV with a mean age of twelve years and three months (5.4 to 21.2) had multi-level minimally invasive surgery following early verticalisation, full weight bearing, and locomotion therapy from day 3 (1 to 5) postoperatively. They were provided by bilateral ankle foot orthoses at the same day and underwent a full rehabilitation program by 3,5 (2 to 5) weeks postoperatively. The minimally invasive techniques included percutaneous lengthening of muscles and osteotomies fixed by locked plates. This group was compared with 30 children and young adults with a mean age of twelve years and six months (6.9 to 20.8) who had conventional single-event multi-level surgery, conventional osteotomies, following short leg casts and a conventional step by step rehabilitation program including standing and walking exercises by 6,8 (4 to 11) weeks postoperatively. Goal attainment scale, isometric muscle strength and gross motor function were assessed before and 12 months after interventions. Postoperative pain has been measured by visual analog scale.

Results: The early mobilisation group had significantly less pain, significantly improved muscle strength as well as gross motor function, and significantly improved GAS outcome. Minimally invasive surgery provided reduced operation time and blood loss with a significantly improved time to mobilisation. There were no complications intraoperatively or during rehabilitation in either group.

Conclusion: We consider that early mobilisation by functional orthoses and locomotion therapy following minimally invasive single-event multi-level surgery can be achieved effectively and safely with significant advantages over conventional surgical and rehabilitation techniques in children and young adults with bilateral cerebral palsy.

Significance: high significance of measured Parameters.

Longitudinal Follow-up of Children with Cerebral Palsy after Single-Event Multilevel Surgery

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LOE–Therapeutic–Level IV

Purpose: Single event multilevel surgery (SEMLS) is an accepted orthopedic procedure to treat musculoskeletal deformities in children with cerebral palsy (CP). However, there is limited evidence of the long-term outcome following SEMLS and there are contradictory results regarding the predictors of good outcome. This retrospective study was undertaken to investigate the short- and long-term outcome of SEMLS in ambulatory patients with CP using kinematic variables from 3D gait analysis and to assess the predictors of good long-term outcome.

Methods: Thirty-one ambulant children with spastic CP (GMFCS I:14, II:12, III:5, 3 unilateral, 28 bilateral involvement) who had undergone a SEMLS at an average age of 12±3 years (range 7–18 years) were included. SEMLS was defined as at least one surgical procedure performed at two different anatomical levels (hip, knee or ankle) constituting both soft tissue and bony surgery or bony surgery only. Kinematics were collected and analyzed using a 16 camera motion analysis system (VICON, UK). Preoperative kinematics, gait profile score (GPS), GPS in the sagittal plane (GPSsag) and GPS in the transversal plane (GPStrans) were compared with values obtained on average, at 1.2, 5 and 8 years follow-up (FU) visits. Pre-operative parameters were explored for their predictive ability of good short- and long-term outcome at different FU periods using univariate correlations and of long-term outcome using a generalized estimating equation.

Results: All gait measures and several kinematics improved significantly at 2y FU and improvements were maintained until 8y FU (Table 1). No change was seen in pelvic tilt and hip extension only improved on the short-term. Age at time of surgery and GMFCS were predictive of positive short-term outcome for GPStrans. Positive long-term outcome on GPS was associated with a low pre-operative GPS and a more extended knee angle at initial contact.

Conclusion: The findings of improvements of gait 2 to 3 times the minimal clinically important difference for GPS that are maintained long-term compare well with data from previous studies. Similarly, we confirmed that less severe pre-operative gait deviations are indicators of good long-term outcome. However, unlike previous findings, age at the time of surgery was not associated with long-term positive outcome.

Significance: The improvement of gait after SEMLS in children with CP was well maintained after 8years FU. Children who are younger at the time of operation eventually attained the same benefits as those who are operated on when older.

Table 1. Mean ± SD of selected gait measures and kinematics from the pelvis, hip, knee and ankle from a group of age-matched typically developing children and pre-operative (pre-op), 2, 5 and 8 years follow-up (FU) from CP children. *p<0.05

		Timing				**Statistics**			
	Reference values from typically developing	Pre-op (n=31)	2yr FU	5yr FU	8yr FU	Wald □□	p-value	Effect size	
Gait Measures									
GPS (°)		16±4	11±3	10±2	11±3	64.8	<0.01	1.51	0-2* 0-5* 0-8*
GPSsag (°)		17±7	12±5	11±3	13±5	49.0	<0.01	0.82	0-2* 0-5* 0-8*
GPStrans (°)		16±7	11±4	12±4	11±4	13.9	<0.01	0.77	0-2* 0-5* 0-8*
Kinematics									
Mean pelvic tilt (°)	11±5	19±7	19±7	19±4	20±6	0.95	0.9	0.05	
Min hip extension in stance (°)	-10±6	11±12	6±8	8±8	8±10	6.4	0.09	0.34	0-2*
Mean hip rotation in stance (°)	2±7	15±14	2±10	3±13	-1±14	36.1	<0.01	1.04	0-2* 0-5* 0-8*
Max knee extension in stance (°)	2±6	24±20	8±12	8±10	7±13	26.1	<0.01	0.94	0-2* 0-5* 0-8*

The Role of Hip Power in the Treatment of "Stiff Knee"

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LOE–Diagnostic–Level IV

Purpose: Rectus femoris transfer (RFT) is performed in children with cerebral palsy to treat stiff knee gait. However, there is no gold standard to identify appropriate candidates for the procedure. Consequently, the results are variable suggesting the need to consider additional factors. Hip and ankle plantar flexion along with their kinetics are two factors determining peak knee flexion during gait. The purpose of this study was to determine whether kinetic pre-operative evaluation of hip power can be a predictor of the outcome of RFT.

Methods: Sixteen children with spastic cerebral palsy, GMFCS I /II (20 limbs total) and underwent RFT (16 unilateral and 4 bilateral surgeries) for stiff knee gait who had pre- and post-operative 3D gait analysis were evaluated in a retrospective review. The mean age at surgery was 12.6yo. All transfers were made to the iliotibial band. Patients were classified as good and poor based on the RFT outcome. A good outcome was a normal total knee range of motion ±2D (>47.1°) during gait or an increase of the peak knee flexion in swing (PKFsw) of more than 1SD (6.4°). Patients were further divided into 2 groups: Group I included patients whose pre-op evaluation was based on peak hip power (PHP) with a cut-off magnitude ≥0.60w/kg; Group II included patients whose pre-op evaluation was based on PHP and the time that PHP occurred during the gait cycle (tPHP) with a cut-off time of ≤ 68% of the gait cycle (GC).

Results: 12 limbs had a good result and 8 limbs a poor result. In Group I 13 limbs had PHP≥0.6 and 84.6% of them had good outcome. Seven limbs had PHP<0.6 and 85.7% had poor results. In Group II 11 limbs had PHP≥0.60 plus tPHP≤ 68%GC and 100% of them had good results. Nine limbs had PHP<0.6 or tPHP more than 68%GC and 88.2% of them had poor results. The PHP plus tPHP had a higher sensitivity and specificity as a predictor outcome than PHP alone.

Conclusion: The Peak Hip Power is an important parameter to be considered during the decision making process for RFT to treat stiff knee gait in children with cerebral palsy. Considering PHP and tPHP together appears to be an even stronger predictor.

Significance: Preoperative kinetic evaluation of the hip power characteristics from 3D gait analysis may, therefore, be very important in predicting the outcome of RFT surgery.

Factors Influencing Outcomes After Medial Hamstring Lengthening with Semitendinosus Transfer in Patients with Cerebral Palsy

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LOE–Therapeutic–Level III

Purpose: This study was performed to evaluate the outcomes after distal hamstring lengthening (DHL) and analyze the factors that influence the improvement and serial change in knee motion after surgery in patients with cerebral palsy (CP).

Methods: The study included 403 ambulatory patients (686 limbs) with CP who were followed up after undergoing DHL as part of a single-event multilevel surgery and who underwent preoperative and postoperative 3-dimensional (3D) gait analyses. Relevant kinematic values, including knee flexion at initial contact, minimum knee flexion in the stance phase, knee range of motion (ROM), and gait deviation index (GDI) score, were the outcome measures. Changes in knee motion and the GDI score were adjusted for multiple factors, such as sex, the Gross Motor Function Classification System (GMFCS) level, the anatomic type of CP, and concomitant surgeries as fixed effects, and follow-up duration, laterality, and each subject as random effects, using a linear mixed mode.

Results: We found significant improvements in knee flexion at initial contact, minimum knee flexion in the stance phase, knee ROM, and GDI score ($p<0.001$); however, there was no change in mean pelvic tilt ($p=0.695$). Patients with GMFCS level III or bilateral involvement did not have favorable results in terms of knee sagittal kinematics.

Conclusion: DHL as a part of a SEMLS was effective procedure in treating flexed knee gait with regard to sagittal knee kinematics and GDI score. During follow-up, patients with GMFCS level I/II or unilateral involvement showed better prognosis than those with GMFCS level III or bilateral involvement.

Significance: Although several studies have investigated the outcomes after DHL, no study has undertaken an approach that included all or most of the important factors that could influence the results.
Based on our results, physicians can predict the improvement in knee function after DHL and inform patients and parents of the possible improvement after DHL for CP with flexed knee gait.

Table. Estimation and fixed effects of the parameter of 3-dimensional gait analysis after distal hamstring lengthening using a linear mixed model

	Mean pelvic tilt (°)			KF at initial contact (°)			Minimum KF in stance (°)			Knee range of motion (°)			GDI		
	Estimation (95% CI)	SE	*p*-value	Estimation (95% CI)	SE	*p*-value	Estimation (95% CI)	SE	*p*-value	Estimation (95% CI)	SE	*p*-value	Estimation (95% CI)	SE	*p*-value
Follow up (year)	0.0 (-0.1, 0.2)	0.1	0.695	**-0.8 (-1.1, -0.5)**	**0.2**	**<0.001**	**-0.8 (-1.1, -0.5)**	**0.2**	**<0.001**	**1.3 (0.9, 1.6)**	**0.2**	**<0.001**	**1.5 (1.2, 9.3)**	**0.2**	**<0.001**
Age at surgery (year)	-0.1 (-0.2, 0.1)	0.1	0.485	**-0.3 (-0.5, -0.1)**	**0.1**	**0.007**	**0.6 (0.4, 0.8)**	**0.1**	**<0.001**	**-1.0 (-1.3, -0.7)**	**0.1**	**<0.001**	0.0 (-0.2, 0.2)	0.1	0.873
Sex	**1.9 (0.9, 2.9)**	**0.5**	**<0.001**	-0.1 (-1.6, 1.4)	0.8	0.865	-1.7 (-3.4, 0.1)	0.9	0.064	**1.9 (0.1, 3.8)**	**0.9**	**0.038**	-1.1 (-2.6, 0.3)	0.8	0.132
Anatomical type of CP	1.3 (-0.1, 2.6)	0.7	0.062	**5.5 (3.4, 7.6)**	**1.1**	**<0.001**	**2.4 (0.0, 4.8)**	**1.2**	**0.049**	0.1 (-2.5, 2.6)	1.3	0.968	-1.8 (-4.6, 1.0)	1.4	0.200
GMFCS level I-II	0.5 (-0.6, 1.6)	0.6	0.382	**2.7 (1.1, 4.3)**	**0.8**	**0.002**	0.9 (-1.0, 2.8)	1.0	0.393	-0.1 (-2.0, 2.0)	1.0	0.960	**-4.0 (-5.5, -2.4)**	**0.8**	**<0.001**
GMFCS level I-III	1.0 (-0.8, 2.9)	0.9	0.268	**6.1 (3.4, 8.9)**	**1.4**	**<0.001**	**4.6 (1.4, 7.8)**	**1.6**	**0.004**	**-5.1 (-8.4, -1.8)**	**1.7**	**0.002**	**-9.7 (-12.1, -7.2)**	**1.3**	**<0.001**
IMPL	**2.1 (0.6, 3.6)**	**0.8**	**0.006**	-1.0 (-3.4, 1.5)	1.3	0.442	-0.1 (-2.8, 2.7)	1.4	0.966	**-3.8 (-6.7, -0.8)**	**1.5**	**0.012**	**-4.8 (-7.2, -2.3)**	**1.2**	**<0.001**
FDO	0.4 (-0.3, 1.1)	0.4	0.272	**1.6 (0.3, 3.0)**	**0.7**	**0.018**	1.0 (-0.4, 2.4)	0.7	0.174	-0.5 (-2.0, 1.1)	0.8	0.568	**-2.8 (-4.2, -1.4)**	**0.7**	**<0.001**
RFT	0.3 (-0.7, 1.2)	0.6	0.581	**2.3 (0.7, 3.9)**	**0.8**	**0.006**	-0.2 (-2.0, 1.6)	0.9	0.796	0.4 (-1.5, 2.4)	1.0	0.665	-1.1 (-3.6, 1.3)	1.3	0.368
TAL	-0.2 (-1.7, 1.3)	0.8	0.788	-0.4 (-2.9, 2.1)	1.3	0.768	-0.8 (-3.6, 2.0)	1.4	0.569	0.6 (-2.5, 3.6)	1.5	0.717	1.2 (-1.3, 3.7)	1.3	0.347
Strayer	-0.0 (-1.6, 1.6)	0.8	0.983	1.3 (-1.4, 3.9)	1.3	0.345	0.6 (-2.3, 3.5)	1.5	0.692	-0.5 (-3.7, 2.6)	1.6	0.743	0.2 (-2.5, 2.9)	1.4	0.878

CI, confidence interval; SE, standard error; KF, knee flexion; IMPL, intramuscular psoas lengthening; FDO, femoral derotation osteotomy; RFT, rectus femoris transfer; TAL, tendo-Achilles lengthening

Rectus Femoris Transfer Surgery Leads to Increased Crouch in Children with Cerebral Palsy at GMFCS Levels III and IV

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LOE–Therapeutic–Level III

Purpose: Previous study has shown that children with cerebral palsy (CP) functioning at Gross Motor Function Classification System (GMFCS) levels III and IV do not benefit from distal rectus femoris transfer (DRFT) due to lack of improvement in stance knee extension. The fate of knees in such subjects who do not undergo DRFT is unknown. The purpose of this study was to compare knee kinematic outcomes in patients with CP and stiff knee gait who underwent single event multi-level surgery (SEMLS) with and without DRFT.

Methods: Pre- and post-operative gait analysis data were retrospectively reviewed for ambulatory patients with CP (GMFCS Levels I to IV) with crouch and stiff knee gait who underwent SEMLS, including hamstring lengthening either with DRFT (N=33) or without DRFT (N=32). The rectus femoris was transferred to the semitendinosus in 30 subjects, the sartorius in 2 subjects and the iliotibial band in 1 subject. Statistical analyses included t-tests and chi-square tests, and multiple regression analysis was performed to adjust for covariates. Data were stratified by GMFCS level groups I/II and III/IV.

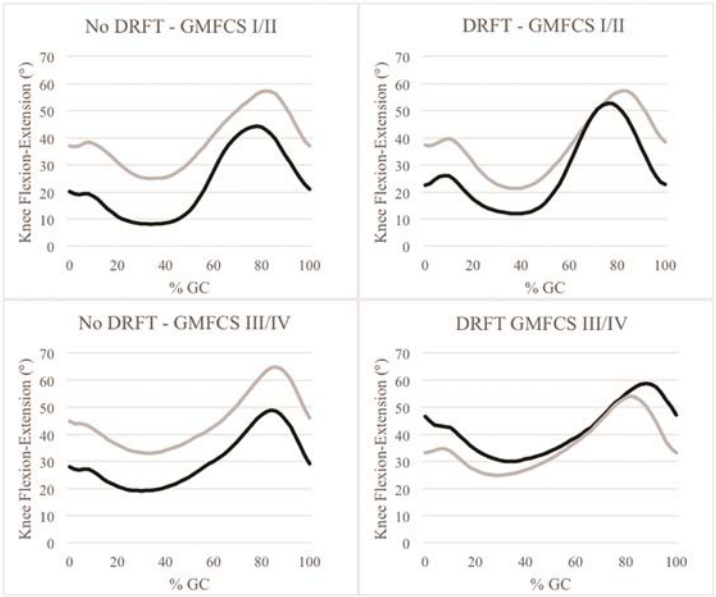
Results: Groups were equivalent for age at surgery, gender and GMFCS distribution. Time from surgery to post-op gait analysis was longer in the DRFT group (35 months) than the no-DRFT group (24 months) ($p=0.03$). This difference was controlled for in the statistical analysis.

Improved maximum knee extension in stance ($p\leq0.03$) was seen for both the DRFT and no DRFT groups at GMFCS levels I/II ($p\leq0.005$), and the no DRFT group at GMFCS levels III/IV ($p=0.02$). Excessive stance knee flexion persisted for those at GMFCS level III/IV after DRFT. Maximum knee flexion in swing was maintained after DRFT but significantly decreased in the no DRFT group ($p<0.0001$) for both GMFCS groups. Change in total knee range of motion (7°, $p=0.02$) and timing of maximum knee flexion in swing (6% of the gait cycle earlier, $p<0.0001$) improved after DRFT in the GMFCS I/II group only. (Figure 1)

Conclusion: In patients with CP functioning at GMFCS levels III and IV, DRFT results in persistent crouch post-operatively. DRFT is not recommended in these patients.

Significance: Given the natural history of progressive crouch in patients with CP and the importance of maintaining upright posture for transfers and function, DRFT should be avoided in patients functioning at GMFCS levels III and IV.

Figure 1. Pre- and post-operative knee flexion/extension graphs (mean for each sub-group) for the DRFT and no DRFT groups, by GMFCS level.



Gray line - pre-operative data; Black line - post-operative data; GC - gait cycle; DRFT - distal rectus femoris transfer; GMFCS - Gross Motor Function Classification System

Increased Hip Intra-capsular Pressure Decreases Perfusion of the Capital Femoral Epiphysis in a Skeletally Immature Porcine Model

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LOE–Not Applicable–Level II

Purpose: Increased intra-capsular hip pressure has been proposed as a potential etiology for osteonecrosis of the proximal femoral epiphysis. This study aims to evaluate if a direct causal relationship exists between intra-articular pressure (IAP) and epiphyseal perfusion pressure (EPP). Additionally, we aim to determine if this relationship is dependent on skeletal maturity.

Methods: After IACUC approval, six Yorkshire hybrid pigs were studied. An arterial line was placed and connected to a patient monitor to record mean arterial pressure (MAP). A curvilinear incision was made proximal to the greater trochanter. Under fluoroscopic guidance, a 3.2 mm guide pin was inserted into the center of the epiphysis. A 6.5 mm cannulated screw was placed over the guide pin and advanced to the proximal femoral physis. A Camino® (Integra LifeSciences, Plainsboro, NJ) pressure transducer was inserted through the screw into the epiphysis to measure EPP. An 18 gauge spinal needle was inserted into the joint capsule, and connected via a two-way stopcock to an arterial line for IAP monitoring, and to a saline pressure bag for joint infiltration. Figures A, B show screw/transducer placement. The joint was infiltrated until well above MAP and slowly aspirated until IAP returned to baseline. Video recording was performed to simultaneously document IAP, EPP and MAP.

Results: There were 3 skeletally young (mean age: 10.6 weeks) and 3 older (mean age: 21.1 weeks) pigs in the study. 19 trials were conducted (10 in the older group, 9 in the younger). In all trials in the older pigs, biphasic epiphyseal perfusion persisted with an average maximum IAP of 173.3 mmHg above MAP (Figure C). In all trials in younger pigs, the biphasic EPP waveform was lost with increases in IAP (Figure D, E). On average, this occurred at an IAP of 28mmHg above MAP. Biphasic waveform returned once IAP fell, on average, 5 mmHg below MAP.

Conclusion: Increased IAP results in tamponade of epiphyseal vasculature in this porcine model. This was noted only in the younger pigs in our study. Presumably, an intact physis precludes intra-osseous metaphyseal vessels from penetrating the epiphysis, leaving it particularly vulnerable to retinacular artery insult.

Significance: This study establishes a relationship between intra-articular pressure and epiphyseal perfusion, with direct implications for clinical practice. It appears that increasing IAP results in tamponade of blood flow to the capital femoral epiphysis, potentially leading to AVN. There is a possible role for hip decompression and early fixation in these patients.

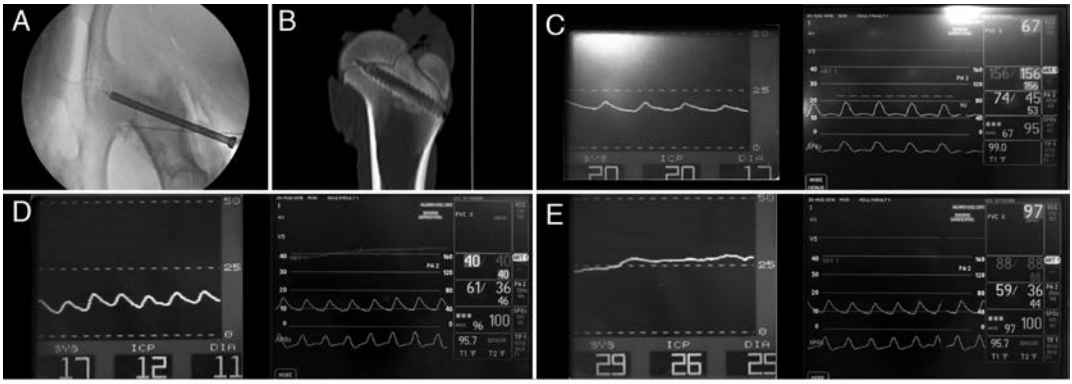

Figure A, B demonstrate images of screw and transducer placement. Epiphyseal pressure is monitored using a pressure transducer placed in the epiphysis through a cannulated screw. Joint infiltration and intra-articular pressure monitoring is performed through an 18 gauge spinal needle inserted into a recess in the inferior capsule. Figure C shows a screenshot demonstrating the persistence of biphasic epiphyseal perfusion (monitor on left) in an older pig, even with an intra-articular pressure of 156 mmHg (top line, right monitor), well above the mean arterial pressure of 53 mmHg (middle line, right monitor). Figures D, E demonstrate similar readings on a skeletally immature pig. Here, the biphasic epiphyseal perfusion pressure with intra-articular pressures below mean arterial pressure disappears with an increase in intra-articular pressure to 44 mmHg above mean arterial pressure.

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3D Printed Highly Functional Implants for Osteochondral Repair and Bone Ingrowth in a Rodent Model

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LOE–Therapeutic–Level III

Purpose: Osteochondritis dissecans (OCD) lesions of the knee are difficult injuries to treat. Despite improvements in the diagnosis of these lesions, optimal treatment remains elusive due to complex interactions between host and lesions specific factors. We investigate the feasibility of using three-dimensional biologically inspired implants, manufactured using novel 3-dimensional printing techniques and synthetic bio-nanomaterial, for treatment of osteochondral defects in a rodent model. We report on the initial bone ingrowth of these implants at the osteochondral junction.

Methods: An osteochondral defect was created in the trochlear groove of the left knee of 16 6-week old female Sprague-Dawley rats. Four implant groups (4 animals per group) included a blank control, a solid hydrogel implant (PEG) and two experimental implants designed to mimic the micro-structure of the osteochondral transition zone: 1) a polycaprolactone and polyethylene glycol blended resin (PCL) and 2) a nanoporous thermoplastic polyurethane (TPU) based material. A lateral parapatellar approach was used and the defect was created with a 2.0mm Kirschner wire, then immediately repaired by press-fitting an implant into the defect. The animals were recovered and permitted to weight bearing ad lib on the experimental limbs. At one month, femurs were harvested and histologic analysis (H-E staining) was performed to assess bony ingrowth of the implant.

Results: Surgery was successful in all animals and all survived to the follow-up time point. Histologic analysis (Figure 1) demonstrated formation of trabecular bone and marrow in the defect and around the implant in the control and PEG groups. The PCL group showed formation of extensive fibrosis and scar tissue around the implant, with minimal bone remodeling. The TPU group showed formation of fully remodeled bone around the implant with some evidence of bone ingrowth into the implant microstructure.

Conclusion: We demonstrate the feasibility of an experimental nanoporous TPU material to be effectively 3D printed into a microstructural implant for the repair of osteochondral defect. This implant appears to facilitate early bony growth without fibrosis, as compared to controls and a PCL experimental design. This material may hold potential to be used as a custom designed implant which could quickly graft to bone in the repair of an OCD lesion.

Significance: These results suggest micro-anatomic mimicking 3-D bio-nanomaterial printed implants may induce bony ingrowth in the osteochondral transition zone in the knee when used to fill osteochondral defects. This bio-anchoring through bony ingrowth is an important first step in the development of synthetic implants to treat OCD lesions.

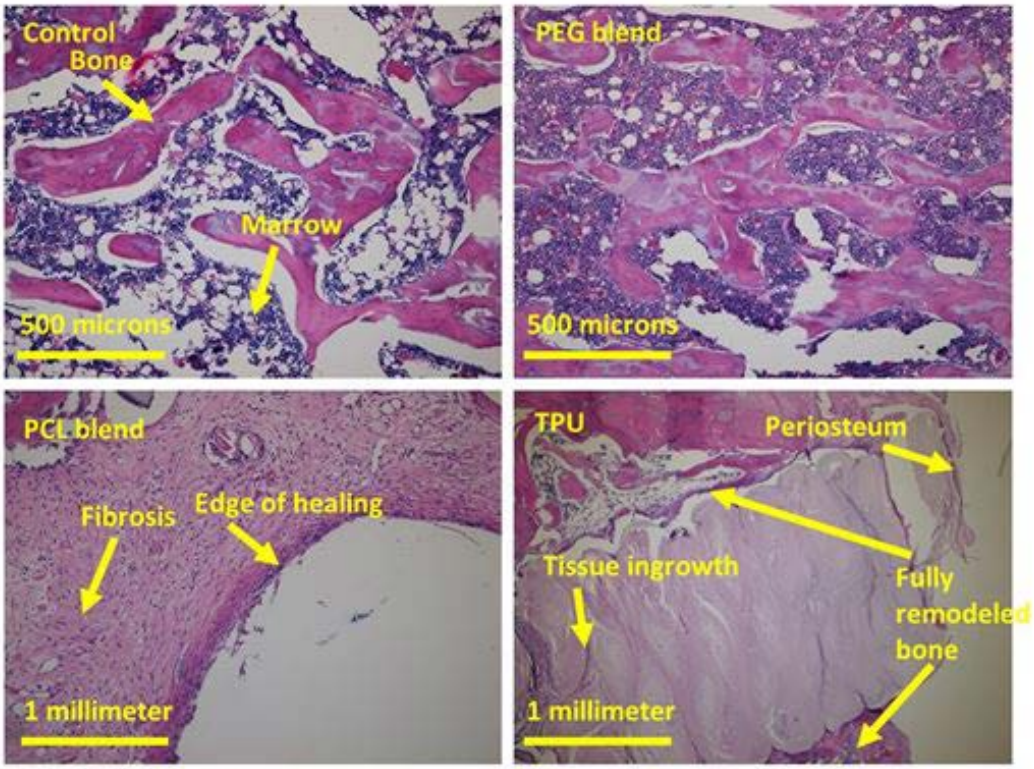

Figure 1: Histology of tissue samples taken from rat osteochondral lesions harvested after 1 month of healing, comparing a control defect (blank defect), a polyethylene glycol (PEG) hydrogel implant, a polycaprolactone (PCL)-hydrogel blended material and a 3D printed and a nanoporous thermoplastic polyurethane (TPU) implant. In the control and PEG samples, trabecular bone remodeling and marrow formation can be observed. In the PCL group, a fibrous scar formed around the defect with some bone remodeling. In the 3D printed implant group, fully remodeled bone and adjacent vasculature could be seen growing around the microstructure, and some tissue can be seen invading the implant. In addition, a periosteum-like membrane formed over the implant articulate surface, creating a contiguous surface with surrounding cartilage. This may be a precursor to cartilage repair.

Combination Antibiotic Therapy Demonstrates a Synergistic Effect in the Treatment of Implant Infection

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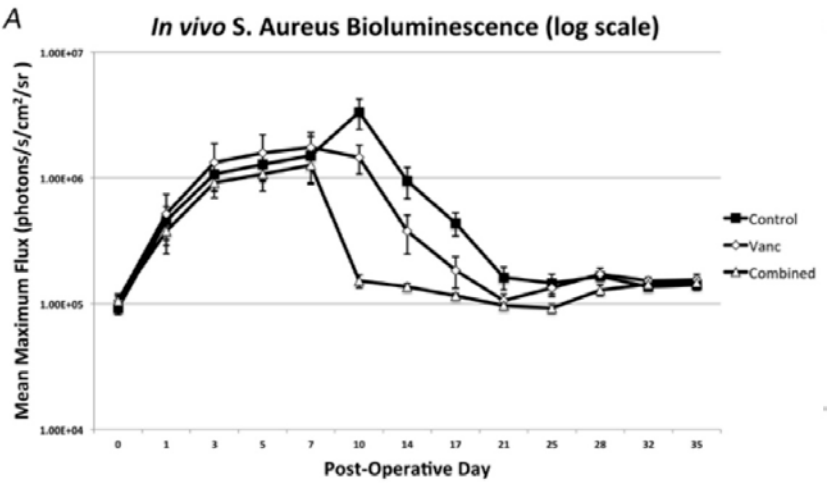
LOE–Therapeutic–Level I

Purpose: Implant infection treatment is difficult, results in significant morbidity to the patient, and incurs high cost to the healthcare system. Biofilm formation further complicates management due to low penetrance of antibiotics and immune cells. Recent *in vitro* studies have shown that vancomycin monotherapy has reduced efficacy against biofilm compared to combination therapy with rifampin. Using an established *in vivo* mouse model of spinal implant infection to monitor infection longitudinally and in real time, we aim to evaluate whether combination therapy with vancomycin plus rifampin has increased efficacy compared with vancomycin alone in reducing bacterial burden.

Methods: A model of posterior-approach spinal surgery was used in which an L-shaped, stainless steel Kirschner-wire was transfixed into the L4 spinous process of 12-week-old C57BL/6 mice. The implant was inoculated with a bioluminescent *Staphylococcus aureus* strain. Mice were randomized into a vancomycin group, a combination group with vancomycin plus rifampin, or a control group receiving sterile saline. All antibiotic and sham injections began on POD 7 to allow for biofilm formation and continued through POD 14. *In vivo* imaging was performed using an optical imaging system to monitor bioluminescence for 35 days. Colony Forming Units (CFUs) were cultured from the implant and surrounding tissues on POD 35 to verify infection.

Results: Bacterial bioluminescence peaked at POD 7-10 for all groups (Figure). The combination group had nearly a 10-fold decrease in bioluminescent signal by POD 10. The vancomycin and control groups did not reach similar levels until POD 17 and 21, respectively. On POD 25 the combination group dropped below baseline, but then rebounded to the same level as vancomycin and control groups for the remainder of the experiment. CFUs collected from the implant at POD 35 confirmed persistent infection.



Conclusion: These data suggest that combination antibiotic therapy causes an initial rapid decline in bacterial burden compared to vancomycin monotherapy in the setting of an implant infection. However, the advantage of this model to longitudinally track the course of implant infection using bioluminescence demonstrates combination antibiotic therapy does not completely clear the infection, which returns after antibiotic therapy cessation.

Significance: This study lends evidence towards the inability of systemic antibiotic therapy to completely eradicate an implant infection and suggests alternative biofilm modifying agents are required.

Celecoxib Leads to Impaired Cartilage and Bone Extracellular Matrix Formation in the Growth Plate of Skeletally Immature Mice

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LOE–Therapeutic–Level II

Purpose: Endochondral ossification in the growth plate is directly responsible for skeletal growth and its *de novo* bone-generating activity. Growth plates are vulnerable for disturbances that may lead to abnormal skeletal development. Non-steroidal anti-inflammatory drugs (NSAIDs) are widely used analgesics, but have been reported to impair endochondral ossification-driven fracture healing. Despite the general awareness that NSAIDs affect endochondral ossification, the consequences of NSAIDs on skeletal development are unknown. We hypothesize that the NSAID celecoxib leads to impaired growth plate development and consequently impairs skeletal development.

Methods: Healthy skeletally immature (5 weeks old) C57BL/6 mice were treated for ten weeks with celecoxib (daily oral administration 10 mg/kg) or placebo (water) (institutional approval 2013-094) (n=12 per group). At 15 weeks postnatally, total growth plate thickness, thickness of specific growth plate zones, (immuno)histological analysis of extracellular matrix composition in the growth plate, cell number and cell size, longitudinal bone growth and bone micro-architecture by micro-CT were analyzed. Inhibition of COX-2 activity was confirmed by determining PGE_2 levels in plasma using an ELISA.

Results: No significant difference in total growth plate thickness or thickness of the resting zone, proliferative or hypertrophic zone was found between groups. Staining of growth plate extracellular matrix components revealed however a significantly higher proteoglycan content and less collagen type II staining in the proliferative zone. In the hypertrophic zone of the growth plates of celecoxib treated mice collagen type X was hardly detectable as compared to placebo mice (Figure 1). In addition, a significantly decreased cell number was observed in the hypertrophic zone of the growth plate and cells were significantly smaller in the celecoxib group. Micro-CT analysis of the subchondral bone region directly under the growth plate showed significantly higher bone density, bone volume density and trabecular thickness following celecoxib treatment. Despite the detected differences in extracellular matrix composition of the growth plate, no difference was found in the length of the tibia in celecoxib treated mice.

Conclusion: In summary, there are no measurable differences found in the murine skeletal formation as a result of treatment with celecoxib. However, there are notable phenotypic features found in maturation of the growth plate (hypertrophic zone and subchondral bone) as a result from the celecoxib treatment, of which the potential consequences we do not yet understand.

Significance: When follow-up effects from the use of celecoxib on the growing individual are found this may warrant re-evaluation for the use of celecoxib in these individuals.

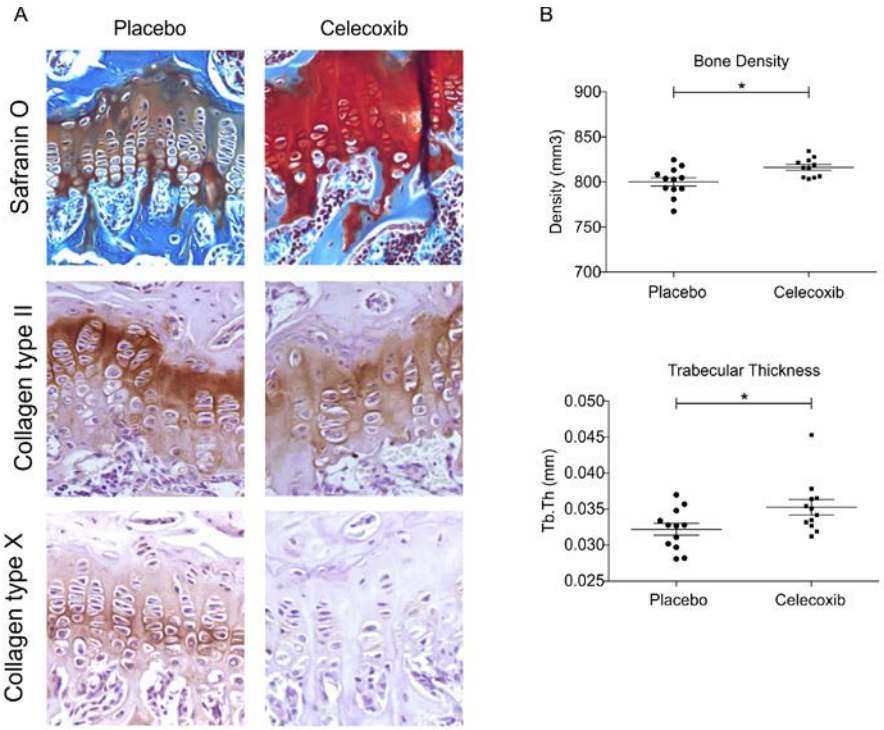

Figure 1: Celecoxib leads to impaired cartilage and bone extracellular matrix formation in the growth plate of skeletally immature mice. A. More proteoglycan content (Safranin O staining) and less collagen type II abundance in the proliferative zone of the growth plate of celecoxib treated mice (10 mg/kg/day; n=12) when compared to placebo group (water; n=12). Collagen type X is almost undetectable in celecoxib treated mice. B. Bone density and trabecular thickness are increased in celecoxib treated mice, as measured by micro-CT analysis.

Sexual Dimorphism in Bone Morphology and Density during Adolescent Growth

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LOE–Not Applicable–Level III

Purpose: Studies in adolescents found transient cortical bone fragility with increased forearm fracture incidence during the peripubertal growth period. Previous study in Hong Kong reported boy-to-girl ratio of limb fracture was 5.5:1 in the adolescent group. This study aimed at investigating the changes of cortical morphology, volumetric bone density and microarchitecture with the different pubertal stages and growth in healthy Chinese adolescent boys and girls.

Methods: 218 boys and 221 girls aged between 7 and 17 years old with no bone diseases were recruited. Maturity was assessed by self-reported Tanner staging. Images of non-dominant distal radius was obtained using HR-pQCT. Proximal 40 slices of 110 slices were analysed by StrAx1.0. Cross-sectional area (CSA), cortical porosity and volumetric bone mineral density (vBMD) and trabecular vBMD were measured. Matrix mineral density was also measured. ANCOVA was used to identify sex difference in bone parameters after adjustment for age, height and weight.

Results: After adjusting for all confounders, boys had 10.1-14.7% larger total CSA than girls in all Tanner stages ($p<0.05$ at Tanner stage 1 and 5; the rest $p<0.001$). Cortical and trabecular CSA were also larger in boys but cortical CSA was similar to girls in Tanner stage 2 and 5 after adjustment. In Tanner stage 1, cortical thickness was 7.0% greater in boys ($p<0.01$) but cortical porosity did not differ from girls. From Tanner stage 2, cortical thickness did not differ by sex while boys had 8.4-12.6% higher cortical porosity (all $p<0.001$) and 0.5-1.4% lower matrix mineral density ($p<0.05$ for Tanner stage 2, $p<0.001$ for Tanner stage 3-5) after adjusting for age. In boys, 10.7 – 19.1% lower vBMD of entire bone and 16.7 – 20.4% lower cortical vBMD were found in Tanner stage 2 to 5 compared to girls. There was no sex difference in trabecular vBMD until Tanner stage 3, after that boys had 14.7-23.3% greater trabecular vBMD after adjusting for age (all $p<0.01$).

Conclusion: Total and cortical CSA increase during pubertal growth in both sexes and are larger in boys. Cortical porosity was higher and matrix mineral density was lower in boys, perhaps because their skeletal maturing takes longer to complete.

Significance: Tranisent physiologically changes of the cortical morphology, reduced bone density and higher cortical porosity in Tanner stage 2 boys might partly decrease bone mechanical strength and contribute to the increased risk of distal forearm fracture.

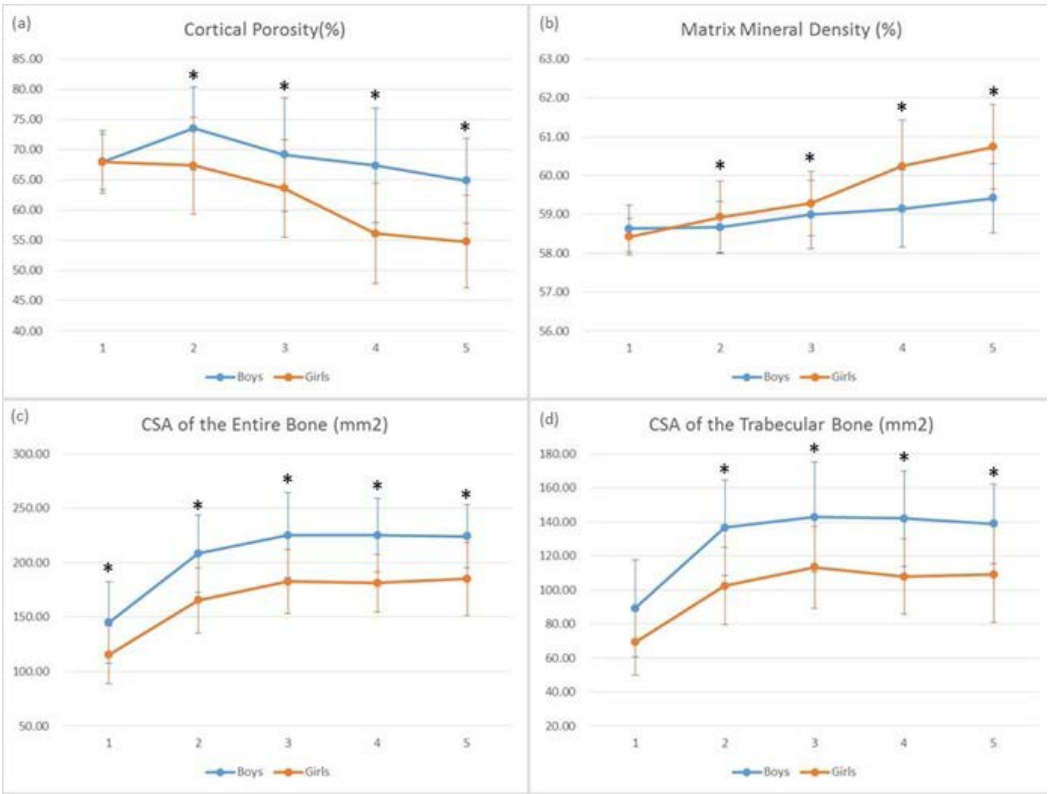

Figure 1: The change of cortical porosity, matrix mineral density, CSA of the entire bone and CSA of the trabecular bone during puberty (Tanner 1-5) in boys (blue) and girls (orange).

Obesity Affects Growth Plate Structure and Gene Expression

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LOE–Not Applicable–Level II

Purpose: Obesity is a public health epidemic withserious musculoskeletal consequences. In children and adolescents,obesity is associated with impaired bone formation and increased fracturerisk. Furthermore, obesity is associated with conditions affectingthe growth plate including adolescent tibia vara, slipped capital femoralepiphysis, and an increased risk of fracture involving the growth plate. We hypothesized that immature rats fed a high fat, high carbohydrate diet wouldddevelop obesity and demonstrate alterations of physeal structure and strength.

Methods: Rats 3-4 weeks old were fed high fat chow (Research Diets 12451) with 10% fructose in drinking water (HF/HC) or control diet (Research Diet 12450B). Femur growth plates were analyzed by microCT to determine growth plate thickness. Biomechanical testing was performed to evaluate the integrity of the proximal tibia physis. Shear tests were conducted using a custom indenter against the epiphysis parallel to the growth plate at a rate of 0.01 mm/s in a posterior to anterior direction. mRNA was harvested from the distal femur physis and RNA-seq analysis was performed.

Results: Mean body weight after 9 weeks of HF/HC diet was 9% higher than controls (527g v 483g) and mean body fat was higher (204g v 165g), although there was greater than expected variation within groups. Metabolic syndrome was present as evidenced by impaired glucose tolerance testing in the HF/HC group. Total volume of the physis was 17% less in the HF/HC rats compared to controls (7.34 vs. 8.80 mm^3, p=.08) and that growth plate volume negatively correlated with percent body fat by DXA (r=-0.81, p=.005). Maximum force and energy to maximum force were decreased, while stiffness was increased in the HF/HC group (see Table 1). These differences did not reach statistical significance. RNA Seq analysis showed upregulation of genes including creatine kinase, alpha actinin and myosin heavy chain. Downregulated genes included MMP-8, defensin, hemogen and krupppel-like factor.

Variable	HF/HC mean (n=9)	Control mean (n=9)	P value
Maximum Force (N)	39.7065	44.4972	0.1243
Energy to Maximum Force (mJ)	25.6175	41.8464	0.3364
Stiffness (N/mm)	39.6207	47.8503	0.3364

Conclusion: HF/HC diet is associated with structural changes in the physis and alterations in genetic programs despite only a modest weight difference. This challenges the paradigm that mechanical loading is the predominant cause of physeal disturbance in obesity and suggests that the early metabolic effects may be important. Changes in genes associated with muscle and inflammatory and hematopoetic system may suggest crosstalk with the physis.

Significance: Further exploration of these findings could lead to new methods of predicting or treating obesity-associated growth plate disorders.

Therapeutic Effect of Metformin in Ischemic Osteonecrosis via Angiopoietin1 Induced Osteoblastic Differentiation

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LOE–Not Applicable–Level II

Purpose: Angiogenesis is closely associated with osteoblast differentiation. Previously, we demonstrated that bone formation can be accelerated by treatment with COMP–Angiopoietin1 (COMP-Ang1), a known angiogenic factor. In this study, we aimed to identify a novel drug that can activate endogenous Ang1 expression as a pharmacological treatment for ischemic osteonecrosis.

Methods: Ang1 expression was examined in U2OS osteoblast-like cells treated with 770 drugs from a library of Food and Drug Administration (FDA)-approved drugs by using ELISA for Ang1. Metformin was selected as a novel drug candidate. Metformin is the first-line medication for the treatment of type 2 diabetes. ELISAs were performed to test whether Ang1 is induced in a dose-dependent manner in human osteoblast-like cell lines, U2OS and MG63. The effects of metformin on osteoblast differentiation and mineralization were evaluated. The expression of proteins related to bone formation and differentiation, such as type I collagen, osteocalcin, bone sialoprotein, distal-less homeobox 5 , Runt-related transcription factor 2, osterix, and ALP, was tested. Rats were divided into the following groups; the sham-operated group, the bovine serum albumin (BSA)-injected group, and the metformin-injected group. At 8 weeks post-surgery animals were sacrificed and radiologic and histomorphometric assessments were performed.

Results: Metformin induced Ang1 expression in a dose-dependent manner in both U2OS and MG63 cells, which was confirmed by ELISA and Western blotting. Also, metformin activated ALP activity in U2OS and MG63 cells as well as ALP expression. Furthermore, metformin enhanced the expression of COL1A1, Runx2, OC, BSP, Dlx5, and OSX mRNA and proteins. Radiographs showed better preservation of femoral head architecture in the metformin group than in the BSA group. Histological findings and immunostainings revealed that metformin group animals showed well preserved femoral head morphology and higher levels of vascularity in the secondary ossification center of infarcted femoral heads.

Conclusion: We demonstrated that metformin increased Ang1 expression and induces bone formation, differentiation, and mineralization in U2OS and MG63 cell lines, which suggests that metformin could be a potential bone production agent. The results of this study demonstrate that metformin increases vascularity and new bone formation in ischemic femoral heads, and suggest that metformin could be used to treat ischemic osteonecrosis.

Significance: These studies will provide novel insight into the specific biomarkers that are targeted and regulated by metformin in osteoblast differentiation and contribute to expand translational research for the treatment of ischemic osteonecrosis.

Heparan Sulfate for OCD Regeneration: An Animal Study

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LOE–Economic and Decision Analyses–Level V

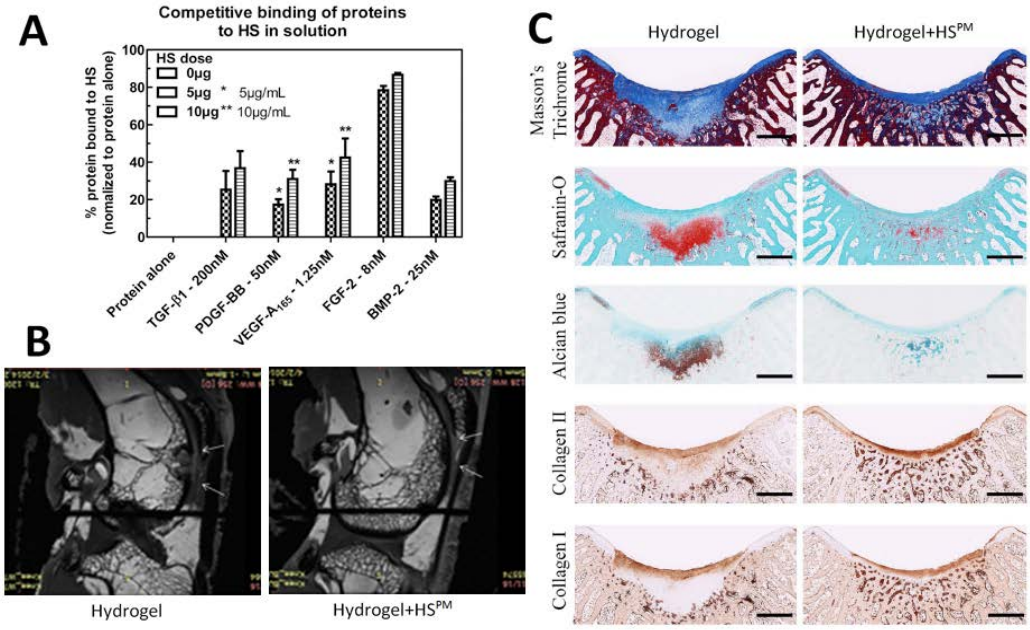
Purpose: End-stage Osteochondritis Dissecans (OCD) presents clinically with large osteochondral defects for which current treatment options offer little improvement. Here we describe the use of an extracellular matrix scaffolding glycosaminoglycan, heparan sulfate (HS), that binds and activates reparative growth factors produced at injury sites, as a device to enhance osteochondral repair andcombat the rising incidence of OCD.

Methods: Surface plasmon resonance (SPR) was used to determine the affinity of HS for growth factors important for osteochondral repair. Osteochondral defects (4 mm wide x 1.5 mm deep) were created in the femoral trochlear groove of skeletally mature New Zealand White rabbits(IACUC #130833) that were divided into Group 1 (Microfracture + Hydrogel (60 µl AuxiGelTM, n=9)) andGroup 2 (Microfracture + Hydrogel + HS (10 µg, n=10)).After 12-weeks, healing was determined by MRI and ISCR I and II scoring and histological assessment of the quality of tissue filling.

Results: SPR revealed that HS binds the pro-reparative growth factors TGF-β1, FGF2, BMP2, PDGF-BB and VEGF-A(Fig-1A). Assessment by MRI showed that surface repair using HS resulted in ~2-fold increase in Marlovits scores compared to gel alone (Fig-1B). Also signal intensity increased by ~2.5-fold over when HS was applied. An assessment of subchondral bone repair showed ~1.5-fold improvement with HS treatment compared to gel alonewith macroscopic ICRS I scores similar between the groups. However 70% of defects treated with HS had ICRS I scores above 10 compared with only 44% when treated with gel alone. Microscopically (Fig-1C), the level of subchondral bone filling was ~1.6-fold greater when treated with HS compare to gel alone. When chondralfilling was assessed both HS and gel alone groups performed similarly, yet treatment with HS results in ~15% of the chondral zone containing hyaline cartilage compared with 0% in the gel alone group. Next, ICRS II scores were compared with HS treatment showing higher values compared to gel alone (Group 1, 78.20±7.91 and Group 2, 86.68±11.10). Moreover, ~66% of defects treated with HS had ICRS II scores above 85 compared to ~34% for the gel alone group.

Conclusion: Our data shows improved healing of osteochondral defects at both macroscopic and microscopic levels follow HS administration.

Significance: We highlight the immense potential that HS-based therapies offers orthopaedic practice.


A
Competitive binding of proteins to HS in solution
% protein bound to HS (nomalized to protein alone)
HS dose
0µg
5µg * 5µg/mL
10µg ** 10µg/mL
Protein alone
TGF-β1 - 200nM
PDGF-BB - 50nM
VEGF-A165 - 1.25nM
FGF-2 - 8nM
BMP-2 - 25nM
B
Hydrogel
Hydrogel+HSPM
C
Hydrogel
Hydrogel+HSPM
Masson's Trichrome
Safranin-O
Alcian blue
Collagen II
Collagen I

Enhancing Human Mesenchymal Stem Cells for Improved Regeneration of OCD Defects

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National University of Singapore, Singapore

LOE–Not Applicable–Level V

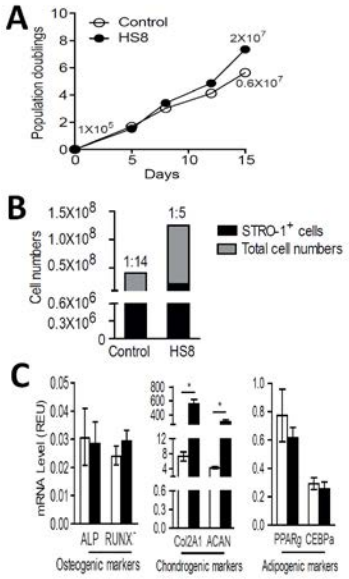
Purpose: To date, non-surgical treatment of pediatric patients with Grade 4 Osteochondritis Dissecans (OCD) offers little hope of success. We have developed anapproach that generates best-in-class bone marrow-derived mesenchymal stem cells (MSCs) for large osteochondral defects. Such high-quality MSCs are obtained after their ex vivo expansion in a glycosaminoglycan-rich microenvironment tuned to more closely mimic that of the bone marrow.

Methods: Human MSCs from the bone marrow of 3 healthy young adult male donors (NHG DSRB #2013/00737)were culture-expanded in standard media (control group) ± the bone marrow-engineered glycosaminoglycan variant HS8 (treatment group) over four consecutive passages. To assess their in vivo efficacy, large osteochondral defects (1.5 mm wide x 1.5 mm deep) created in the femoral trochlea groove of NIH nude rats (NUS IACUC #141/12) were treated by press-fitting one of four great ps (n=6) into the defect. Group 1: No treatment, Group 2: Fibrin gel, Group 3: Fibrin gel + control-expanded MSCs (0.5 x106), and Group 4: Fibrin gel + HS8-expanded MSCs (0.5 x106). After 12 weeks, the extent of healing was determined (ISCR I and O'Driscollscores) and related to macroscopic imaging and histology.

Results: The data shows that mimicking the bone marrow microenvironment by culture supplementation with HS8 enhances the growth of MSCs while maintaining their naïve stem cell state. In contrast, MSCs cultured in standard conditions (control), had shorter telomere lengths and reduced stem cell potential. HS8-supplemented MSCs grew at approximately three-foldthe rate of cells in control conditions (Fig-1A) and were enriched two-fold in their expression of the key MSC quality biomarker, STRO-1 (Fig-1B). Expanded MSCs readily differentiated into adipocytes (PPARg, CEB-Pα), osteoblasts (ALP, RUNX2) and chondrocytes (Col2 and ACAN) (Fig-1C). In theosteochondral defect model, treatment with HS8-expanded MSCs resulted in ICRS I scores of 8.94±1.71 (Fig-1D) and an O'Driscoll score of 86.42±6.39, a result comparable with control MSCs(Fig-1E). However, animals treated with HS8-expanded MSCs were 63% more likely to give O'Driscoll scores above 12. For defects left untreated or treated with fibrin alone, no animals had O'Driscoll scores above 12. This highlights the positive effects of treating osteochondral defects with high-quality MSCs, such as those produced by culture-expansion with the bone marrow-mimicking glycosaminoglycan, HS8.

Conclusion: HS8 treatment enhanced the quantity and quality of expanded MSCs, which led to superior osteochondral healing.

Significance: The use of best-in-class, glycosaminoglycan-treated MSCs represents a novel strategy for the treatment of OCD.


A
Control
HS8
Population doublings
Days
1X10^5
2X10^7
0.6X10^7
B
Cell numbers
1.5X10^8
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0.3X10^6
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1:14
1:5
STRO-1+ cells
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Control
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Col2A1
ACAN
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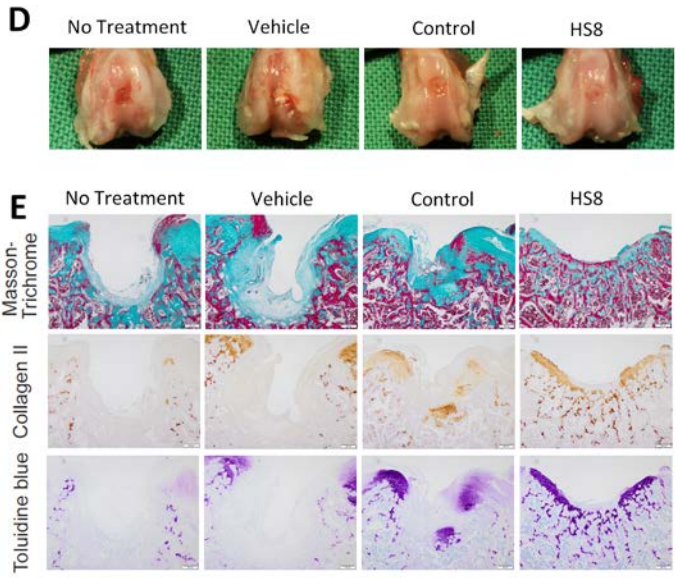
PPARg
CEBPa
Adipogenic markers


D
No Treatment
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HS8
Masson-Trichrome
Collagen II
Toluidine blue

Investigation of Regulation and Function of ST2 in Controlling Chondrocyte Differentiation

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Medical University Graz, Graz, Austria

LOE–Not Applicable–Level II

Purpose: Growth plate is a cartilaginous organ located at the end of long bones in children. In the growth plate endochondral ossification occurs which leads to the longitudinal bone growth. Whereas the cellular and molecular mechanisms of bone growth are not fully understood, fracture in this region also remains challenging which might results in bone growth defects. The IL-33/ST2 signaling is one of the key regulators of osteoclastogenesis thus affecting new bone formation. In this study, we aimed to identify the components and elucidate the role of IL-33/ST2 signaling pathway in the growth plate chondrocyte postnatally which have not been investigated so far.

Methods: Quantitative real time PCR (qPCR), Immunohistochemistry, Immunoblotting, Gene knockdown (siRNA), Gene Overexpression (cDNA transfection), Electrophoretic Mobility Shift Assay (EMSA), Chromatin Immunoprecipitation Assay (ChIP), and Luciferase assay.

Results: Immunohistochemical analysis of tibia and femur from a three-week old mouse indicated increased to strong ST2 expression in pre-hypertrophic and hypertrophic chondrocytes in growth plates. Similarly, qPCR showed robust expression of both ST2L and sST2 isoforms during hypertrophic stage of murine ATDC5 chondrogenic cell line. IL-33, the natural ligand for ST2L surface receptor was also progressively increased during ATDC5 differentiation. The ST2 upregulation was concomitant with the expression of hypertrophic markers Runx2, MMP-13 and Collagen 10 suggesting ST2 might play a role during hypertrophic chondrocyte differentiation. The qPCR and immunoblotting confirmed induction of ST2 isoforms by master transcription factor Runx2 in ATDC5 and primary human growth plate chondrocytes revealing ST2 a novel target of Runx2. As confirmed by EMSA, ChIP and luciferase assays, the ST2 induction was demonstrated to be through Runx2-ST2 promoter interactions. To investigate the possible effect of ST2 expression on the chondrocyte differentiation, ST2 knockdown in ATDC5 cells changes the mRNA expression value of maturation and hypertrophic markers collgen 2, collagen 10 and osteocalcin indicating that ST2 is seemingly involved in the regulation of early and late stages of chondrocyte differentiation.

Conclusion: Our results for the 1st time reveal the expression, regulation and the potential function of ST2 in the chondrocytes proposing ST2 as a new regulator of chondrocyte differentiation.

Significance: The functional characteristics of ST2 in regulating chondrocyte differentiation will give rise to a new insight into the process of bone growth in children with possible knowledge enhancement on identification of molecules and signaling pathways involved in the repair mechanism.

Fiber Optic Detection of Spinal Ischemia During Vertebral Column Distraction

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LOE–Not Applicable–Level I

Purpose: Spinal cord injury can follow spine trauma and spine surgery. Spinal cord ischemia has been proposed as the underlying pathophysiologic process. The ability to continuously monitor for spinal cord ischemia during surgery would make surgery safer by alerting the surgeon to the earliest stage of injury. Currently available electrophysiological approaches are associated with a significant delay between the onset of spinal cord ischemia and the occurrence of electrophysiological changes. A recently developed fiber optic technology employing diffuse correlation spectroscopy (DCS) permits the rapid detection and continuous monitoring of changes in spinal cord blood flow. The purpose of this study was to examine the amount of distraction associated with spinal cord ischemia and compare the temporal sensitivity of the fiber optic probe with electrophysiology.

Methods: Surgery was performed on Dorset sheep (n = 8). The spine was exposed sub-periosteally from T11 to L2. A laminotomy was created at the L1/L2 level and the fiber optic probe was placed in the epidural space and advanced to the planned distraction site under fluoroscopic imaging. At the lowest two thoracic levels, pedicle screws were placed and were connected with bilateral rods. Baseline flow data was obtained. The spine was distracted at 2-mm intervals and flow and electrophysiological data were recorded. When 50% drop in either flow or electrodiagnostic signal was obtained, distraction was halted for 10 minutes and then removed. The sheep were allowed to recover for 24 hours and the spinal cord harvested for histologic analysis.
Results: Data demonstrated that blood flow to the spine decreases at approximately 24 mm distraction. Flow changes preceded electrophysiological changes by approximately 4.5 minutes.

Conclusion: A fiber optic DCS probe utilizing DCS detects spinal cord ischemia at a mean of 14.6±9.5 mm. The ischemic event occurred 4.5 minutes before electrodiagnostic changes.

Significance: A novel fiber optic probe utilizing DCS technology reliably detects spinal cord ischemia in a sheep distraction model. This technology may have clinical utility and make spinal deformity surgery safer in its ability to continuously monitor spinal cord blood flow.

Genomewide Association Identifies FSTL5 Associated with Idiopathic Clubfoot

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LOE–Not Applicable–Level III

Purpose: Idiopathic clubfoot (iTEV) is a congenital rotational deformity that presents as an isolated foot deformity without co-occurring contractures or other developmental sequela. Despite evidence for a genetic contribution to iTEV, no genes have been associated with iTEV in population studies. Two genes, *TBX4* and *PITX1*, have been implicated in rare subjects with clubfoot, and these genes regulate early stages of embryonic limb development. We performed the largest and most comprehensive genomewide association study to identify novel genes associated with iTEV.

Methods: Genomewide variant genotyping of 399 non-hispanic white iTEV and 7,820 ethnicity-matched control subjects was performed and used to impute additional variants genomewide. More than 47 million total variants were imputed in all subjects. After quality and allele-frequency filtering, ~8 million variants were tested for genetic association with iTEV. Association analysis was performed using gender and ten principal components as covariates. Replication was performed in an independent 335 and 2,738 ethnicity-matched iTEV and control subjects, respectively. Multiple animal models were used to determine the relevance of iTEV-associated genes in regulating embryonic limb development.

Results: Association analysis identified a single genomewide-significant locus located within an intron of the *FSTL5* gene ($P_{GWAS}=1.92\times10^{-8}$), encoding follistatin-like 5. Replication of a highly correlated variant (rs76811724, $r^2 = 0.94$) confirmed the locus is associated with iTEV (rs76811724: $P_{GWAS}=2.06\times10^{-7}$, $P_{COMBINED}=2.99\times10^{-9}$). During mouse embryonic limb specification and early development, *Fstl5* is expressed at levels significantly lower than *Fstl1*, which is known to regulate embryonic limb development. However, expression of *Fstl5* increased throughout these timepoints, suggesting it may regulate later stages of limb development. Indeed, *Fstl5* expression is evident during later stages of mouse limb development, more in the hindlimb than forelimb, and is restricted to the condensing cartilage mesenchyme. Furthermore, FSTL5 protein regulates Versican, a critical regulator of hindlimb development, and the YAP signaling pathway.

Conclusion: In the largest genomewide association study to date, we identified the first gene, *FSTL5*, associated with iTEV. Our ability to impute millions of variants genomewide identified multiple additional loci with suggestive associations that will require independent replication and functional follow-up.

Significance: Identification of iTEV-associated genes in addition to functional characterization of *Fstl5* in animal models suggest that iTEV may result from developmental abnormalities during later stages of distal limb development rather than during earlier stages of limb specification and development, as suggested by previous findings of *TBX4* and *PITX1* variants in congenital clubfoot. Our results suggest novel spatio-temporal contexts for the development of clubfoot.

Arthroscopic Release for Shoulder Internal Rotation Contractures Secondary to Brachial Plexus Birth Palsy in Children Four Years of Age and Older

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LOE–Therapeutic–Level IV

Purpose: Brachial plexus birth palsy (BPBP) can lead to glenohumeral dysplasia and shoulder internal rotation contractures. Arthroscopic contracture release (ACR) and glenohumeral reduction is commonly performed to improve shoulder function, and is currently indicated for patients <4 years due to the decline in glenohumeral remodeling potential after this age. There are no known reports of the results of this procedure in patients ≥4 years. The purpose of this study was to investigate the outcomes of ACR and glenohumeral reduction in patients ≥4 years with BPBP internal rotation contractures.

Methods: A retrospective review of all BPBP patients ≥4 years that underwent ACR and glenohumeral reduction over a 5 year period at 2 institutions was performed. Outcomes measured were shoulder range of motion (ROM) and function, as measured by the Modified Mallet (MM) scale. Pre and post-operative measurements were compared between all patients.

Results: 10 patients ≥4 years underwent ACR and glenohumeral reduction over the 5 year time period. 7 patients had complete records of MM scores and 6 patients had complete records of ROM measurements. The mean age at surgery was 8.56 (4.2 to 17.2) years in the MM group, and 7.12 (4.2 to 14.3) years in the ROM group. All patients were male. Mean follow up time was 13.87 (5.12 to 41.65) months in the MM group, and 22.36 (5.82 to 40.67) months in the ROM group.
Mean active external rotation improved pre to post-operatively from -6.67 to 21.67 degrees ($p=0.08$). Mean MM scores improved from 1.86 to 3.29 ($p<0.05$) for external rotation, 2.57 to 3.43 for hand to neck ($p<0.05$), 3.43 to 3.86 for global abduction ($p=0.20$), 3.43 to 3.71 for hand to mouth ($p=0.56$), and 14.29 to 17.14 for total MM ($p<0.05$). Hand on spine scores decreased from 3.0 to 2.86 ($p=0.61$), however, the minimum score improved from 1 to 2. Subgrouping patients by pre-operative MM global abduction scores of <4 or ≥4 showed mean external rotation changes of -5 and 45 degrees, respectively ($p<0.05$), and mean MM external rotation score changes of 1.6 and 1.0, respectively ($p=0.54$).

Conclusion: ACR and glenohumeral reduction in patients ≥4 years results in substantial gains in shoulder function as measured by ROM and MM, particularly with respect to external rotation.

Significance: ACR and glenohumeral reduction can be considered in patients ≥4 years of age with BPBP shoulder internal rotation contractures, particularly if there is a MM abduction score ≥4.

Double versus Single Tendon Transfers to Improve Shoulder Function in Brachial Plexus Birth Palsy

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Dan Zlotolow, MD
Shriner's Hospital for Children, Philadelphia, Pennsylvania, United States

LOE–Therapeutic–Level III

Purpose: In children with brachial plexus birth palsy (BPBP) undergoing tendon transfers to augment shoulder external rotation, it is unclear whether transfer of the latissimus dorsi with its conjoined teres major tendon (cLT) versus isolated teres major tendon transfer (iTM) yield different outcomes.

Methods: Records of patients with BPBP who underwent shoulder tendon transfers to augment external rotation were retrospectively reviewed. Transfer type (cLT or iTM) was considered indiscriminate by virtue of surgeon preference. Modified Mallet Scale (mMS) and Active Movement Scale (AMS) scores were recorded. Patients with <12 months follow-up, C7 or lower palsy, humeral osteotomy, shoulder procedure(s) within 8 months, microsurgery within one year, or recurrent glenohumeral subluxation confirmed by postoperative imaging were excluded. Matched cohorts were identified within each tendon transfer group to yield similar preoperative shoulder function and glenohumeral alignment status. Outcomes for all tendon transfers as well as differences between cLT and iTM cohorts were analyzed.

Results: Among 121 cLT and 34 iTM transfers, matching cohorts yielded 28 patients (14 cLT and 14 iTM) for study inclusion. Average age at time of transfer was 2.2±1.0 years. Follow-up averaged 2.3±1.9 years. There were no statistically significant preoperative differences between cohorts, thus matching criteria were validated. Regardless of tendon(s) transferred, mMS external rotation improved (1.9 to 3.7, $p<0.001$) while mMS internal rotation decreased (3.9 to 3.1, $p<0.001$). When comparing cohorts, cLT transfer produced a greater mMS external rotation improvement than iTM (2.1 versus 1.5, respectively; $p=0.025$). Loss of midline function (defined as mMS external rotation <3) occurred in five cLT and two iTM patients.

Conclusion: Both cLT or iTM transfer are effective at augmenting shoulder external rotation in children with C5-C6 BPBP. Furthermore, cLT transfers may be superior in most patients given a larger improvement in external rotation. However, both techniques slightly decrease shoulder internal rotation. Given that more total cLT patients lost midline function, iTM transfer may still be considered when limited midline function is a concern.

Significance: The data suggest there may be a functional difference between combined versus isolated tendon transfers of the latissimus dorsis and/or teres major tendons for children with external rotation deficits related to brachial plexus birth palsy. However, surgeons need to be equally cautious of a reciprocal decrease in postoperative internal rotation that can impede midline function.

Humeral Lengthening with a Magnetic-Powered Lengthening Nail

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Baltimore, Maryland, United States

LOE–Therapeutic–Level IV

Purpose: Different types of external fixation have been used for humeral lengthening, and successful outcomes have been reported in literature. Motorized intramedullary (IM) lengthening nails have evolved as an alternative to external fixation for lengthening of the lower limbs. This study is the first report on using this new IM lengthening technology for humeral lengthening.

Methods: A multicenter, retrospective study was conducted that included 6 humeri in 5 patients (2 males and 3 females; mean age, 20 years) who underwent lengthening with IM lengthening nails at 2 centers in the USA. The etiology was humeral growth arrest after bone cyst (2 segments), post-septic growth arrest (2 segments), and multiple hereditary exostosis (2 segments in 1 patient). The outcomes measured were length achieved, distraction index (DI), consolidation index (CI), complications, and functional outcomes. Consolidation was described as healing of 3 of the 4 cortices.

Results: Mean follow-up period was 1.4 years (range, 0.7-1.9 years). All segments achieved the lengthening goal; mean lengthening amount was 5.1 cm (range, 4.5-5.8 cm). Mean DI was 0.7 mm/day (range, 0.5-0.8). Mean CI was 36 days/cm (range, 25-45 days/cm). No complications were observed. At the last follow-up, all patients had maintained preoperative shoulder and elbow range of motion. QuickDASH score and upper extremity functional index showed postoperative improvement compared with the preoperative scores.

Conclusion: IM lengthening nails can provide the same results and fewer complications than humeral lengthening with external fixation. IM lengthening nails are able to provide accurate control over the lengthening process.

Significance: This study is the first in the literature to report humeral lengthening using IM lengthening nails.

Finger Tip Amputation in New York State: Correlation with Abuse and Neglect

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LOE–Not Applicable–Level IV

Purpose: Pediatric finger tip amputations are injuries that have the potential for long-term functional and psychosocial implications. Often they are thought of an accidental injury. To date, no epidemiologic studies have been conducted on the demographics and admission (ER and inpatient) history of patients sustaining distal tip amputations to evaluate for the potential of abuse or neglect.

Methods: The New York Statewide Planning and Research Cooperative System (2004-2013) administrative database was used to identify children aged 1-12 years who presented with a fingertip injury (amputation, avulsion or crushed finger) using ICD-9 diagnosis codes. All prior and subsequent visits that were linked to these children were identified in order to examine reasons for multiple admissions to this pediatric population. Demographics and the number of admissions per patient overall and specifically for fingertip injuries in this time period are described.

Results: A database review revealed that 76,180 patients presented with 78,454 finger tip amputations under the age of 12 who required multiple admissions. There were 77,939 patients treated as an outpatient and 515 treated as an inpatient. Males were the majority (61.9%). The white race comprised 55%, African Americans 21.6%, and Asian 2.3%. Children of one year of age made up the largest percentage (14.1%). Insured patients made up the largest demographic (35%) followed by unknown payment (31.6%) and Medicaid (13.1%). The most diagnosis codes were for a URI (5.1%), otitis media (5.0%), viral infection (3.9%), acute pharyngitis (2.6%), and asthma (2.6%). Repeat visit for injuries of potential neglect or trauma accounted for 25% of all repeat admissions including open wound of forehead/scalp, contusion of face and scalp, open wound of jaw, open wound of ankle, abrasion of head, open wound of lower extremity, contusion of fingers, sprain/wrist hand, distal radius fractures or pain in the extremities. Theses codes were 52% higher in the finger tip amputation. Codes for abuse were compared between all patients presenting over the same time period and the repeat admission patients resulting in a increased rate of 35% in the finger tip population.

Conclusion: Patients who sustain pediatric finger amputations are likely to represent to the ER or as an inpatient with injuries associated with abuse or neglect.

Significance: Clinicians should have a high suspicion of abuse or neglect and a low threshold to evaluate for other injuries and the social environment of the patient to ensure the patients safety.

Radial Head Changes in Osteochondritis Dissecans of the Humeral Capitellum

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LOE–Prognostic–Level II

Purpose: Osteochondritis dissecans (OCD) of the elbow has almost exclusively been described in the humeral capitellum. The purpose of this investigation was to characterize concomitant lesions in the radial head (RH).

Methods: Ninety-three elbows in 88 patients, mean age 13.5 (sd,2.2) years, were treated for capitellar OCD and enrolled in a prospective registry. Pre- and post-operative clinical and radiographic data were compared between those with and without RH lesions, with mean follow-up of 8.8 (sd,8.4) months. Advanced imaging was used to characterize RH changes and capitellar OCD. Sagittal MRI was used to determine RH lesion size (as percentage of diameter of the RH) and location, as well as OCD Nelson grade and size.

Results: RH lesions were present in 59 (63%) elbows, of which 44 (74.6%) were in the dominant arm. Chronological age of patients with RH lesions was 13.9 years compared to 15.1 years in those without RH lesions (p=.066). Skeletal age in those with and without RH lesions was 12.8 and 13.6 years, respectively (p=.030). Edema was present in 22 (25.3%) elbows. (Figure 1) The average width and depth were 41.5% (sd,20.8%) and 13.0% (sd,5.1%), respectively. 17 of 22 edematous lesions involved the anterior third of the RH. Subchondral sclerosis was present in 51 (58.6%) elbows. Average width was 52.0% (sd,22.9%) and depth was 10.9% (sd,5.3%). Forty-one (82%) sclerotic lesions were located in the anterior third. Cystic lesions were present in 4 (4.6%) elbows. The average width and depth were 12.0% (sd,6.4%) and 8.6% (sd,5.7%), respectively. Two cystic lesions were located in the anterior third. RH blunting was present in 10 (11.5%) elbows, all in the anterior third. Percentage of capitellar OCD surface area, OCD width, and OCD depth were not associated with the presence of RH lesions. Elbows with RH lesions had a smaller ratio of capitellar radius to AP RH length (.435) compared to those without lesions (.457) (p=.004). Pre- and post-operative pain scores, range of motion, mechanical symptoms, and Nelson grade did not differ between those with and without RH lesions.

Conclusion: Edema, sclerosis, cysts, and/or blunting of the radial head were seen in almost two-thirds of elbows with capitellar OCD. Lesions predominantly occurred in

the anterior RH in more skeletally immature patients.

Significance: This study describes radial head changes that may occur in patients with elbow OCD. Future work will investigate the potential implications of RH lesions and biomechanical properties predisposing younger patients to these changes.

Long-term Outcome Following Surgical Treatment of Wrist Contractures in Children with AMC

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LOE–Prognostic–Level III

Purpose: To evaluate the long-term results following surgical treatment of wrist contractures in AMC according to the level of spinal cord lesion.

Methods: 90 patients (162 wrists) with wrist contractures in AMC were examined and treated at the age from 6 months to 17 years during 2009-2015. Patients were divided into 3 groups according to the level of spinal cord lesion: C_6-C_7, C_5-C_7 and C_5-Th_1. The following clinical variants of wrist contractures were observed: flexion contracture of wrist, flexion contracture with ulnar deviation, which were the most commonly seen, and isolated ulnar deviation of the wrist that occurred rarely. 162 procedures were performed using 4 types of surgical technique according to the variant and severity of wrist contracture: tendon transfers, carpal wedge osteotomy, tendon transfers combined with carpal wedge osteotomy, and tendon transfers combined with carpal wedge osteotomy and shortening osteotomy of the forearm bones.

Results: 90 patients (162 wrists) were evaluated. The average age at the time of surgery was 4,8 years (from 6 month to 17 years). The duration of follow-up was from 1 to 8 years (1-3 years /97 wrists; 4-8 years /65 writs). For objective assessment of surgical treatment results following criteria were used: resting position of the wrist, amplitude of active extension, cosmetic appearance and functional capacity for grasps. All results were divided into 3 groups: good, satisfactory, unsatisfactory. Children with C_6-C_7, C_5-C_7 level of spinal cord lesion had 88% good, 12% satisfactory and 84% good, 16% satisfactory outcomes respectively. In both groups restoration of active wrist extension up to the neutral position or more and significant improvement of cosmetic appearance and functional capacity for grasps were achieved. In C_5-Th_1 group patients had 11% of good, 79% of satisfactory and 10% of unsatisfactory results. Improvement of wrist position and appearance and minimal increase of functional capacity for grasps were observed. Recurrence of wrist deformity were revealed in 13% (21 wrists), in most cases (13 wrists) in patients from C_5-Th_1 group.

Conclusion: Long-term follow-up revealed that proper selection of surgical approach to treatment of wrist contractures in cooperation with determination of the spinal cord lesion level can provide predictable results in wrist function in children with AMC. Increased amount of damaged spinal cord segments results in higher percentage of unfavorable outcomes and higher recurrence rate.

Significance: Preoperative determination of segmental spinal cord damage level can be helpful in making the decision choosing the type of procedure and predicting the results.

Incidence of Compartment Syndrome in Patients with Supracondylar Humerus and Floating Elbow Fractures

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LOE–Prognostic–Level III

Purpose: While acute compartment syndrome is associated with pediatric supracondylar humerus (SCH) fractures, there is limited data describing its incidence and risk factors. The purpose of our study was to report the incidence of acute compartment syndrome with isolated SCH and floating elbow (concomitant SCH and forearm) fracture patterns.

Methods: We retrospectively queried data for SCH fracture patients over a four-year period from our institution (a level I pediatric trauma center) and the National Trauma Database (NTDB). Data on demographics, mechanism of injury, open versus closed fracture, length of stay, presence or absence of forearm fractures and incidence of traumatic compartment syndrome were analyzed. Student's t and chi-square tests were utilized for group comparisons of continuous and categorical variables, respectively. Logistic regression was employed to identify risk factors for compartment syndrome. Results are summarized as means with standard deviation or odds ratios (OR) with 95% confidence intervals (CI). Statistical significance was set at $p<0.05$.

Results: At our institution, 839 patients with SCH fractures met inclusion criteria. 814 (97.02%) patients (average age: 5.96±2.58 years) sustained isolated SCH fractures during the indicated timeframe. SCH fractures with an associated forearm fracture were identified in 25 (2.98%) patients (average age: 7.00±3.03 years). Three patients (0.36%) with isolated SCH fractures were observed to have compartment syndrome. No compartment syndromes were identified in the patients with floating elbows.
Within the same time period, the NTDB identified 34,767 SCH fractures that met inclusion criteria. Of those, 32,786 patients had isolated SCH fractures (average age: 5.49±2.87 years). 70 of the isolated SCH patients (0.21%,$p<0.0001$) had documented acute compartment syndrome (average age: 7.44±3.63 years). The NTDB identified 1978 patients with floating elbows, including 29 (1.47%) who developed compartment syndrome (average age: 8.9±3.81 years). As with our population, the most common mechanism of injury was falls (85.3%). In the regression analysis, male gender (OR 2.27, 95% CI:1.45-3.57, $p<0.001$), older age (OR 1.19, 95% CI:1.12-1.25, $p<0.001$), and floating elbow fracture pattern (OR 5.50, 95% CI:3.54-8.56, $p<0.001$) were identified as risk factors for developing compartment syndrome.

Conclusion: Data from our institution and NTDB reveal that acute traumatic compartment syndrome is rare, occurring in approximately 2-3 fractures out of 1000. There is an increased risk of compartment syndrome with floating elbow fractures, males, and older patients.

Significance: Characterizing the incidence and associated risk factors of acute compartment syndrome with concomitant SCH and forearm fracture patterns can improve clinical understanding and management of pediatric patients.

Divergence between AAOS Appropriate Use Criteria Recommendations and Actual Management of Pediatric Supracondylar Humerus Fractures at a Pediatric Level One Trauma Center

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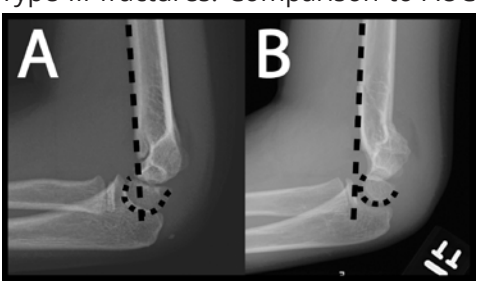
LOE–Not Applicable–Level IV

Purpose: The Appropriate Use Criteria (AUC) for pediatric supracondylar humerus fractures (SCHF) is a tool created by the American Academy of Orthopedic Surgeons (AAOS) to assist with clinician decision-making, providing recommendations for 220 clinical scenarios. The purpose of this study was to characterize management of SCHF at a level 1 trauma center and identify factors contributing to divergence in management from AUC recommendations.

Methods: A query revealed 556 patients with diagnoses of SCHF between 2013-2015 at a Pediatric Level 1 Trauma center. Patients were excluded if they were younger than 2 years old, older than 12 years old, were erroneously coded as supracondylar humerus fracture, were polytrauma patients, or if there was not sufficient clinical or radiographic documentation for thorough retrospective review, resulting in 449 patients. The AUC's web-based application was used to acquire AUC management recommendations. Urgent/emergent intervention was defined as surgery within six hours of presentation. Binomial logistic regression assessed whether various factors predicted operative versus nonoperative management.

Results: The study population consisted of 203/449 (45.2%) Type I fractures, 111/449 (24.7%) Type II fractures, and 135/449 (30.1%) Type III supracondylar humerus fractures. Operative management was performed in 0/203 (0%) Type I fractures, 61/111 (55.0%) Type II fractures, and 135/135 (100%) Type III fractures. Comparison to AUC recommendations revealed disagreement over operative versus nonoperative management in 48/449 (10.7%) patients, all with a Type II SCHF managed nonoperatively (Figure). 31/48 (64.6%) had a radiographic anterior humeral line intersecting the middle third of the capitellum and 15 of the remaining 17 were ≤ 6 years old. The AUC more frequently recommended urgent/emergent operative intervention (144/449, 32.1%) than was performed (44/449, 9.8%). The majority of this disagreement consisted of Type III SCHF treated operatively in > 6 hours (93/100, 93.0%). The only factor predicting operative management was whether the anterior humeral line intersected the middle third of the capitellum (OR 0.045, p<0.001). Decreasing age trended towards significance as a predictor of nonoperative management (OR 1.31, p=0.062).



The anterior humeral line intersects the middle third of the capitellum in minimally displaced (A) rather than widely displaced (B) Gartland II supracondylar humerus fractures.

Conclusion: The AAOS AUC recommended operative and urgent/emergent intervention more frequently than was performed at a Level I Pediatric Trauma Center.

Alignment of the anterior humeral line with the capitellum, though not specifically addressed in the AUC, was most predictive of operative versus nonoperative management at our institution.

Significance: The AUC may over-recommend operative and urgent/emergent interventions for SCHF. We recommend that alignment of minimally displaced SCHF should be considered when determining management and that the criteria for urgency be reexamined.

The Impact of Direction of Displacement, Pin Configuration, and Surgeon Training on Clinical and Radiographic Outcomes in Type III Pediatric Supracondylar Humerus Fractures

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LOE–Therapeutic–Level III

Purpose: Displaced supracondylar humerus fractures are associated with higher rates of neurovascular injury and malunion and are treated surgically. Lateral displacement likely disrupts the medial periosteum, so all-lateral pinning restores only lateral stability, and may be prone to higher rates of fixation failure and malunion. This study aims to evaluate the impact of fracture displacement, pin configuration, and surgeon training on clinical and radiographic outcomes.

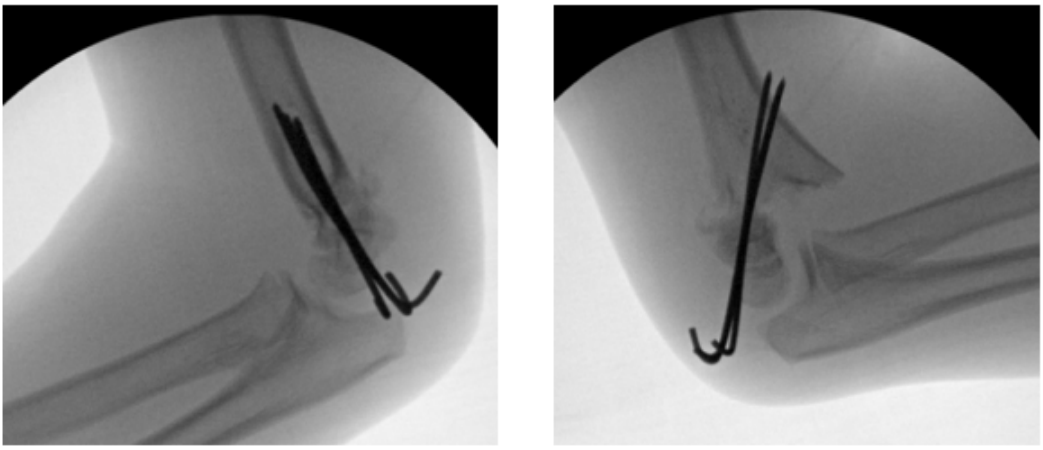
Methods: Patients aged two to twelve years with Gartland type III fractures were identified over a ten-year period at two separate institutions; an academic center and a local community hospital. Fracture characteristics were recorded, including the direction of displacement, as well as surgeon training. Pin configuration, coronal, and sagittal alignment were recorded from postoperative radiographs and at final follow up. Initial, postoperative, and final neurovascular status was recorded. Complications recorded included permanent neurovascular deficit, coronal and sagittal malunion, rotational instability (malunion or reduction loss), and reoperation rate. Statistical analysis included chi-square, Fisher's exact, and T-tests.

Results: 1715 patients were identified, yielding 151 type III fractures. 99 were included in the analysis. 57% of patients were treated with a crossed-pin construct and 43% with all-lateral pins. 53% of patients were treated by pediatric fellowship-trained surgeons. Posteromedially displaced fractures had a higher rate of coronal malunion (p-0.002), while posterolaterally displaced fractures had increased extension malunions (p=0.035). Straight posterior displacement had a lower total malunion rate (p=0.048). All-lateral constructs had increased rotational instability as compared to cross-pinning (p=0.009), and trended towards increased combined malunions (p=0.054), with no difference in neurovascular complications. Though not significant, laterally displaced fractures trended toward being less rotationally stable with all-lateral fixation (p=0.073). Laterally-based constructs that had no rotational instability had a mean pin spread of 15.2 mm at the fracture site, as compared to 9.2 mm for rotationally unstable constructs (p=0.026). There was no difference in complications for fellowship vs non-fellowship trained surgeons for neither fixation type.

Conclusion: For type III supracondylar humerus fractures, all-lateral fixation has higher rates of rotational instability. Increasing the spread of pins at the fracture site limits this. Posteromedially and posterolaterally displaced fractures have higher rates of coronal and sagittal malunion, respectively, while straight posteriorly displaced fractures appear more stable.

Significance: Lateral fixation is less rotationally stable, but this may be mitigated by

wider pin spread at the fracture. Displacement direction appears related to malunion rates. It is safe to treat displaced supracondylar humerus fractures without fellowship training.



External Rotation

A

Internal Rotation

B

Figure 1. Type III fracture treated with all lateral pinning that remained rotationally unstable and required revision at 1 week. A) Lateral view with the shoulder externally rotated at the time of revision, prior to removing the original pins. B) Lateral view with the shoulder internally rotated, demonstrating marked rotational instability.

A Retrospective Review of 10 Years of Pediatric Both Bone Forearm Fractures: Comparison of Single Bone versus Both Bone Fixation

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LOE–Therapeutic–Level III

Purpose: Forearm shaft fractures are among the most common bony injuries in children and are typically treated with closed reduction and casting. These fractures may, however, require operative treatment due to loss of acceptable alignment. This study compares the treatment outcomes of these fractures with fixation of both the radius and ulna to fixation of just the radius or ulna.

Methods: This was a retrospective study investigating patients under the age of 18 years undergoing operative fixation of both bone forearm fractures between 2003 and 2013 at a single institution. Complications, including need for revision surgery, malunion, nonunion, and symptomatic hardware, were also analyzed. Comparative analysis of time to union, complication rate, tourniquet time and overall cost of treatment were examined across different fixation types. Fixation types included plate and screw construct, elastic stabilized intramedullary nails, or a combination of the two.

Results: A total of 401 patients were included in the study, of which 333 patients (83.0%) received fixation of both and radius and ulna fractures, while 68 (17.0%) received single bone fixation. The average age was 9.3 years in the single bone fixation group compared to 11.9 in the both bone fixation group. Patients undergoing single bone fixation had a shorter time to radiographic union compared to both bone fixation (126.7 vs 155.1 days; $p<0.001$). Single bone fixation also had a shorter tourniquet time (24.4 vs 38.8 minutes; $p=0.0167$) and a lower hospital encounter cost ($11,383.24 vs $18,517.95; $p<0.0001$). The complication rates, when excluding removal of hardware, were not significantly different between groups (21.0% single bone versus 18.9% both bone; $p = 0.367$). A total of 17 revision procedures were performed: 6 in the single bone fixation group and 11 in the both bone fixation group (8.0% single bone, 3.3% both bone; $p=0.367$).

Conclusion: This study demonstrates that single bone fixation may have a shorter time to union, similar complication rates, shorter operative time and less overall cost than similar patients who receive fixation of both the radius and the ulna. Intraoperative assessment of stability after fixation of one bone remains the best criteria for determination of suitable patients for single bone fixation. The overall hospital encounter cost and tourniquet time were significantly less with single bone fixation.

Significance: Single bone fixation, in which adequate stability of both bones is obtained, is a viable and cost-efficient treatment model for the treatment of both bone forearm fractures in pediatric patients.

Variation Amongst Pediatric Orthopaedic Surgeons When Treating Medial Epicondyle Fractures

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LOE–Prognostic–Level V

Purpose: Medial epicondyle fractures account for 11-20% of elbow fractures in children and adolescents. The indications for surgical intervention are currently evolving. This purpose of this study was to determine the current variability amongst pediatric orthopaedic surgeons when treating pediatric and adolescent medial epicondyle fractures and attempt to identify factors that lead to operative intervention.

Methods: A discrete choice experiment (DCE) was conducted to determine which patient and injury attributes influence the management of medial epicondyle fractures by pediatric orthopaedic surgeons. An orthogonal and balanced fractional factorial design combined patient attributes and levels based on a Bayesian D-Optimal design. A convenience sample of 13 pediatric orthopaedic surgeons reviewed 60 case vignettes of medial epicondyle fractures that included anteroposterior and lateral elbow radiographs and patient/injury characteristics (gender, mechanism of injury, type of sport participation, and presence of concurrent elbow dislocation). Displacement was incorporated into the study model as a fixed effect. Surgeons were queried if they would treat the injury with immobilization alone or open reduction and internal fixation (ORIF). Statistical analysis was performed using a mixed effect regression model.

Surgeons also filled out a demographic questionnaire (age, gender, years in practice after fellowship, subspecialty in pediatric orthopaedics, and frequency of being on-call) and a risk assessment (Jackson Personality Inventory Risk-taking Likert Subscale) to determine if these factors affected clinical decision-making.

Results: Elbow dislocation and fracture displacement were the only attributes that significantly influenced surgeons to perform an operation ($p < 0.05$). The presence of an elbow dislocation had the largest impact on surgeons when choosing operative care ($\beta = -0.14$; $p = 0.02$). In addition, for every 1 mm increase in displacement, surgeons tended to favor ORIF by a factor of 0.09 ($p < 0.01$). Gender, mechanism of injury, and sport participation did not influence decision-making.

54% of the surgeons favored ORIF. Based on the personality Likert-scale, participants were neither high-risk takers nor extremely risk adverse with an average risk score of 2.24. Participant demographics did not influence clinical decision-making.

Conclusion: There is substantial variation amongst pediatric orthopaedic surgeons when treating medial epicondyle fractures. The decision to operate is significantly based on the degree of fracture displacement and if there is a concomitant elbow dislocation.

Significance: There is currently no standardization regarding how to treat medial epicondyle fractures in the pediatric and adolescent population. Treatment algorithms are needed in order to provide optimal patient outcomes with the least morbidity.

Non-operative Management of Stable Pediatric Osteochondritis Dissecans of the Capitellum

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LOE–Therapeutic–Level IV

Purpose: To determine the healing potential of stable osteochondritis dissecans (OCD) of the capitellum treated non-operatively, as well as factors predictive of successful non-operative management.

Methods: Retrospective chart review was performed for patients age 18 and under who presented with OCD of the capitellum. Eighty-nine patients (94 elbows) who presented with stable OCD on MRI and were initially treated non-operatively for a minimum of 2 months were included. The average age was 12.7 years (range 8.9 - 18.6 years); there were 49 males. Eighty-eight of 89 patients (98.9%) participated in a sport, with baseball (31) and gymnastics (31) being the most common. All patients presented with elbow pain, and 15 had mechanical symptoms. All patients were treated with initial activity restriction, physical therapy, and progressive return to activity. Average clinical and radiographic follow-up was 12.0 months (range 2.6 – 63.7 months). Successful non-operative treatment was defined as return to full activities, including sports, and radiographic healing (sclerosis on x-ray or lesion size reduction and decreased high signal around the lesion on MRI). A multivariate logistic regression model was used to determine independent predictors of healing.

Results: Fifty-one of 94 (54.3%) elbows had successful healing with non-operative treatment at mean 8.3 months (range 2.1 – 51.7 months). Symptom duration was found to be significantly shorter in the group that healed than that which failed (5.15 ± 4.27 versus 8.80 ± 9.03 months, respectively, $p = 0.01$). There were no significant differences in age at presentation, physeal status, gender, or hand dominance. On MRI, those with HEFTI stage 1 lesions had a higher rate of healing (64.3%) than those with stage 2 lesions (31.4%, OR 3.93, $p = 0.005$, 95% CI 1.51 to 10.18). Those without subchondral cysts also had a significantly higher healing rate (66%) than those with cysts (20.8%, OR 6.27, $p = 0.001$, 95% CI 2.02 to 19.43). Area of the lesion normalized to the overall area of the capitellum was significantly larger in the nonhealing group (26.9% vs 18.8%, $p= 0.0001$, 95% CI -11.98 to -4.23).

Conclusion: Over half of stable capitellar OCD lesions have the potential to heal with activity restriction. Larger, more advanced lesions are less likely to heal with nonoperative treatment.

Significance: Osteochondritis dissecans (OCD) of the capitellum is a rare but potentially debilitating condition. Factors including lesion size and stage should be taken into account when formulating a treatment algorithm.

The Effect of Co-Surgeon on Outcomes in CP Spine Surgery

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LOE–Economic and Decision Analyses–Level III

Purpose: Spinal fusion for patients with cerebral palsy is time-consuming, expensive and associated with a high complication rate in comparison to spinal fusion in the idiopathic population. The purpose of this study was to evaluate outcomes and associated costs for spinal fusion performed by two attending co-surgeons vs. a single attending surgeon with a surgical trainee acting as surgical assistant.

Methods: An IRB-approved retrospective review of all children with cerebral palsy who underwent posterior spinal fusion performed by a single surgeon between 2011 and 2015 was completed. All included patients were fused from T1/2 to the pelvis with a unit rod and sublaminar wires. Two groups were identified – those in which a co-surgeon was utilized and those in which an orthopaedic trainee assisted. Comparisons were made in regards to procedure time, blood loss, transfusions, length of ICU and hospital stay, complications and reoperations. Costs were compared in regards to OR time, ICU time and transfusions. Statistical analysis was completed using independent t-tests and chi-square tests.

Results: Of the 44 cases identified, 16 were performed with an attending co-surgeon and 28 were performed with an orthopaedic trainee. The patients in each group were similar in terms of age, weight, comorbidities, GMFCS level and pre-operative cobb-angle. Curve-correction between the groups was similar ($p>0.05$) but those performed with a co-surgeon resulted in shorter operative times (246 vs. 288 minutes, $p=0.013$), decreased blood loss (2231mL vs 3225mL, $p=0.011$) with decreased transfusions needs (1328mL vs. 1940mL, $p=0.016$), decreased post-operative length of intubation (1 vs. 3 days, $p=0.001$) and decreased ICU length of stay (1 vs. 3 days, $p=0.001$) with similar overall hospital lengths of stay ($p>0.05$). Complications and 90-day re-operation rates were similar amongst groups ($p>0.05$). In comparing costs based on these notable differences, there was an overall savings of $2349.44 per case when a co-surgeon was utilized. This includes $535.44 in savings from reduced OR time, $470.00 in savings from reduced transfusions and $1344.00 in savings from decreased ICU nursing costs.

Conclusion: Utilizing a co-surgeon for spinal fusion in patients with cerebral palsy decreases operative time, red blood cell transfusions and post-operative days intubated, all of which directly decreases hospital costs.

Significance: In the cerebral palsy population, utilizing a co-surgeon for spinal fusion is both medically efficacious and cost effective and should be strongly encouraged whenever possible.

Assessing the Risk/Benefit Ratio of Surgery in CP: Is Surgery Worth It?

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LOE–Therapeutic–Level II

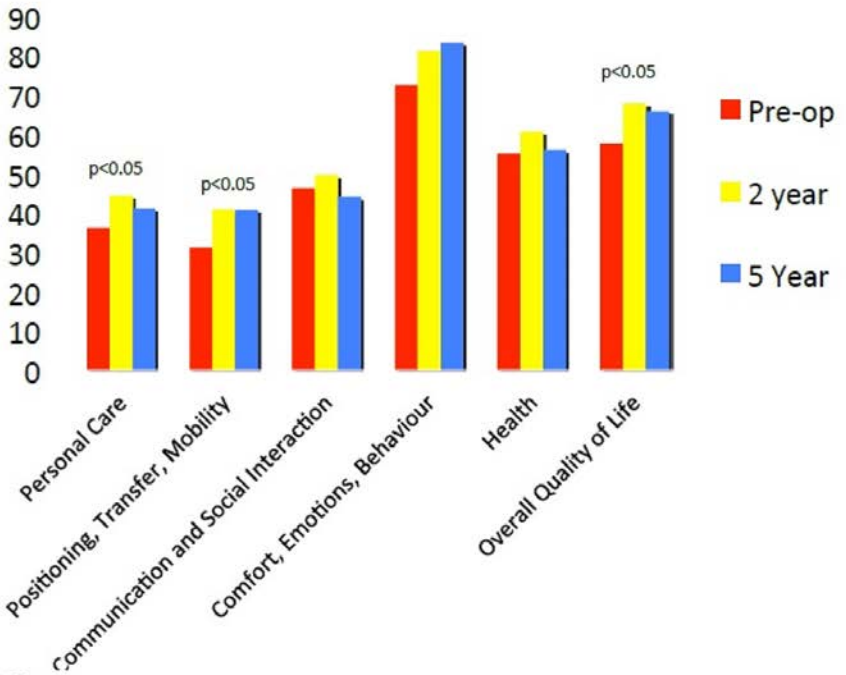
Purpose: Literature around benefits for surgical intervention in patients with CP remains inconclusive. Most long-term data rely on retrospective reviews of limited quality primarily reporting on radiographic outcomes and lack any validated patient/care-giver outcome metric. Our objective was to determine the benefit of spinal arthrodesis in this patient population as determined by the CP Child questionnaire at long-term follow-up and also evaluate the reported complications at 2-year and 5-year follow-up.

Methods: A prospective, longitudinal, multi-center database evaluating surgical outcomes for CP patients was analyzed. All patients with 5-year follow-up were included in the analysis. CP Child outcome scores as well as surgeon-reported complications were the primary outcomes of interest and were compared at 2 time points: 2 years following surgery and 5 years following surgery. Radiographic data was also compared at these two post-op intervals.
Results: 40 patients were analyzed. Mean age at surgery was 13.0±2.6 years with majority female (62.5%). Most patients were GMFCS V (94.9%) with a mean major pre-op Cobb of 89.2°±27.6° improved to an average 30.8°±11.1° at 2 years and at 5 years was an average 29.8°±12.8°. Improvements in CP Child scores were noted at 2 years post-op and were maintained at 5-years post-op in all domains except communication and social interaction. Significant improvement was achieved in overall quality of life, personal care and positioning, transfer and mobility domains at 2 years post-op with no significant change at 5 years post-op ($p<0.05$). Overall complication rate was 35%, majority occurring within 2 years (30%, $p=0.013$). The rate of complications occurring >2-5 years requiring intervention was significantly lower than those requiring intervention within 2 years of surgery (2.5% vs 17.5%, $p=0.03$). The only newly observed complications beyond 2 years were surgical site infection (2.5%) and instrumentation issues (2.5%), the latter not requiring intervention.

Conclusion: Despite a 17.5% complication rate requiring intervention within 2 years following surgery a significant improvement was found in CP Child HRQoL scores at 2 years post-op, which was maintained at 5 years post-op. An insignificant rate of newly observed complications occurred at >2-5 years post-op suggesting that the benefits of surgery appear to outweigh the risks in this fragile population.

Significance: The risk/benefit ratio of spine surgery in CP appears favorable with CP Child scores significantly improving at 2-years post-op, being maintained at 5-years post-op. No significant rate of newly observed complications requiring intervention occurred at >2-5 years post-op emphasizing favorable outcomes of spinal fusion in CP.

CP Child Scores Pre-op, 2-year, 5-year Comparison



Table

Patient Demographics						
Mean Age at Surgery (years)	13.0 ± 2.6					
Gender	M=37.5%; F= 62.5%					
Mean Weight (kg)	29.6 ± 7.32					
GMFCS Level (%)	IV:5.1%; V:94.9%					
				Comparisons (P-value)		
Radiographic Measures	**Pre-op**	**2-year f/u**	**5-year f/u**	**Pre-op to 2-year**	**2-year to 5-year**	**Pre-op to 5-year**
Mean Major Cobb (°)	89.2± 27.6	30.8± 11.1	29.8± 12.8	0.000*	0.689	0.000*
T2-T12 (°)	42.8± 29.3	37.4± 13.4	36.1± 12.6	0.297	0.671	0.196
T5-T12 (°)	35.0± 23.7	24.9± 12.0	23.2± 11.8	0.021*	0.514	0.007*
Lordosis(°)	-30.6±31.6	-51.6±13.2	-51.3±13.9	0.000*	0.918	0.000*
Overall Complication Rate	**<=2 year**	**>2-5 year**	**P-value**			
Required Intervention+	7 (17.5%)	1 (2.5%)	0.03*			
No Intervention Required	5 (12.5%)	1 (2.5%)	0.219			
Total Complications	12(30.0%)	2 (5.0%)	0.013*			

* - indicates point at which a significant difference ($p<0.05$) found

+ Intervention = medical or surgical

Perioperative Management of Patients with Cerebral Palsy Undergoing Scoliosis Surgery: Survey of Surgeon Practices

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LOE–Not Applicable–Level V

Purpose: Progressive scoliosis significantly impacts the quality of life in patients with cerebral palsy (CP). Spinal fusion is the mainstay of treatment of progressive spinal curves to improve quality of life and caregiver satisfaction. Patients with CP and scoliosis have increased rates of perioperative complications compared to patients with idiopathic scoliosis, leading to increased hospital stays and costs. Our study aims to identify approaches used by pediatric spine surgeons to optimize care of patients with CP undergoing scoliosis surgery.

Methods: Study Design: Consensus survey

Study Participants & Setting: A survey was distributed electronically to 181 POSNA / SRS members with an established interest in pediatric spinal deformity surgery.

Materials/Methods: The survey included 33 multiple choice questions to determine each surgeons' protocol and approach to optimize outcomes of scoliosis surgery in patients with cerebral palsy. We obtained 81 responses, representing a 45% response rate. Descriptive statistics were used for data analysis. Using the Delphi consensus guidelines, agreement > 75% was considered as consensus.

Results: There were several areas of agreement and discordance amongst responders. We had consensus on 15 out of 33 questions (46%). 97% of responders identified nutrition status as a comorbidity which could be optimized. However, the timing of obtaining a nutritional assessment and the measurements used in the assessment varied. 92% used shared decision making with the family but only 22% used a decision aid. 83% use antifibrinolytics routinely, 81% used a surgical site infection prevention protocol, 78% obtained preoperative pulmonary consult and 88% took steps postoperatively to prevent pulmonary complications, 75% of surgeons reported that they have specific perioperative protocols in place for the management of patients with CP and scoliosis.

Conclusion: There is significant variability in the current practices of pediatric spine deformity surgeons with regard to optimizing perioperative management of patients with CP undergoing scoliosis surgery. There was a clear consensus that specific perioperative protocols should be in place for this fragile population in order to manage blood loss, infection risk, nutritional status and pulmonary complications. However, there were several areas of discordance.

Significance: This data can be used in future studies to create a standardized integrated care pathway to optimize care, improve outcomes, reduce complications and costs of health care in pediatric patients with cerebral palsy undergoing scoliosis surgery.

The Use of Guided Growth Technique for Coxa Valga in Cerebral Palsy Children

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LOE–Therapeutic–Level IV

Purpose: Coxa valgus deformity is a common pathologic condition in children with cerebral palsy. Without appropriate intervention, acetabular dysplasia may occur and pose a risk of hip subluxation or dislocation. Guided growth techniques have been used to alter growth in the lower extremity but only few reports in correcting coxa valgus deformity. This study aims to evaluate the effect of using a transphyseal screw guided growth in reducing coxa valga in cerebral palsy.

Methods: From 2012 to 2014, cerebral palsy children who had progressive bilateral hip subluxation with coxa valga were recruited. Guided growth technique was performed by inserting a transphyseal screw through the medial one-third capital epiphysis. All patients were followed for at least one year after surgery. Radiographic parameters were measured including head-shaft angle (HSA), center-edge angle (CEA), Reimer's migration percentage (MP) and the change of continuity of Shenton line.

Results: Forty-four hips of 22 cerebral palsy subjects (16 boys and 6 girls) meet the criteria with the mean age of 7.7 years at time of surgery (range 5.5-11.7). The mean duration of follow-up was 27 months (14-40 months) and the mean GMFCS was 3.5. The mean HSA had a significant improvement from pre-operative 161.8° to post-operative 152.3° ($p < 0.01$). There were slight decreased MP (from 32.3 to 30.7) and increased CEA (from 11.8 to 12.0) without statistical significance. The pre-operative Shenton line disruption was detected in 31 hips (70%) and 11 of 31 hips (35%) were shown with better continuity at the last visit. The screw back-out resulting in loss of purchase through the capital physis was observed in 17 hips in 10 patients (38%). The percentage of fully-threaded screw back out was 30% (6 of 20), while 46% (11 of 24) in partially-threaded screw. Among them, 11 hips in 6 patients required revision of screw placement. There were three patients required proximal femoral varus osteotomy with acetabuloplasty due to progressive hip subluxation and acetabular dysplasia.

Conclusion: Guided growth through a transphyseal screw has the potential benefit for gradual correction of the coxa valgus deformity in cerebral palsy. Significant improvement was noted in HSA but limited effect in migration percentage and center-edge angle. The fully-threaded screw was recommended to avoid the early hardware back-out complication.

Significance: Guided growth for coxa valga may correct the deformity and prevent hip subluxation in cerebral palsy children.

Reverse Periacetabular Osteotomy in the Treatment of Neurogenic Hip Dysplasia in Cerebral Palsy

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LOE–Therapeutic–Level IV

Purpose: In the setting of spastic neuromuscular hip dysplasia, acetabular deficiency is common. After closure of the triradiate cartilage, the Bernese or Ganz periacetabular osteotomy (PAO) can be used to provide improved coverage of the femoral head. Since 2005, the Bernese PAO has been utilized at the authors' institution to correct acetabular dysplasia in ambulatory and non-ambulatory patients with cerebral palsy (CP). In CP, neuromuscular hip dysplasia commonly results in posterolateral acetabular deficiency.

Methods: All patients with spastic CP who underwent Bernese PAO between 2005 and 2014 were reviewed. All clinical and radiographic parameters were collected to assess success of acetabular reorientation, specifically the CP hip classification and posterior wall index (PWI).

Results: Twenty-four Bernese PAOs were performed on patients with cerebral palsy in the study period and included. Twenty of twenty-four procedures (83%) primarily involved correction of posterolateral acetabular insufficiency. All twenty experienced improvements as measured by improvements in the PWI. Twenty PAOs (83%) were performed in the setting of other multi-level orthopaedic surgery. Eleven of twenty-four hips had improvement in cerebral palsy hip classification, two worsened, and the remainder of hips maintained their classification.

Table 1. Concomitant procedures performed at the time of PAO as part of single-event, multilevel surgery.

Ipsilateral			
Bony	**#**	**Soft-tissue**	**#**
Proximal femoral osteotomy	13	Adductor lengthening	8
Tibial derotational osteotomy	3	Psoas lengthening at pelvic brim	7
Hardware removal	1	Gastroc-soleus lengthening	3 (1)*
Hyerostosis excision	1	Medial hamstring lengthening	2
DFEO/PTA	1 (1)*	Foot reconstruction	2 (1)*
		Frost lengthening	2
		Hip capsulorrhapy	1
		Rectus femoris transfer	1 (1)*
		Hardware removal	1
Contralateral			
Tibial derotational osteotomy	3	Adductor lengthening	1
		Patellar tendon advancement	1
		Psoas lengthening	1
		Quadricepsplasty	1
		Medial hamstring lengthening	1
		Gastroc-soleus lengthening	1

DFEO/PTA = Distal femoral extension osteotomy with patellar tendon (or tubercle) advancement
* = parentheses denote separate procedures performed in staged fashion, i.e. within one week of PAO

Conclusion: The periacetabular osteotomy of Ganz is successful in correcting the posterolateral insufficiency commonly present in neuromuscular hip dysplasia associated with cerebral palsy, and can be safely performed in conjunction with other single-event multilevel procedures.

Significance: The neurogenic hip dysplasia of both ambulatory and nonambulatory cerebral palsy patients can be corrected with reverse PAO, either as an isolated procedure or in conjunction with single-event multilevel surgery.

Does Correction of Femoral Lever-Arm Influences the Effect of Selective Dorsal Rhizotomy on Gait in Children with Spastic Diplegic Cerebral Palsy?

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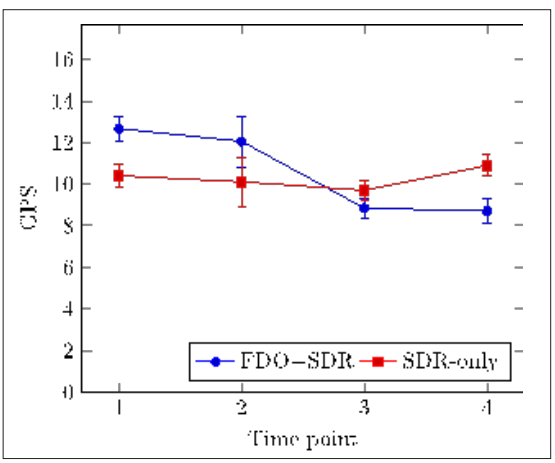
LOE–Therapeutic–Level III

Purpose: Selective dorsal rhizotomy (SDR) results in improved gait and function in children with spastic diplegic Cerebral Palsy (SDCP). However, some studies also report decline of gait at long term, with increased anterior pelvic tilt (PT) and crouch. It is known that increased femoral anteversion (FA) often leads to increased PT and hip flexion. Femoral Derotation Osteotomy (FDO) corrects for this increased FA. We will evaluate the long-term outcome of SDR on gait and the role of previous correction of femoral lever-arm.

Methods: In a retrospective cohort study of children who received SDR, two groups were identified. Group A first received FDO and afterwards SDR (n=14). Group B (n=15) only received SDR. 3D gait data were obtained at 4 time points: preFDO (or baseline in group B) (t1), pre SDR (t2), 1y post SDR (t3) and 3-5y post SDR (t4). Gait Profile Score (GPS), mean pelvic tilt (PT), maximum hip extension (HE), knee angle at initial contact (KIC) and maximum knee extension stance (KE) were analysed and a mixed ANOVA with repeated measure 'time' was performed.



Results: In group A, there was no significant difference in GPS after FDO. However, 1 year after the SDR, the GPS decreased significantly in this group. Three to five years after the SDR, the GPS stabilized. In group B, in contrast to group A, there was no significant decrease in GPS after SDR. Three to five years after the SDR, the GPS increased significantly in this group.
Comparison between both groups at different time points: *GPS*: significantly different at t1 (A:12.67, B:10.41) but comparable at t2. At t4: significantly less gait deviation in group A (A:8.71; B:10.91). *PT:* only significant difference at t4 in favour of group A. *HE:* more hip extension in group A at t3 and t4. *Knee:* KIC and KE were only significantly different at t4 in group A.

Conclusion: Children with SDCP who first underwent FDO and later SDR have less gait deviations 3 to 5 years after SDR than children who only underwent SDR. This was confirmed by a lower GPS, as well as less PT and less knee flexion in stance.

Significance: The effect of SDR in children with SDCP is significantly better at long term if femoral bony lever-arms were corrected in advance. Hence, the outcome after SDR is dependent on a good alignment. Receiving only a FDO or only a SDR only provides slight improvements.

The Effect of Scoliosis Surgery on Pulmonary Function in Spinal Muscular Atrophy Type II Patients

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LOE–Therapeutic–Level IV

Purpose: Various result of previous literatures related to surgical effect on pulmonary function of spinal muscular atrophy (SMA) patients might be due to different SMA type, different fusion level and technique. The aim of this study was to determine the value of scoliosis surgery for SMA type II patients with regard to pulmonary function, under the same fusion level, fusion technique and average long-term follow-up.

Methods: Ten SMA II patients who underwent spinal correction procedures from 1993 to 2010 were identified. Data on clinical features and pulmonary function, including forced vital capacity (FVC) and forced expiratory volume in 1st second (FEV_1), were collected. The data on pulmonary function were divided into preoperative, postoperative short-term (0-5 years), mid-term (5-10 years), and long-term (> 10 years). Statistical comparisons were made using the Wilcoxon test for pulmonary function and body weight analysis. Questions were answered by parents on how surgery influenced the frequency of respiratory infection and the ability to sit at school.

Results: The average length of postoperative pulmonary function follow-up was 12.3 years (range: 4.9-15.9 years). There was no significant difference in FVC or FEV_1 between preoperative and each postoperative period. However, a significant decline from mid-term to long-term was observed (p=0.028). Body weight increased significantly in all postoperative periods and was moderately correlated to pulmonary function (r= 0.526 for FVC). The answers to the questionnaire revealed that 80% of the patients had obvious improvement in the frequency of respiratory infection and 100% were tolerable sitting at school.

Table 6. Review of relevant literature: effect of scoliosis surgery on pulmonary function of SMA II patients

	This study	Aprin et al.	Piasecki et al.	Merlini et al.	Brown et al.	Granata et al.
Total patients*	10	13	9	7	19	15
SMA II	10	6	2	4	7	8
Mean age at scoliosis surgery (y: m)	12:9	12:9	15:0	11:9	13:3	16
Average Follow up (longest y: mo)	12:4 (15:11)	4:11(9:5)	7: 5 (13: 10)	3: 6(4:3)	2: 0	5:2 (9:7)
Effect of scoliosis surgery on pulmonary function of SMA II patients	FVC and FEV_1 maintained the same under long-term F-U	Three had increased average 15% vital capacity at short-term F-U; three had decreased average 22% at mid-term F-U (only six patients had data)	One had increased vital capacity at long-term F-U; the other had decreased vital capacity at short-term F-U (only two patients had data)	Vital capacity increased at short-term F-U	Predicated FVC decreased about 10% at 2 years F-U	Vital capacity increased at mid-term F-U (4 patients) and decreased in three of four patients at short-term F-U.

Robinson et al., Thacker et al., Chng et al., Fujak et al. all published on the surgical effect on pulmonary function; however, the exact number of SMA II patients or how pulmonary function of SMA II patients influenced was not mentioned.

*: pulmonary function data reported, y: years, mo: months, F-U: follow-up, FVC: forced vital capacity, FEV_1: forced expiratory volume in 1 second

Conclusion: Surgical correction for scoliosis in SMA II patients results in pulmonary function being maintained during long-term follow-up. In addition, the advantages of surgery also include body weight gain, better sitting tolerance, and reduced frequency of respiratory infection.

Significance: This is the first study to determine the value of scoliosis surgery for SMA type II patients with regard to pulmonary function, under the same fusion level, fusion technique and average long-term follow-up. This study demonstrates surgical correction for scoliosis in SMA II patients maintains pulmonary function during long-term follow-up.

Improvement of Pulmonary Function Measured by Patient-Reported Outcomes in Patients with Spinal Muscular Atrophy after VEPTR Surgery

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LOE–Therapeutic–Level IV

Purpose: Surgical intervention with constructs such as the Vertical Expandable Prosthetic Titanium Rib (VEPTR) can halve the rate of decline of pulmonary function and allow lung growth. While pulmonary function has traditionally been assessed via PFTs, disease severity and young age in a number of patients precludes them from taking PFTs. This study aimed to demonstrate that the Early Onset Scoliosis Questionnaire (EOSQ-24) PF domain could be used to evaluate pulmonary function changes in SMA patients after VEPTR implantation.

Methods: We conducted a multi-center retrospective cohort study and queried a national Early Onset Scoliosis registry for patients with SMA operated on between 2005 and 2015. Patients diagnosed with SMA and treated with VEPTR implantation were eligible for our study. Pre-operative and post-operative EOSQ24 pulmonary function domain scores at 1-year and 2-year were collected and PFT results measured by forced vital capacity (FVC) were also assessed.

Results: We identified 49 patients meeting inclusion criteria (averages: Cobb=58.2°; 55%F; 6.9 years at implant). Average initial Cobb correction was 19.5°. EOSQ24 pulmonary function scores increased significantly from 60.71 pre-operatively to 90.0 (p=0.039) at one year post-operatively and to 86.31 (p=0.057) at two years. There was no significant difference observed between pre-operative and post-operative FVC values.

Conclusion: Pulmonary function in SMA patients measured by patient-reported outcomes demonstrated significant improvement after VEPTR surgery. Patient reported outcomes indicate improvement in pulmonary function despite difficulties to objectively measure this domain using PFTs.

Significance: While the effect of posterior growing rods on quantitatively measured pulmonary function remains to be rigorously evaluated, this study reports improvement in quality of life including pulmonary function domains. This study reiterates the utility of straying from traditional objective measures to patient-reported outcomes in evaluating the efficacy of surgical procedures. The EOSQ24 questionnaire should be used as a model for development of future surveys for patient well-being and satisfaction.

The Impact of Pamidronate on the Progression of Vertebral Fractures in Patients with Duchenne Muscular Dystrophy Undergoing Corticosteroid Treatment

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LOE–Therapeutic–Level III

Purpose: Corticosteroids can be used to prolong ambulation in patients with Duchenne Muscular Dystrophy (DMD); however, this can decrease bone mineral density (BMD), resulting in development of vertebral fractures (VFs). The bisphosphonate pamidronate can improve BMD in osteoporosis; therefore, patients with DMD managed by corticosteroids may benefit from pamidronate. The purpose of this study was to examine the impact of pamidronate on VF progression and BMD in patients with DMD on corticosteroids.

Methods: A retrospective radiographic and chart review was performed on 46 patients diagnosed with DMD and managed with the corticosteroid deflazacort. Deflazacort and pamidronate treatment, total body and lumbar BMD Z-scores were examined. Radiographs were assessed at two intervals for number of VFs, fracture location and fracture grade. The rate of VF progression and BMD loss was compared between patients on deflazacort treated with pamidronate versus patients on deflazacort alone over a mean period of 3.3 years.

Results: In total, 16 patients treated with pamidronate and 9 without were included. An additional 21 patients were also analyzed, but had not been on deflazacort for sufficient time for comparison. Patients were on deflazacort an average of 7.4 years at initiation of pamidronate treatment. At this time, 13/16 (81%) patients had developed VFs compared to 2/9 (22%) patients on deflazacort for a comparable time (6.8 years). Lumbar and whole body BMD was lower at baseline in the pamidronate group (-2.4 and -3.5 versus -2.0 and -3.1, respectively). After 3.3 years on pamidronate, progression of VFs was seen in 10/16 patients, in contrast to only 1/9 patients not on pamidronate. Patients developed VF at a rate of 0.42 VF/year prior to pamidronate, and a rate of 0.32 VF/year during treatment. The non-pamidronate group developed VF at an average rate of 0.05 VF/year. Pamidronate did not prevent, but marginally slowed the loss of BMD (-0.15 Z-score/year with pamidronate versus -0.26/year without).

Conclusion: A subset of patients with DMD develops VF on deflazacort, with VF incidence and progression markedly higher in this group. Pamidronate is typically prescribed once VFs have become apparent. At this stage, pamidronate does not appear to markedly slow VF progression or improve BMD.

Significance: Although numbers are too small for meaningful statistical comparison, certain patients with DMD are particularly susceptible to developing VF on deflazacort. If we can identify characteristics of this group, pamidronate treatment can be initiated early, thereby providing benefit that appears to be lost once VF have already developed.

The Alteration of Lower Limbs' Muscle Size During Growth in Ambulant Children with Cerebral Palsy

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LOE–Not Applicable–Level III

Purpose: Cerebral palsy is a neurological disorder that can cause muscle dysfunction [1]. Although the primary neurological problem is not progressive, the muscle pathology does progress with growth affecting muscle morphology [2]. It's known that children with CP could lose their walking abilities during growth and this could be related to muscle force in the lower limbs, that has shown to be proportional to cross-sectional area (CSA) as well as to muscle volume [3,4]. Our aim was to investigate whether muscle size increases with age in ambulant children with CP.

Methods: 18 spastic children with CP (Hemiplegia N=7, Diplegia N=11, GMFCS levels: I: N= 10, II: N=8; age: 12 ±3.8 years) and 18 age-matched typically developing (TD) children underwent MRI acquisition for the lower limbs. 3D subject-specific muscle reconstructions [5] were performed for the hamstrings, hip adductors (brevis, magnus and longus), vastii, rectus femoris, gracilis, gastrocnemii, soleus and anterior tibialis in order to calculate belly muscle volumes and CSA. Muscle volumes and CSA were compared using ANCOVA, controlling for BMI. Partial correlations were performed between muscle volume, CSA and age, while controlling for BMI.

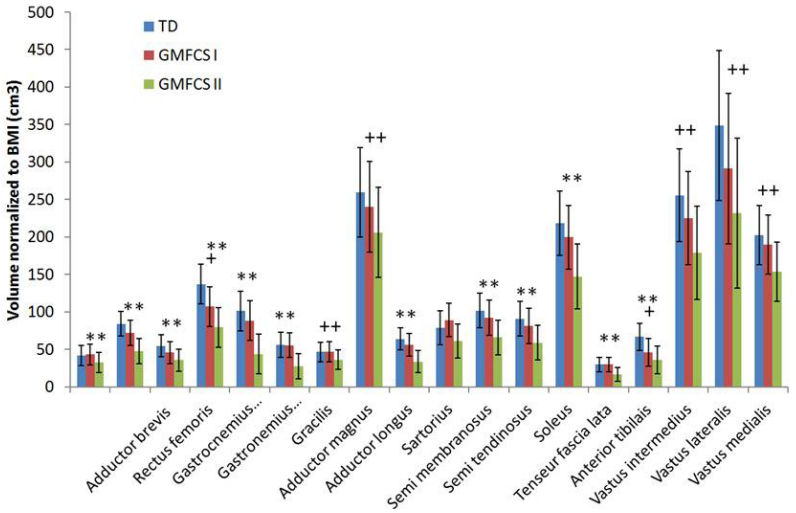
Results: The comparison of the normalized muscle volumes and CSA in TD children and children with GMFCS levels I and II are represented in figure 1. In TD children, volumes and CSA of all muscles were significantly correlated to age (r ranged between 0.5 and 0.8, $p<0.05$). Children with GMFCS level II didn't show a significant correlation between either volume or CSA and age for the hamstrings, adductors, gastrocnemii and soleus ($p>0.05$). In children with GMFCS level I, the volume and CSA of the anterior tibialis and rectus femoris seems not to increase with age ($p>0.05$).

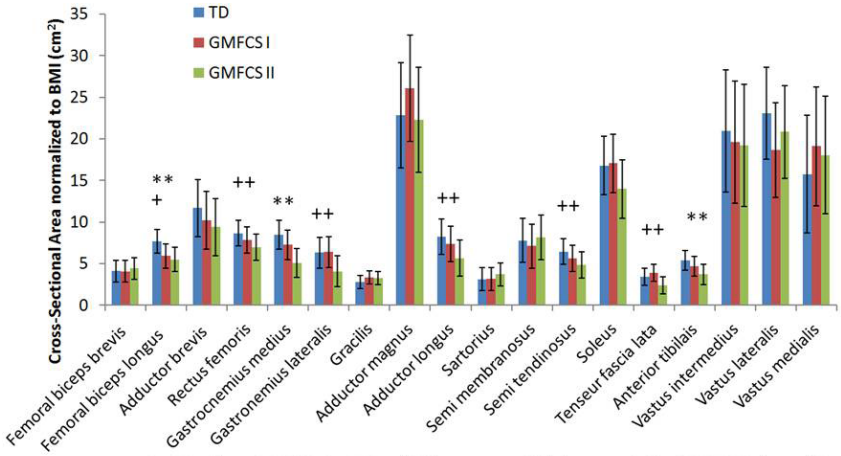
Conclusion: Muscle sizes were significantly decreased in subjects with CP, especially with GMFCS level II, compared to TD children. The lack of increased muscle size with age, in children with GMFCS level II, could explain the deterioration of their walking abilities during growth. Despite the cross-sectional nature of this study, the analysis took into account possible confounding factors in order to elucidate the relationship between muscular morphology and age.

Significance: This study showed that hamstrings, adductors, gastrocnemii and soleus sizes do not increase with age in children with GMFCS level II, which could partly explain the deterioration of their walking abilities with age.

References

[1]Graham 2016; [2]Barber 2016; [3]Lieber 2000; [4]Fukunaga 2001; [5]Jolivet 2008





+p<0.05; *p<0.001 in TD children vs children with GMFCS level I

++p<0.05; **p<0.001 in TD children vs children with GMFCS level II

A Novel Risk Severity Score to Predict Pediatric Spine Surgical Site Infection in Patients with Cerebral Palsy Ranges from 0.88% to 23.3%

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LOE–Not Applicable–Level II

Purpose: Cerebral palsy (CP) is one of the most common childhood disabilities, and up to 67% reportedly have comorbid scoliosis. Surgical treatment of scoliosis, especially neuromuscular etiologies like CP, is associated with high levels of complications. In particular, surgical site infections (SSI) lead to significant physical and financial burden on the patient, caregivers, healthcare system, and society as a whole. Therefore, the purpose of this study was to develop a risk severity scoring (RSS) system to predict SSI in children with CP undergoing spinal surgery.

Methods: This multicenter case control study determined the risk factors for SSI in patients with CP following surgical scoliosis correction. Inclusion criteria were pediatric patients with CP and history of index spinal fusions and revisions. Patients were identified from 4 academic institutions between January 2006 and December 2011. Data collected include patient characteristics, clinical/surgical data, and preoperative labs. SSI was defined as infection within 90 days of surgery, as per the Centers for Disease Control.

Results: In total, 255 patients were identified. Of these, 146 (57%) were male and 109 (43%) were female. The mean age at surgery was 14.5 years. The overall SSI risk was 11.7%. Regression analysis showed that ambulatory status (OR 5.0), bowel incontinence (OR 3.7), Cobb angle >90° (OR 1.5), behavioral disorder/delay (OR 1.1), revision surgery (OR 1.1), and hemoglobin < 14 g/dL (OR 1.1) were prognostic of SSI. The RSS model predicted SSI risk of 0.88% when none of these factors were present, and 23.3% when all factors were present. The predictive ability of the RSS was 71%, demonstrating that the model is able to discriminate between true and false positives.

Conclusion: The present study shows that patients with CP experience high risk of SSI(11.7%) subsequent to spinal surgery. A RSS to predict the probability of SSI developing within 90 days after spinal surgery was developed, which incorporates ambulatory status, bowel incontinence, Cobb angle magnitude, presence of behavioral disorder, revision surgery, and hemoglobin level.

Significance: The CP RSS is a significant addition to a surgeon's arsenal for predicting SSI risk following spine surgery. It facilitates perioperative planning discussions among the clinical team as well as between patient and family members. By identifying patients with high risk of SSI, preoperative optimization can help reduce SSI incidence. This has the potential to improve patient outcomes, reduce health care costs associated with SSI, and serves as a stepping stone for future research.

Long-term Outcomes after Distal Femoral Extension Osteotomy and Patellar Tendon Advancement in Individuals with Cerebral Palsy

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LOE–Therapeutic–Level III

Purpose: 1) Determine the long-term effects of distal femoral extension osteotomy plus patellar tendon advancement (DFEO+PTA) in individuals with cerebral palsy (CP) who had those surgeries (cases) on body structure and function, activity, participation, and pain compared to baseline and individuals who did not have those surgeries (controls). 2) Determine if improvements in gait achieved with a DFEO+PTA at short-term (Stout et al., 2008) are maintained at long-term.

Methods: This was an IRB approved prospective cohort study. All participants had CP, walked in crouch (knee flexion angle >2 SDs above typically developing at initial contact and minimum flexion) and had knee flexion contracture(s) ≥10° at baseline, were ≥20 years old at long-term, and ≥8 years post-DFEO+PTA (cases). Controls had no or alternative treatments to DFEO+PTA. At long-term, participants completed questionnaires (quality of life, satisfaction with life, functional assessment questionnaire, frequency of participation, functional mobility scale, pain) and a subset completed a gait analysis, 5-times sit-to-stand (5xSTS), and timed-up-and-go (TUG). Statistical tests used included Wilcoxon rank sum, signed rank, and chi-square (α=0.05). Robust effect sizes (γ*) were calculated.

Results: Twenty-eight cases and 24 controls participated in the study (5 additional cases and 9 controls completed questionnaires only). A short-term gait analysis (~1 year post-DFEO+PTA) was available for 13/28 cases. At baseline, cases had more abnormal gait and higher oxygen consumption than controls ($p<0.05$, Table 1). Between baseline and long-term, gait deviation index (GDI) scores worsened for controls but knee flexion angles did not change, whereas GDI and knee flexion angles improved for cases (Table 1). From short- to long-term, cases lost 6.1° ($p=0.004$) and 5.9° ($p=0.007$) of knee extension at initial contact and minimum flexion, respectively, but GDI did not significantly change (short-term: 70(18), long-term: 64(16), $p=0.138$). Among case and control limbs, 36% and 61%, respectively, were in crouch at long-term ($p=0.045$). The 5xSTS was completed by 42% of each group. Controls tended to perform it faster (d=0.68, $p=0.17$). There were no differences in TUG or questionnaire responses at long-term follow-up.

Conclusion: DFEO+PTA surgery has beneficial effects on knee kinematics during gait into young adulthood for most individuals (compared to baseline and short-term), which is superior over no or alternative treatment(s). On average, however, the superior knee kinematics did not affect life satisfaction, activity, participation, or pain relative to controls.

Significance: Physicians should use the findings to counsel patients who are considering this surgery for the treatment of crouch gait and aid in goal setting.

Table 1. Comparison between case and control groups that complete baseline and long-term follow-up analyses (median(IQR)).

	Ambula-tory, n (%)	Assistive device, n (%)	Limbs (n)	Age at gait analysis (yrs)	FAQ	GDI	Knee flexion θ IC (°)	Min knee flexion θ (°)	Peak knee extensor moment (ND)	Knee flexion contracture (°)	O_2 cons (ND % speed-matched TD)	TUG (sec)	5x STS (sec)
BASELINE													
Case	28/28 (100%)	15/28 (54%)	40	13.5 (4.3)	7(3)	59(9)[B]	42.4 (13.7)[B]	38.3 (10.7)[B]	0.100 (0.040)[B]	15(10)[B]	375 (147)[B]		
Control	24/24 (100%)	11/24 (46%)	34	13.1 (2.3)	8(2)	68(11)[B]	36.1 (9.6)[B]	27.1 (10.3)[B]	0.083 (0.034)[B]	10(5)[B]	263 (172)[B]		
Effect size (γ_1^*) between groups					0.00	0.84	-0.52	-1.64	-1.44	-1.97	-0.82		
LONG-TERM													
Case	27/28 (96%)	15/27 (56%)	40	25.9 (6.3)	8(4)	64(14)[C]	28.4 (13.3)[C]	11.9 (18.8)[I,C]	0.069 (0.037)[C]	0(5)[I,C]	253 (64)[C]	17.1 (13.7)	20.3 (10.1)
Control	22/24 (92%)	11/22 (50%)	34	27.4 (7.0)	8(4)	62(13)[C]	35.2 (19.5)	21.1 (20.2)[I]	0.066 (0.044)	10(8)[I,C]	254 (139)	15.0 (20.9)	14.4 (8.9)
Effect size (γ_1^*) between groups					-0.09	-0.10	0.92	0.58	-0.74	1.04	-0.13	-0.14	-0.97
TD reference (mean±SD)					10	100±10	3.9±5.7	6.0±6.1	0.043± 0.013	0	100		

Cons: consumption; **FAQ**: functional assessment questionnaire; **GDI**: gait deviation index; **IC**: initial contact, **ND**: non-dimensional; **TD**: typically developing; **TUG**: timed up-and-go; **5x STS**: 5 times sit-to-stand.

[B] significant difference between groups at baseline ($p<0.05$)

[I] significant difference between groups at long-term follow-up ($p<0.05$)

[C] significant difference from baseline values ($p<0.05$)

Comparison of Early Lower Extremity Functional Recovery in Pediatric Patients following Anterior Cruciate Ligament Reconstruction Using Transphyseal Hamstring versus Physeal-Sparing IT Band Autograft

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LOE–Therapeutic–Level II

Purpose: The influence of graft type and gender in anterior cruciate ligament reconstruction (ACLR) has not been adequately studied in pediatric patients. The purpose is to compare parameters of early lower extremity functional recovery among three cohorts of pediatric patients under 15 years-old who underwent ACLR with one of two different techniques, which involve the harvesting of different types of autograft: pediatric males with transphyeal ACLR with hamstring (PM-HS), pediatric females with transphyseal ACLR with hamstring (PF-HS), and pediatric males with physeal sparing ACLR with IT band (PM-ITB).

Methods: A prospective cohort study design was used. Approximately 6 months following ACLR, thigh circumference, knee ROM (extension and flexion), strength (quadriceps, hamstrings, hip abductors, and hip extensors), Y-balance (anterior, posterolateral, and posteromedial reach), and functional hop tests (single, triple, cross-over, and 6 meter timed hops) were assessed in all ACLR patients under 15 years-old. Limb symmetry index was used to compare deficits between involved and uninvolved limb between the three graft groups (PM-HS, PF-HS, and PM-ITB). There were inadequate numbers of pediatric females who underwent ITB ACLR for analysis. Analysis of variance (ANOVA) with post-hoc correction was employed.

Results: A total of 87 pediatric ACLR patients (PM-HS: N=20, Age:14.3±1.1; PF-HS: N=33, Age:13.9±0.7; PM-ITB: N=34, Age:13.2±1.3) were examined. There was no statistically significant difference in ROM and Y-balance tests performance between the cohorts. Of the various additional comparisons analyzed, only the following findings were statistically significant: (a) PM-HS demonstrated greater thigh circumference deficits (-3.7% relative to healthy limb) than PM-ITB (-1.5% relative to healthy limb, p=0.024). (b) PM-HS group showed greater hamstring strength deficits (-34.1% relative to healthy limb) than PM-ITB (-7.1% relative to healthy limb, p=0.001). The hamstring strength deficits of PF-HS (-13.3% relative to healthy limb) were not different from either of the male cohorts. (c) PM-HS cohort showed greater deficits in the triple hop test (-40.1% relative to healthy limb) compared to PM-ITB (-17.9% relative to healthy limb, p=0.019) and PF-HS (-10.2% relative to healthy limb, p=0.001).

Conclusion: At approximately 6 months following ACLR, PM-HS patients demonstrated significant deficits in thigh circumference, hamstring strength, and functional hop test performance, compared to PM-ITB.

Significance: Autograft harvest and procedure selection may influence strength and functional recovery following ACLR in pediatric patients. Approximately at 6 months

post-operatively, PM-ITB generally showed superior recovery compared to PM-HS. Additional research correlating timing and nature of functional recovery with graft retear and athletic performance are warranted.

Magnetic Resonance Imaging Detection of Meniscal Injuries in Pediatric and Adolescent Patients with Anterior Cruciate Ligament Tears

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LOE–Diagnostic–Level IV

Purpose: Magnetic resonance imaging (MRI) is the primary diagnostic tool for imaging soft tissue knee injuries. Prior research has shown decreased sensitivity and negative predictive value of meniscal injury detection using MRI in the setting of acute anterior cruciate ligament (ACL) tears in an adult population. This has yet to be investigated in a younger population. The objective of this study was to assess the diagnostic ability of MRI in detecting meniscal injuries for pediatric and adolescent patients undergoing arthroscopic ACL reconstruction.

Methods: From August 2012 through June 2016, 175 arthroscopic ACL reconstructions were performed at our institution. After excluding patients with prior ACL or meniscal surgery, age greater than 18 years old, missing operative report details, and time from MRI to surgery greater than 90 days, 75 patients were ultimately included in our analysis. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of meniscal tears (medial, lateral, or both) on MRI were calculated. ANOVA and two-sample t-tests were used to compare event rates between medial meniscal (MM) and lateral meniscal (LM) tears.

Results: The median age of our cohort was 15 (range: 7-18). Figure 1 shows the accuracy of MRI for patients with arthroscopically confirmed meniscal tears with a concurrent ACL tear. There were 24 (32.0%) cases in which a meniscal injury not detected on MRI was discovered arthroscopically (MM: 4 knees, LM: 19 knees, both: 1 knee). These false negative MRIs were more commonly a LM tear ($p<0.001$) and of the vertical tear type (12/24 tears, 50.0%). The posterior horn was the most common location for a missed LM tear ($p<0.001$). In comparison to an adult cohort studied previously (median age: 32, range: 16-61), the MRIs of our patients with LM tears had a decreased NPV ($p<0.001$).

		Arthroscopic Finding		
		Tear Present (+)	Tear Absent (-)	Total
MRI Finding	Tear Present (+)	42	3	45
	Tear Absent (-)	24	6	30
	Total	66	9	75
Sensitivity	63.6%			
Specificity	66.7%			
PPV	93.3%			
NPV	20.0%			

Figure 1: Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of MRI in detecting meniscal tears (medial, lateral, or both) in pediatric and adolescent patients with concurrent ACL injuries.

Conclusion: For our pediatric and adolescent patients with ACL injuries, there were 24 (32.0%) cases in

which preoperative MRI failed to detect a meniscal tear. LM tears in the posterior horn were more commonly missed on MRI versus MM tears. Also, a vertical tear was the most commonly missed tear type. In comparison to an adult cohort, the MRIs of pediatric and adolescent patients with LM tears had a decreased NPV.

Significance: These findings have implications regarding patient preoperative counseling, operative planning, anticipatory guidance regarding postoperative rehabilitation, recovery expectations, and surgical outcomes.

Analysis of Failure and Outcomes After Revision Medial Patellofemoral Ligament Reconstruction

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LOE–Therapeutic–Level IVPurpose: Introduction: MPFL reconstruction (MPFLR) is preferred treatment for patellar stabilization. With increasing practice of MPFLR, there is an increase in the number of its failures. The purpose of our study was to report on the analysis of failure of primary MPFLR and outcomes after revision MPFLR.

Methods: Materials and Methods: 217 patients underwent MPFLR between 2008- 2013 at our institution. Of these, 15 patients (16 knees) underwent revision MPFLR (incidence 6.9%). Medical chart and radiologic studies were evaluated for analyzing failure of primary MPFLR and outcomes of revision MPFLR.

Results: The average age at primary MPFLR was 13.4 years (range, 7-19 years) and 15.4 years at revision surgery. There were 11 girls; 9 right knees. 5/12 patients with simultaneous bilateral MPFLR and 2/19 with staged bilateral MPFLR required revision surgery. The average time between 2 surgery was 27.5 months (range, 7 to 41 m). Revision MPFLR was performed for increased patellofemoral pain (4 knees), recurrent lateral instability (7), medial instability (2) and traumatic disruption (3). Patellar cartilage lesions were present in 44% patients. Associated procedures during revision surgery included patellar chondroplasty (6 knees), tibial tubercle osteotomy (2), lateral retinacular release (1) and lateral retinacular repair (1). The previous MPFL graft was stretched (5 knees), too tight due to anterior femoral tunnel (3), or torn from femoral attachment (1). All patients had patella alta and trochlear dysplasia. Soft tissue allograft was used in 9 patients; others had autograft. Complications after revision MPFLR included patellar fracture (1 knee), patellofemoral arthrosis necessitating patellar chondroplasty (2), sciatic nerve injury from regional block (1) and patellar subluxation (1). At latest follow-up, 13/16 knees had satisfactory outcomes after revision MPFLR.

Conclusion: Failure rate of isolated MPFLR is about 7% in a large series of patients with patellar instability. Common reasons for failure are pain and persistent or recurrent instability. Patients with bilateral MPFLR were more likely to have failure compared to unilateral MPFLR. Revision MPFLR is a viable alternative after failure of primary MPFLR, though additional procedures are frequently required.

Significance: Analysis of failure of MPFLR could potentially help to avoid such complications. Risk factor stratification including bilaterality and dysplastic anatomy of patellofemoral joint could help counsel patients about possibility of failed MPFLR. Revision MPFLR has higher complication rate but it's an effective option for patellar stabilization after failed primary MPFLR.

The Warm-up Programme "FIFA 11+ Kids" in Prevention of Injuries in Children's Football: A Cluster Randomized Controlled Trial

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LOE–Prognostic–Level I

Purpose: To evaluate the efficacy of a new prevention programme ("FIFA 11+ Kids") in regards to its potential to reduce football related injuries in 7-13 year old players.

Methods: Children's football teams from Switzerland, Germany, the Czech Republic, and the Netherlands were randomised to an intervention (INT, 2040 players) and a control group (CON, 1855 players), and followed for one season 2014/2015. The INT replaced their usual warm-up by the "FIFA 11+ Kids"programme, while CON warmed-up as usually. The programme consists of seven different exercises, each with 5 levels of difficulty. The primary outcome of the study was the overall risk of injuries. Secondary outcomes were the risks of severe injuries and lower extremity injuries. Severe injuries led to absence from games/trainings for more than 28 days. Every week the contact person of each team entered exposure and injury data into an online injury recording system. Time-to-injury data were analyzed, and hazard ratios (HR) calculated using extended Cox regression models.

Results: 3895 player seasons (mean age 10.8 years, SD 1.4) and 292749 hours of football exposure were recorded. During the study period 374 injuries occurred (INT = 139; CON = 235). Overall injury rate in INT was reduced by 48% compared to CON (HR 0.52; 95%-confidence interval 0.32 – 0.86, P = 0.01). Severe injuries (74% reduction, HR 0.26; 95%-CI 0.10 – 0.64, P = 0.003) and lower extremity injuries (55% reduction, HR 0.45; 95%-CI 0.24 – 0.84, P = 0.01) were also reduced. Mean lay-off time and total number of days lost due to injury were significantly lower in INT. Knee, ankle, thigh, and hip/groin injuries were less frequent in INT with HRs ranging between 0.40 and 0.52. Joint/ligament, muscle injuries, fractures, as well as overuse-related complaints showed HRs between 0.12 and 0.56. Also running/jumping, overuse/growth, and collision-related injuries were lower in INT with HRs between 0.30 and 0.52. Injury risk decreased with increasing compliance. A frequency from minimum one regular session with programme per week led to a significant reduction of injury risk.

Conclusion: "FIFA 11+ Kids" is effective in reducing injuries in children's football. Considerable effects were found for overall, severe, and lower extremity injuries. The preventive benefit depends on compliance. The programme should be used at least once per week.

Significance: A broad implementation of the programme may help to reduce the number of injuries in children's football and to support the health benefits of playing football in the long term.

Arthroscopic Capsulolabral Reconstruction for Posterior Shoulder Instability Is Successful in Adolescent Athletes

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LOE–Therapeutic–Level III

Purpose: Posterior shoulder instability is an increasingly common pathology recognized in athletes. Adolescent athletes are especially at risk due to widespread participation in numerous sports, including both overhead throwing and collision activities. However, little data is available regarding surgical outcomes in these athletes with only a single small case series (N=25) currently published.

Methods: One hundred ten adolescent athletes (121 shoulders) with unidirectional posterior shoulder instability were treated with arthroscopic posterior capsulolabral reconstruction and underwent evaluation at a mean of 36 months postoperatively. The average age was 17 years (range 13-19), with 97 males (80%) and 24 females (20%). Eighty athletes (67%) participated in contact sports and 46 (38%) participated in overhead throwing sports. Data collected prospectively both pre- and post-surgery was retrospectively reviewed, and included ASES score, subjective stability score, strength, range of motion, and return-to-play status. Intraoperative findings and methods of fixation were also recorded.

Results: Mean ASES score improved from 47.2 to 85.9 ($P < .001$) following surgery. There were also significant improvements in stability, pain, and functional scores following surgery. Contact athletes showed a tendency towards improved subjective stability following surgery when compared to non-contact athletes (1.8 vs. 2.5; t=2.3, p=.02), but otherwise, the two groups were similar. Throwers showed no differences in preoperative or postoperative outcomes compared to non-throwers. Female athletes tended to have significantly lower pre- and post-operative ASES scores, specifically within the pain domain when compared to males. However, when considering the change in outcomes scores between pre- and post-operative time points, there was no difference with regard to the degree of improvement in ASES scores and the pain domain. Patients who underwent capsulolabral plications with suture-anchors showed a trend towards greater improvement in ASES scores, but did not reach statistical significance. Overall, 88% of athletes were able to return to competition, with 67% returning to their pre-injury level of play. No significant differences were noted with regard to return-to-play rates based on gender or type of sport.

Conclusion: Arthroscopic capsulolabral reconstruction is a reliable treatment for unidirectional posterior shoulder instability in an adolescent population, and does well for athletes involved in both contact and overhead-throwing sports. Female athletes with posterior instability have lower outcomes scores than their male counterpoints both before and after surgery, but they show similar post-operative improvement and return to play following surgery.

Significance: Arthroscopic capsulolabral repair for posterior shoulder instability is successful in adolescent athletes participating in a wide range of sporting activities.

12 Year Follow Up of Autologous Chondrocyte Implantation (ACI) for Knee Juvenile Osteochondritis Dissecans (JOCD)

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LOE–Therapeutic–Level IV

Purpose: Salvage options after failure of knee JOCD primary surgical intervention are controversial. Concern regarding ability of ACI to correct for the bone and cartilage pathology of knee JOCD exists. Short and mid-term results have been promising. Long term outcomes have not been reported on ACI in knee JOCD.

Methods: A single institution, longitudinal cohort study design combining medical record review and outcome surveys was used. Inclusion criteria included isolated JOCD diagnosis, failed primary healing of operatively treated JOCD, ACI surgery > 5 years ago, and <23years of age at time of ACI. IKDC, KOOS, and modified Cincinnati Knee Rating outcome scores were collected. Scores reported as mean ± standard deviation

Results: 10/26 eligible patients (38%) participated. (M:F=5:5, age at ACI: 18.3±2.5y, current age: 30.8±5.1y, current BMI: 24.6±2.1). Follow up was 12.0±4.5y. Lesion size at ACI: 9.1±6.1cm2. Femoral condyle location: Medial =6, Lateral=4. All required treatment at some point for knee symptoms after ACI: physical therapy=8pts, brace=5pts, injection=3pts, re- operation=3pts. During the past one year, four patients received treatment: brace=2pts, work restrictions=1pt, oral medications=1pt. IKDC score: 71.8±9.7. KOOS scores: pain [88.7±7.1], symptoms [78.2±14.4], activity of daily living [94.7±6.0], function, sports, and recreational activities [73.0±16.9], and quality of life [57.5±18.4]. Modified Cincinnati Knee Rating score: 7.9±1.2. Only BMI and lesion size had moderate to good correlation with KOOS Symptom score (Table 1).

Correlation Coefficient Analysis of the Three Outcome Scales, Lesion Size, BMI, and Age at ACI Implantation

	Lesion Size	BMI	Age at ACI Implantation
IKDC Total Score	- 0.29	- 0.28	- 0.08
KOOS Symptoms	- 0.51*	- 0.51*	0.32
KOOS Pain	0.04	- 0.49	- 0.03
KOOS Function, activity of daily living	- 0.02	0.01	- 0.09
KOOS Function, sports and recreational activities	- 0.30	- 0.18	0.23
KOOS Quality of life	- 0.12	- 0.06	0.22
Modified Cincinnati Knee Rating Total Scores	- 0.01	0.40	- 0.36

Values were expressed by correlation coefficient value r. *Two variables: Moderate to good relationship were found between KOOS symptoms and Lesion size (p=.135) and KOOS symptoms and BMI (p=.133), but non-significant.

Conclusion: This is the first long term study of ACI treatment of knee JOCD patients. This study confirms sustained results of ACI in knee JOCD patients and results which are similar to or better than adult OCD patients. Patients should be advised of the high need for further treatments including non-operative and operative interventions after ACI.

Significance: Follow up of JOCD patients undergoing ACI after failed primary operative treatment shows it is a viable treatment option with sustained improvement in outcome scores through 12 years despite the high need for continued treatment.

Pediatric ACL Reconstruction and Return to the Operating Room: Graft Failure is Less Than Half of the Story

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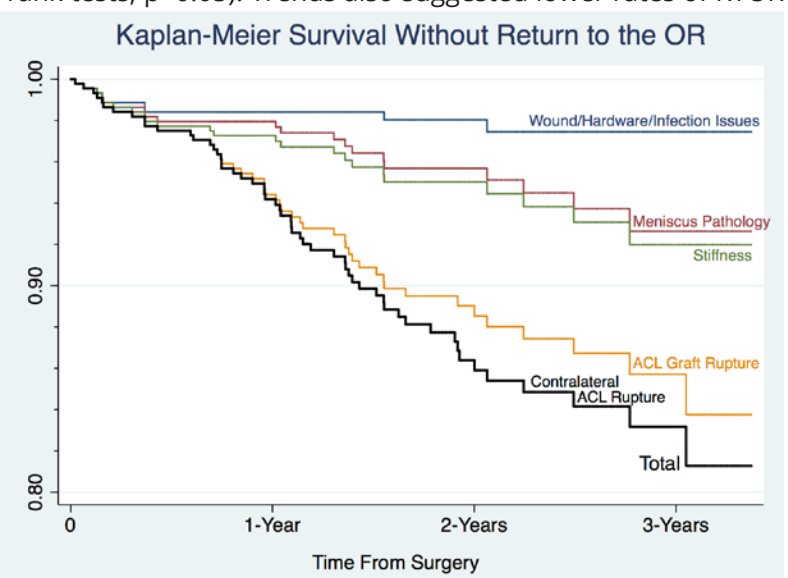
LOE–Therapeutic–Level III

Purpose: Anterior cruciate ligament (ACL) reconstruction is one of the most common pediatric orthopaedic procedures. While most ACL reconstruction (ACLR) outcomes studies focus on the risk of graft failure (re-tear), few describe the likelihood of unplanned return to the operating room (RTOR) for all injury-related causes.

Methods: Primary and revision ACLR procedures performed at one hospital between May 2013 and December 2015 were evaluated. After exclusion criteria (coexistent Salter-Harris femur/tibia fracture, concomitant proximal fibula fracture, planned staged reconstruction, congenital absence of the ACL) were applied, 440 subjects remained. Baseline and operative data were recorded. Subsequent OR procedures were considered as "unplanned" return trips to the OR if they reasonably pertained to the patient's ACL injury or a potential predilection for knee injury. These incidents were further classified by indication. Survival analyses for this retrospective cohort were performed using Kaplan-Meier estimators.

Results: Patients ranged in age from 8-23 years. Survival data showed an 18.5% incidence rate for unplanned RTOR within 3 years and 4 months of ACLR. The main indications in the first 6 months were wound dehiscence or irritation, symptomatic hardware, and infection (very rare). After 9 months, ACL graft rupture became a risk, with the incidence rate reaching 8.1% over the follow-up period. Notably, 42% of ACL graft ruptures occurred prior to the patient being released to full activity.
At 1-year post-op, patients with all-epiphyseal ACLR, autograft ACLR, or ACLR with simultaneous meniscus repair or meniscectomy all had lower rates of RTOR than the rest of the cohort (log-rank tests, $p<0.05$). Trends also suggested lower rates of RTOR for African-Americans and those with all-inside ACLRs. The event rate varied by the sport being played at injury, with skiiers/snowboarders (36%) and soccer players (27%) having particularly high rates of RTOR by 3 years and 4 months.



Conclusion: While RTOR after ACLR is a significant cause of morbidity in pediat-

ric patients, ACL graft rupture accounts for less than half of the total incidence rate. Almost half of the re-tears documented occurred as a result of patient actions before full release to activity. This suggests that strict patient adherence to activity restrictions during the rehabilitation phase may drastically reduce the risk of graft failure. On the other hand, participation in sports such as skiing, soccer, and volleyball may increase the risk of unplanned RTOR after ACLR.

Significance: This is among the first studies to comprehensively report on return to the operating room after ACL reconstruction in the pediatric population and thus may be used to properly counsel pediatric patients on the immediate and mid-term risks of ACLR. For clinicians, this work details the potential for increased morbidity with ACLR and identifies interventions that may reduce these risks.

Risk of Graft Failure after All-Epiphyseal ACL Reconstruction Compared to Adult-Type ACL Reconstruction with Hamstrings Autograft Tissue in Young Athletes

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LOE–Therapeutic–Level II

Purpose: The most common complication of ACL reconstruction in young patients is graft re-tear, with the incidence reported up to 20%. The purpose of this study was to compare the graft failure rate in a cohort of skeletally immature patients who receive an all-epiphyseal ACL reconstruction (ACLR) procedure to comparably active adolescents undergoing ACLR with HS autograft tissue. The hypothesis tested was that no significant difference would be observed between skeletally immature patients who received an all-epiphyseal ACLR with HS autograft tissue and adolescents undergoing a traditional adult ACLR with hamstring (HS) autograft tissue.

Methods: 100 patients with a mean age of 15.7(±2.5) years old underwent ACLR with HS autograft tissue. Twenty of the patients were skeletally immature (12.3±1.9 yrs) and underwent an all-epiphyseal ACLR (PEDS-ACLR), while the remaining 80 subjects were sufficiently mature (16.5±1.9 yrs) to undergo a traditional, trans-epiphyseal ACLR with femoral and tibial drill holes and HS autograft tissue (Ad-HS ACLR). These patients were enrolled in a prospective, observational cohort study and were tracked for incidence of 2nd ACL injury after ACLR for a median of 62 months. 17 patients sustained a graft failure after ACL and RTS. Fisher's exact analyses were used to determine which patient group (PEDS vs. Ad-HS) was more likely to suffer an ipsilateral graft failure.

Results: 14 patients (17.5%) who received a traditional adult ACL reconstruction with HS autograft suffered an ipsilateral graft re-tear injury after RTS, with 11 of these occurring in the first 12 months after RTS. Similarly, 3 (15%) of the patients receiving an all-epiphyseal ACLR with HS autograft suffered graft failure after RTS with 1 occurring in the first 12 months after RTS. No statistically significant difference existed in graft failure rate between the PEDS ACLR group and the Ad-HS ACLR group at 12 months post-ACLR (p=0.451) and also at long term follow-up (p=1.0).

Conclusion: These findings support the hypothesis that young, skeletally immature patients who receive an all epiphyseal ACLR have comparable graft failure rates compared to young skeletally mature patients of comparable activity level, who receive a traditional, trans-epiphyseal ACLR.

Significance: Graft failure rates were observed to be comparable; hence, use of an all epiphyseal ACLR technique in skeletally immature patients may be an optimal method to restore mechanical stability in young athletes after ACL injury and theoretically minimize the risk of iatrogenic growth disturbance.

Early Results and Safety of the "Hybrid" Physeal Sparing ACL Reconstruction in Skeletally Immature Athletes

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LOE–Therapeutic–Level IV

Purpose: Anterior cruciate ligament reconstructions (ACLR) in skeletally immature athletes is being performed more frequently today than in the past. Delaying reconstruction until skeletal maturity has been shown to have adverse effects including risk of chondral and meniscal injuries. Therefore the quest to find a safe and successful technique to perform ACLR in the skeletally immature is important. Several physeal sparing techniques have been described and some are appropriate for prepubescent athletes. The pubescent aged athletes represent a higher risk group. This study looks to review the results of a hybrid, physeal-sparing technique for ACLR in these pubescent athletes.

Methods: Surgical logs of ACLR performed at a single pediatric / adolescent sports medicine center since 2011 were reviewed. Athletes with open physes who had ACLR with a femoral physeal sparing tunnel and trans-physeal tibial tunnel placed centrally and vertically were identified. Their demographics, operative reports, rehabilitative course, time to return-to-play, outcome scores, and post-operative radiographs were collected and analyzed.

Results: Thirty-eight patients met the criteria: average age 12.7 years (9.9-15.1), 26 males, 24 patients had returned to play (1 lost to follow-up, 5 still in rehabilitation and 7 cleared but status unknown) at or above their pre-injury competitive level at an average of 8.7 (5.8-13.8) months for males and 8.1 (5.0-12.2) months for females. Average Pedi-IKDC scores were 92.4 (10.2), and ACL-RSI Score were 85.8 (16.1) at an average of 1.4 years (0.5 – 4.7 years) after surgery. Nineteen had radiologic evaluation performed including long legged mechanical axis films at an average of 18.9 months (5.8-58.8) post-operatively. One patient had an identified growth disturbance on clinical and/or radiographic exam. That patient had femoral and tibial growth acceleration treated with growth modulation surgery.

Conclusion: The femoral physeal sparing with trans-physeal tibial drilling "hybrid" technique in skeletally maturing athletes appears to have a high rate of success with low morbidity. However, the possibility of physeal abnormalities does exist and demonstrates the importance of close post-operative follow-up and evaluation until skeletal maturity is achieved.

Significance: ACLR in skeletally immature patients is performed on an increasingly regular basis. Establishing the best and the safest technique to do so is therefore important. It appears that in skeletally maturing athletes – those athletes at high risk of suffering ACL injuries – that the hybrid technique is effective and safe.

Arthroscopic Implantation of Meniscal Scaffold for the Treatment of Irreparable Meniscal Injury - Preliminary Study

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LOE–Therapeutic–Level IV

Purpose: Subtotal, irreparable injury to the meniscus in adolescents is a rare and severe condition. Loss of meniscus in young age may provoke early degenerative changes. Meniscal scaffold implantation can be considered as an effort to prevent those changes. The purpose of this study was to investigate the safety and efficacy of meniscal scaffold implantation in adolescents.

Methods: A retrospective analysis was performed in 12 patients (5 males, 7 females) that sustained severe, irreparable injury to the meniscus. In those patients meniscal scaffold was arthroscopically implanted. Mean age at the surgery was 16,4 years (15-17), mean follow-up was 26,1 months (12-41). 7 patients underwent ACL reconstruction prior to meniscal implantation. There were 7 medial and 5 lateral menisci implanted. All patients underwent the unified 24-week physiotherapy protocol. Clinical examination and MRI evaluation was performed at 12 months post-op and clinical examination only, at each next 12 months interval.

Results: 11 patients achieved good MRI and clinical result (mean IKDC value – 78) at 12 moths post-op. One patient, 3 months post-op, sustained acute knee injury resulting in destruction of reconstructed ACL and scaffold. 3 patients, due to meniscal symptoms and discomfort in operated knee, underwent arthroscopy that showed scaffold injury, instability and degeneration in the second year of follow-up. The total failure rate was 33% (4/12 knees; 3 medial and 1 lateral meniscus). All failures were noted in patients with previously reconstructed ACL. Failure rate was 57% (4/7 knees) in this group. The remaining group of patients presented good or excellent clinical outcome (IKDC value - 88) at final follow-up. Mean surgery time was 55 min (40-85), there was no complication in early post-op period.

Conclusion: Two third of adolescent patients with meniscal scafold implantation have good or excellent result in 2-years follow-up. Patients with reconstructed ACL are in the high failure risk group, thus the special attention should be paid in this group and postponement of the surgery should be considered.

Significance: This study should be considered as the initial evaluation of the method of meniscal replacement in adolescent. This study shows that the method can be safe and effective however, some modifications in inclusion criteria must be implemented. However, the main goal of the method is prevention of the early degenerative changes, to be able to confirm this thesis further investigation must be performed in future.

Effect of Meniscal Tear on Strength and Functional Performance in Young Athletes at 6 Months Following Anterior Cruciate Ligament Reconstruction with Hamstring Autograft

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LOE–Therapeutic–Level III

Purpose: To assess the performance on strength, dynamic balance, and functional hop tests of a cohort of pediatric and adolescent patients 6 months following anterior cruciate ligament reconstruction (ACLR), with and without meniscus tears. These measures were analyzed for the effect of age, gender, and meniscal repair on readiness to return to sports.

Methods: Prospectively collected 6-month post-operative return to play assessments were retrospectively analyzed on 165 patients ≤25 years of age. All patients underwent ACLR with autograft hamstring between January 2011 and October 2015 at a large pediatric tertiary referral center. Strength (quadriceps, hamstrings, hip abductors, and hip extensors), dynamic balance (anterior, posterolateral, and posteromedial reach), and functional hop tests (single, triple, cross-over, and 6 meter timed hops) were assessed. Limb symmetry index (LSI) was used to compare deficits between involved and uninvolved limb. Demographic, surgical, and LSI data were analyzed.Sub-groups were compared using analysis of covariance (ANCOVA) models.

Results: 115 females (70%) and 50 males (30%) with a mean age of 16.4 years (range 12.3 - 25) and a mean BMI of 24 were analyzed. 58% of patients had concomitant meniscal tears (59% lateral, 27% medial, 14% lateral and medial), consisting of 54% of females and 66% of males. 61% of tears were repaired whereas 39% were treated with partial meniscectomy, rasping, or trephination. All patients who underwent meniscal repair had some range of motion and weight bearing limitations in the first 6 weeks post-operatively. The meniscus tear group had greater hamstring strength deficits at 6 months post-operatively than those with no tear (32.3% vs. 24.6%, p=0.028). The meniscal repair group had greater hamstring strength deficits than the meniscectomy/rasping/trephination group (34.3% vs. 26.2%, p=0.023). Performance on dynamic balance and functional hop tests were similar between all meniscus sub-groups. There were no gender effects on any sub-group comparisons.

Conclusion: At 6 months post-operatively, this cohort of young athletes who underwent ACLR with hamstring autograft had significant hamstring strength deficits, compared to their non-operative leg. These deficits were similar between genders. Presence of a meniscus tear and treatment with meniscus repair, or its related rehabilitation restrictions, appear to have adverse effects on post-operative recovery of hamstring strength.

Significance: More sophisticated strength testing during post-ACLR return to play assessments, with consideration of delayed return to sport between 7-9 months in the presence of a meniscal repair, may be warranted. Additional investigations into the functional implications of such performance deficits, and the associated ACL re-tear rates, is warranted.

Are Basketball and Soccer Risk Factors for Juvenile Osteochondritis Dissecans of the Trochlea? A Cohort Study of 34 Trochlear Lesions

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LOE–Prognostic–Level IV

Purpose: To evaluate the clinical characteristics, radiographic findings, and outcomes of patients with juvenile osteochondritis dissecans (JOCD) of the trochlea. To our knowledge, this is the largest cohort reporting JOCD lesions in this unusual location. We hypothesize that trochlear JOCD lesions are associated more with young athletes who play soccer and basketball. We report that trochlear JOCD may have better surgical results than previously thought.

Methods: This is a retrospective study of 34 trochlear JOCD lesions in 30 patients. Demographic data, sports played, comorbidities, surgical procedures, and clinical data were extracted from charts. Pre- and post-operative radiographic imaging including magnetic resonance images (MRIs) and X-Rays were evaluated.

Results: Our cohort consisted of 34 consecutive trochlear JOCD lesions in 30 patients (26 boys, 4 girls). Average age at diagnosis was 13.8 years (9.6-18.0). Twenty-seven (90%) patients were active. Of the sports played by this active cohort, soccer and basketball were the most common. Thirteen of the 27 (48%) active patients played soccer, 15 of 27 (56%) played basketball, and 23 (85%) playing either or both. The area of the lesions averaged 276 mm^2 (17.2-839.6). Twenty-one knees (62%) underwent operative treatment (Figure 1). Sixteen of the surgical patients underwent repair and fixation with bioabsorbable nails. All fixation procedures used 1.6 mm bioabsorbable nails, with an average of 6 nails (4-8). Ten of the patients who underwent fixation reached clinical and/or radiological follow-up of at least 12 months, with an average follow-up of 21.7 months (12.0-37.3). Average MRI follow-up was 22.0 months (12.0-37.3) with no patient demonstrating loss of fixation. Ten of the patients who underwent fixation were active, and nine of these patients reported successful return to sports. Only one patient needed revision debridement and chondroplasty following initial fixation. At one year follow up, this patient reports lack of pain and has returned to sports.

Conclusion: JOCD lesions are rarely located in the trochlea. In this study, we examined the largest cohort of patients with lesions in this unique location. Patients with trochlear lesions were mainly teenage boys who participated in jumping and cutting sports which load the patellofemoral joint such as basketball and/ or soccer (84%). Trochlear JOCD patients tended to have a high surgical rate, where over half of the patients un-

derwent operative treatment. Repair and fixation produced good outcomes at short-term follow-up.

Significance: This study encourages awareness of trochlear JOCD as a differential diagnosis for anterior knee pain in adolescents playing basketball and soccer.

Transplantation of Autologous Culture-Expanded Bone Marrow Cells and Platelet Rich Plasma for Bone Regeneration-Comprehensive Clinical Study of the Lower Limb Lengthening-

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LOE–Therapeutic–Level III

Purpose: Since 2002, we have performed a cell therapy using autologous culture-expanded bone marrow cells (BMC) and platelet rich plasma (PRP) to accelerate bone regenerates during the limb lengthening (Bone 2004, 2007, JPO 2007, 2009). In the present study, we comprehensively compared clinical outcome of the lower limb lengthening between the bones treated with and without cell therapy.

Methods: We reviewed the charts and radiographs of 108 consecutive patients who underwent lower limb lengthening at our institution during the period 1990-2015. Patients were divided into two groups. The BMC group that was treated with BMC and PRP transplantation, consisted of 133 bones in 54 patients while the control group that had no additional cell therapy, consisted of 97 bones in 54 patients. True complications described by Paley (Clin Orthop 250:81-104, 1989) were defined as adverse events. Clinical outcome was primarily assessed based on the healing time and associated adverse events. Good clinical outcome was defined as the bones with the healing index of 50 days/cm or less with no adverse events. Since the bone regeneration could be affected by an underlying etiology, we evaluated the outcome individually by three separate groups according to the classification of Launay, (Orthop Traumatol Surg Res 99:72-79, 2013). Group 1 (congenital deficiencies such as fibular hemimelia) consisted of 29 bones, Group 2 (achondroplasia or other skeletal dysplasias) consisted of 146 bones, and Group 3 (healthy bones such as post-trauma or post-infection) consisted of 55 bones.

Results: There were no transplantation-related complications. Clinical outcomes of each etiology were shown in Table 1. The outcome was better in Group 2 and poorer in Group1 in both treatment groups. Clinical outcome was significantly improved by cell transplantation in Group 2 and 3, although there was no significant difference in the age of surgery in both groups. In Group 1, although healing was accelerated by cell therapy, clinical outcome did not reach statistical significance. The rate of adverse events in each etiology was similar in both treatment groups, while the healing was promoted by BMC and PRP transplantation.

Table 1

Group 1	Age (years)	Length gained (cm)	Healing index (<50/50≦)	Advers events (-/+)	Outcome (good/poor)
BMC (N=10)	11.0±4.7	6.7±2.7	6/4	8/2	4/6
Control (N=19)	14.5±6.7	4.2±2.2	2/17	14/5	2/17
P value	0.0581	0.0131*	0.0089*	0.7056	0.0625
Group 2	Age (years)	Length gained (cm)	Healing index (<50/50≦)	Advers events (-/+)	Outcome (good/poor)
BMC (N=96)	15.0±3.9	8.7±1.5	86/10	87/9	79/17
Control (N=50)	15.3±4.7	8.1±2.1	39/11	40/10	33/17
P value	0.7157	0.2014	0.0584	0.0702	0.0271*
Group 3	Age (years)	Length gained (cm)	Healing index (<50/50≦)	Advers events (-/+)	Outcome (good/poor)
BMC (N=27)	14.0±4.3	6.8±2.2	23/4	24/3	20/7
Control (N=28)	15.8±4.6	4.2±2.2	8/20	23/5	5/23
P value	0.0502	< 0.0001*	< 0.0001*	0.4781	< 0.0001*

Conclusion: Transplantation of BMC and PRP improved clinical outcome of the lower limb lengthening by accelerating bone regenerates in various etiologies.

Significance: The bone lengthening is a tough procedure that needs significant time and efforts for patients as well as physicians. BMC and PRP transplantation is an easy and safe technique that can reduce the degree of difficulty of the bone lengthening.

Simultaneous Acute Femoral Deformity Correction and Gradual Limb Lengthening Using the Retrograde PRECICE® Femoral Nail: Technique and Clinical Results

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LOE–Therapeutic–Level III

Purpose: Patients with leg length discrepancies often have other concomitant deformity. This combination usually requires the use of an external fixator to comprehensively correct the alignment. With the advent of the intramedullary lengthening nails, new surgical techniques have been developed that allow multiplanar correction without the use of post-operative external fixation. This study describes the outcomes of acute, fixator-assisted deformity correction with gradual lengthening, using the retrograde femoral PRECICE® nail.

Methods: This was a multi-center, retrospective series of patients undergoing the same surgical technique for correction of multiplanar deformity. Each patient had angular or rotational femoral deformity combined with a leg length discrepancy. The surgical technique used a fixator-assisted method to correct the femoral deformity acutely through a percutaneous osteotomy. A retrograde femoral PRECICE® nail was inserted with blocking screws to maintain the alignment and the fixator was removed intraoperatively. The PRECICE® nail was used post-operatively to gradually correct the limb length discrepancy.

Results: Twenty-seven patients were treated with this technique. The mean follow-up was 13 months. The average pre-operative leg length discrepancy was 3.1 cm. Secondary deformities were mainly valgus (15 patients) and varus (10), and averaged 7 degrees out of alignment. The mean pre-operative LLRS-AIM score for each patient was 4.6 $\pm$ 2.3 (range, 1-11). The average pre-operative knee arc of motion was 125 degrees. Post-operatively, 93% of patients corrected to within 3 mm of length discrepancy (mean lengthening, 30 mm), and 81% had mechanical axis deviation corrected within 8 mm. Mechanical lateral distal femoral angle corrected to an average of 88 degrees postoperatively. Of all study patients, 96% had excellent final Paley scores. The average number of blocking screws per patient was 1.3. Mean post-operative knee arc of motion was 123 degrees. There were no infections, fractures, hardware mechanical failures, or hardware breakage in any of the patients. There were no cases of insufficient regenerate bone formation.

Conclusion: Using the fixator-assisted technique and supplemental blocking screws, the retrograde femoral PRECICE® nail effectively corrected both limb length discrepancy and deformity, with excellent overall outcomes.

Significance: Prior to the advent of intramedullary lengthening nails, multiplanar deformity with leg length discrepancy could only be corrected with an external fixator. This novel technique allows the entire correction to be performed without the use of an external fixator post-operatively. Consequently, the concerns for common complications observed with prolonged external fixator use, such as pin track infections, are eliminated.

The Creation and Validation of a Bone Age Atlas Utilizing Knee MRIs

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LOE–Not Applicable–Level IV

Purpose: In managing pediatric knee conditions such as osteochondritis dissecans, patella instability, and ACL tears, accurate bone age assessment is critical for diagnostic, prognostic, and treatment purposes. Knee MRIs are almost ubiquitously ordered for these conditions. The purpose of this study was to create an atlas of knee MRIs spanning the pediatric and adolescent years that would enable an accurate skeletal age to be assessed and forgo the need for a left hand radiograph.

Methods: 843 knee MRIs ordered for pain or trauma were retrospectively reviewed. Exclusion criteria included: evidence of tumors, infections, skeletal dysplasia, or systemic processes affecting the physes. 20 to 25 MRIs were evaluated for each age (2 to 19 years) and each gender. Radiographic features specific to the patella, tibia, fibula, and femur were documented for their presence or absence. From this data, age and gender "standards" were created. A separate cohort of MRIs with 10 patients in each age group and gender was then used to validate the reliability and reproducibility of the atlas.

Results: 412 female and 431 male MRIs were used to create the atlas. The gender distribution and age at presentation of key radiographic features are shown in Table 1. The patella, tibia, fibula, and femur were noted to undergo a consistent and reproducible sequence of skeletal maturation and ossification. The patella provided the best age assessment in early childhood. Features specific to tibia particularly ossification of the tibial spines and the tibial tubercle are of particular importance between the ages of 6 and 12 years. MRI features of the fibula and femur, particularly ossification of the fibular styloid, and closure of both physes, serve a more important role with age assessment later in skeletal maturity. A separate cohort of 323 MRIs (156 female and 167 males) was utilized to subsequently validate the atlas showing a strong correlation between chronologic age and bone age and excellent inter-observer and intra-observer reliability (Figure 1).

Conclusion: The predictable ossification and maturation pattern of the patella, tibia, fibula, and femur, enable accurate bone age calculations to be determined from knee MRIs.

Significance: When treating conditions about the knee that require an MRI, an additional left hand radiograph for bone age is unnecessary. Using information available on knee MRIs can avoid additional radiation exposure,

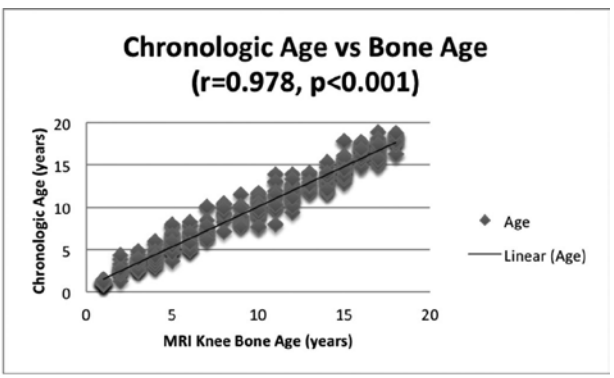

Figure 1. Scatter plot demonstrating excellent correlation between the patient's chronologic age and their bone age as assessed using the newly proposed MRI-based bone age atlas.

impart cost savings, and lead to more clinic efficiency.

		Male			Female		
		1st	Median	All	1st	Median	All
Tibia 2nd ossification center present		Present in all subjects in cohort			Present in all subjects in cohort		
Tibial spines ossified	Partial	5.1	6.85	9.9	4	5.9	8
	Complete	8.1	9.1	10	5.3	7.1	8.1
Tubercle extension		8.2	10.15	11	6.1	7.3	8.1
Tubercle apophysis present		10.1	11.8	12.6	7.3	10	11.4
Tubercle apophysis fused with epiphysis	"crack"	11.8	12.8	14.9	9	10.7	11.9
	yes	10.1	13.7	15	9.8	11.5	12
Complete ossification of tibia		12.8	16.1	16.9	12.4	13.5	14
Tibia closing		14.7	16.2	16.9	12.4	14.3	15
Tibia closed		14.7	18.1	19.8	13.3	16.4	17.8
Fibula 2nd ossification center present		3	4.4	4.9	2.5	4	4.7
Fibular styloid ossified		14	16	16.9	12.1	13.3	13.9
Fibula closing		14.7	16.9	17.7	12.9	15.7	17.8
Fibula closed		16.1	18.15	19.8	14.7	16.7	18
Femur 2nd ossification center present		Present in all subjects in cohort			Present in all subjects in cohort		
Complete ossification of femur		10.1	13.7	15.3	9.8	11.9	12.3
Disappearance of "oreo sign"		13.4	16	16.9	12.1	14	15
Femur closing		14.7	16.95	17.7	12.9	16.15	17.8
Femur closed		16.1	18.7	19.8	14.7	17.2	>19
Patella ossified	<25%	3	4.7	7.9	2.5	3.3	3.4
	25-49%	4	5.4	7.8	3.2	4	5.7
	50-74%	5.4	7.2	9.9	4	5.75	7.7
	75-99%	5.9	10.6	15	5.3	8.9	11.9
	Complete	10.1	13.35	15.3	6.2	11.5	12
Patella inferior tip ossified		9.4	10.7	11.4	7	10.05	11.4

Sagittal Plane Deformity after Temporary Epiphysiodesis for Correcting Leg Length Discrepancy

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LOE–Therapeutic–Level IV

Purpose: Outcome of the temporary epiphysiodesis procedure for leg length discrepancy (LLD) is commonly evaluated in the coronal plane. The purpose of this study was to investigate implant position and complications in the sagittal plane.

Methods: We retrospectively reviewed 33 patients with LLD who underwent temporary epiphysiodesis of the distal femur using staples (11 patients) or eight-plates (22 patients) during 2007-2015 and were followed until removal of the implants. Patient consisted of 10 male and 23 female patients, with a mean age of 9.7 years (range, 6-13 years) at the time of epiphysiodesis. Four patients simultaneously underwent epiphysiodesis of the proximal tibia. The implants were removed after a mean period of 2.6 years (range, 0.8-4.8 years) from the epiphysiodesis, either with the observation of the physis closure or the LLD improvement. Correction amount of LLD was measured on anteroposterior long leg standing radiographs. Implant position was evaluated from knee lateral radiograph at the time of epiphysiodesis. Extension deformity of the distal femur (>5° from epiphysiodesis to removal of implant) and patella baja (the epiphyseal line midpoint method <1.0, described in 1989 by Koshino and Sugimoto) were evaluated in the sagittal plane using lateral knee radiographs. Spearman's rank test was used to perform for all the statistical analysis of them.

Results: The average correction amount of LLD was 17.4 mm (range, 0-34 mm). The average implant position was 42% (range, 28-55%) from the anterior edge of the distal physis of the femur. At removal surgery, 19 (57.6%) patients had extension deformity of the distal femur. Two patients showed patella baja at the time of epiphysiodesis, however, 16 (48.5%) patients had patella baja at the time of removal surgery. There were correlations between implant position and extension deformity of the distal femur ($r=-0.51$, $p<0.01$) and as well as between correction amount of LLD and patellar baja ($r=-0.55$, $p<0.01$).

Conclusion: After temporary epiphysiodesis for the treatment of LLD, extension deformity of the distal femur and patella baja occurred frequently. The extension deformity of the distal femur became significantly more prominent with the anteriorly placed implants. Excessive correction of LLD was associated with patellar baja.

Significance: Proper implant position in the sagittal plane to prevent extension deformity of the femur may be about 50% from the anterior edge of the distal physis of the femur. Excessive correction of LLD should be avoided to prevent patellar baja.

Can We Predict Amount of Correction Using Guided Growth Around the Knee?

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LOE–Therapeutic–Level IV

Purpose: To define and validate a constant predicting amount of correction using temporary hemiepiphysiodesis around the knee in patients with idiopathic etiology.

Methods: Retrospective multicenter study conducted at 5 centers including data on 372 physes in 206 patients (110 males 96 females), with an average follow up of 16 months after plate insertion. Alignment analysis was compared preoperatively and in at least 2 measurements postoperatively; after calculating average rate of correction (degrees/month) the result was used as a constant - predicting amount of correction in several points along the follow up period. Correlation between actual and calculated amount of correction was evaluated by Pearson correlation coefficient.

Results: Statistically significant correlation was found between calculated and actual mechanical lateral distal femoral angle (mLDFA) in valgus deformity during the first year of correction ($r=0.73-0.87$, $p<0.01$). Calculating the mLDFA later is not predictable. Calculated mLDFA of varus deformity didn't correlate the actual mLDFA.
Similar correlation was found also between calculated and actual mechanical medial proximal tibial angle (mMPTA) in valgus deformity during the first 8 months of correction ($r=0.74-0.94$, $p<0.01$). Calculating the mMPTA later is not predictable. Statistically significant correlation was also found between calculated and actual mMPTA in varus deformity correction during all follow up period ($r=0.74-0.92$, $p<0.01$).

Conclusion: Valgus correction by guided growth in the distal femur / proximal tibia in idiopathic patients is highly predictable during the first 12/8 months of correction respectively. Varus correction in the femur is less predictable.
Valgus correction in the tibia is predictable during the first 8 months after initial surgery, Varus correction in the tibia was found to be highly predictable during all follow up period.

Significance: This study presents a validate tool to predict the amount of correction in guided growth of idiopathic coronal plane deformities around the knee. This constant can be used when evaluating patients before surgical intervention to determine timing of surgery.

Is Proximal Fibula Epiphysiodesis Necessary When Performing a Proximal Tibial Epiphysiodesis?

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LOE–Therapeutic–Level III

Purpose: Proximal tibia epiphysiodesis (PTE) is a common procedure for the treatment of leg length differences (LLD). A concomitant proximal fibula epiphysiodesis (PFE) has been recommended, particularly in younger children, to help prevent fibular overgrowth. These recommendations, however, are based on a limited number of studies with relatively few patients. The purpose of this study is to compare fibular growth and the tibia-fibula relationship between patients who underwent PTE with and without PFE.

Methods: This retrospective radiographic analysis includes all patients who underwent PTE or combined distal femoral epiphysiodesis (DFE)/PTE as a single procedure for idiopathic or congenital LLD at our institution between 1980-2011. Their pre- and postoperative after skeletal maturity scanograms and/or calibrated radiographs of the lower extremities were used for the following measurements: tibia/fibula lengths, distance between proximal tibia/fibula, distance between distal tibia/fibula, the tibia/fibula ratio. Two groups were compared: PTE or DFE/PTE without PFE (**noPFE group**) vs. PTE or DFE/PTE with PFE (**PFE group**). These groups were analyzed based on **chronological and bone age** (**young**=females ≤ 11.25, males ≤ 13.25 years vs. **old=**females >11.25, males >13.25 years).

Results: 245 patients (129 females, 116 males) were included (80 noPFE group, 165 PFE) with no differences in gender between groups.
When analyzed based on **chronological** age, the **young** (n=110, males 104) included **43 noPFE vs. 67 PFE**. There were no statistical differences between groups for pre- to postoperative change in tibia or fibula length or proximal tibia/fibula distance. The PFE group had a significant increase in post-op distal tibia/fibula distance (0.28±0.98 cm, range -2.3-2.8 cm) vs. the noPFE group (0.04±1.06 cm, range -2.8-2.6 cm, $p<0.05$) and concomitant significant change in tibia/fibula ratio ($p=0.01$). Despite the statistical significance, radiographic review of the ankle in these patients did not reveal any clinically significant changes.
There were no statistical differences in the change in proximal or distal tibia/fibula distances or the tibia/fibula ratio between noPFE and PFE groups in the **chronological old** group (n=135, females 123). Similarly, there were no significant differences between noPFE and PFE groups when analyzed by **bone age**, both **young** (n=92, males 86) and **old** subgroups (n=135, females 116).

Conclusion: In patients with at least 3 years of expected growth remaining based on chronological (predominantly male) or bone age (predominantly female), no clinically relevant fibular overgrowth was identified.

Significance: Proximal fibular epiphysiodesis does not appear to be necessary to prevent clinically significant relative fibular overgrowth regardless of age performed.

Assessment of Femoral Deformity in Blount's Disease

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LOE–Prognostic–Level III

Purpose: An associated femoral deformity in patients with Blount's disease is not commonly described in the literature. The purpose of this study was to establish if there were compensatory changes in the distal femur in response to the proximal tibia varus that occurs in each group of Blount's disease, to determine the degree of the deformity and significance on surgical management of the distal femur in addition to primary surgery for the tibia.

Methods: This retrospective review included plain radiographs taken between January 2000 and December 2014. Demographic data was recorded retrospectively. 74 patients met the inclusion criteria, (15 Infantile, 31 Juvenile and 28 Adolescent Groups). The measurements of the anatomic lateral distal femoral angle (aLDFA) was recorded and compared to a control group.

Results: Seventy four children with Blount's disease were included in the study. Forty three cases were bilateral giving a total number of 117 affected legs. Overall there were 56 females and 18 males in the study. An associated distal femoral varus deformity was seen in the majority of children with Blount's disease. The average aLDFA for all patients was 86.4° (Range 73°-100°). The aLDFA was increased (varus) in most patients in the Infantile Group (Average 88°, Range 83°-100°). In the Juvenile Group it was variable showing an increase (varus) of the aLFDA in 66% of the patients (Average 83.9°, Range 73°-100°). In the Adolescent Group, only one patient had a decreased aLDFA with the rest having a varus deformity of the distal femur (Average 88.5°, Range 73°-95°). The groups were further divided into under (Infantile and Juvenile Blount's) and over 10 years (Adolescent Blount's) of age. In the Group under ten years of age (74 extremities in 46 patients) the average aLDFA was 85.4° (Range 73° – 100°) and in the Group over ten years of age (43 extremities in 28 patients) the average aLDFA was 88° (Range 73° – 95°).

Conclusion: This study is the largest series of children with Blount's Disease measuring the aLDFA and shows that most patients in all Groups had a distal femoral varus contribution to the overall genu varum deformity of the proximal tibia. The femoral varus was significantly greatest in the Adolescent Group.

Significance: The degree of varus in the distal femur does not always justify distal femoral valgus osteotomy but growth modulation surgery may be a consideration and is a topic for future research.

Risk Factors for Short-Term Morbidity in Pediatric Orthopedic Patients Undergoing Pelvic and Femoral Osteotomies

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LOE–Prognostic–Level II

Purpose: Pelvic and femoral osteotomies are associated with adverse outcomes in pediatric orthopedics. The purpose of this study is to determine patient and operative characteristics for short-term morbidity in pediatric patients undergoing pelvic and femoral osteotomies.

Methods: We analyzed data using the prospective pediatric National Surgical Quality Improvement Program (NSQIP) database from 2012 to 2014. Patients younger than 18 years of age undergoing pelvic, femoral or combination osteotomy were included. Univariate and multivariate logistic regression analyses were used to identify patient demographics, underlying comorbidities, and operative variables associated with short-term morbidity.

Results: 1737 patients met inclusion criteria. The average age of all patients was 9.07 ± 4.44 years and the majority were female (52%). Unplanned related reoperations occurred in 1.7% (n=30) and related readmissions occurred in 3.7% (n=65) of patients. Readmission rate was higher among patients with one or more comorbidities (p=0.0457). Prolonged length of stay (>30 days) was associated with increased comorbidity (p<0.0001), medical complication rate (p<0.0001) and surgical complication rate (p<0.0001). Medical complications occurred in 6% (n=104) of the cohort. Medical complication risk factors included respiratory disease (p=0.0045), gastrointestinal disease (p=0.0135), nutritional history (p<.0001) and history of cancer (p=0.0328). Surgical complications occurred in 24% (n=421) of patients. Variables associated with surgical complication included neurological history (p=0.0226), congenital malformation (p=0.0120), increased patient age (p<0.0001), longer anesthesia time (p<0.0001) and procedure type (p<0.0001). Patients undergoing combined pelvic and femoral osteotomy, with or without open reduction of the hip, or pelvic osteotomy with open reduction were associated with a higher rate of surgical and medical complications compared to patients undergoing femoral osteotomy alone (p<0.0001 and p=0.0007, respectively). Significant variables include patient age (7.84 ± 4.14 vs. 9.84 ± 4.04) (p<0.0001), BMI (15.2 ± 7.28 vs. 18.1 ± 8.16) (p<0.0001), duration of anesthesia (327 ± 100 vs. 285 ± 107) (p<.0001), total operation time (237 ± 90.9 vs. 205 ± 96.5) length of hospital stay (4.21 ± 3.87 vs. 3.92 ± 4.28) (p<0.0081) and elevated American Society of Anesthesiologists class (p<0.0001).

Conclusion: Underlying comorbidities, age at time of surgery, duration of anesthesia and procedure type are risk factors associated with short-term morbidity in pediatric patients undergoing pelvic and femoral osteotomies.

Significance: These results provide focus for evidence-based interventions to reduce risk and minimize costs.

8 Plate Epiphysiodesis: Are We Creating an Intra-articular Deformity?

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LOE–Therapeutic–Level III

Purpose: Guided growth using "8" plates is commonly used for correction of angular deformities in growing children. The principal is of tethering at the physeal periphery while enabling growth in the rest of the physis. The method is also utilized for epiphysiodesis to correct limb length discrepancy (LLD). Concerns have been raised regarding the potential of this method to create an epiphyseal deformity, however this has not been investigated. The purpose of this study was to detect and quantify the occurrence of deformities in the proximal tibial epiphysis following treatment with 8 plates.

Methods: A retrospective study was performed including all children undergoing 8 plate insertion in the proximal tibia for correction of coronal plane deformities or LLD between 2008 and 2015. Medical records, PACS data and conventional radiographs were reviewed. Measurements included Interscrew Angle, lateral and medial plateau Slope Angles measured between the plateau surface and the line between the ends of the physis, and tibial plateau Roof Angle defined as 180^0 minus the sum of both plateau angles. Measurements were compared between radiographs performed adjacent to surgery and those at latest follow up and between operated and non-operated plateaus. Statistical analysis was performed using BMDP Statistical Software.

Results: 64 plates were inserted in 42 patients at a mean age of 10.8 years (3.7-15.7). 48 plates (34 patients) were inserted to correct angular deformities and 16 plates (8 patients) for LLD.
Slope angle increased in 49.2% of operated epiphyses by a mean of 5^0 (1^0-23^0) compared to 31.9% in non-operated epiphyses (p=0.043). Roof angle decreased in 46.0% of operated tibias and in 27.5% of non-operated ones by a mean of 5^0(1^0-18^0) (p=0.028). Slope angle change frequency was similar in patients with LLD, varus and valgus correction (p=0.37) but roof angle changes were slightly more frequent in LLD (p=0.059) and correlated with the change in inter screw angles (R=0.74 p=0.001).

Conclusion:
1. The use of 8 plates in the proximal tibia for deformity correction and limb length equalization causes a change in the morphology of the tibial plateau in a significant number of patients.
2. The effect is more pronounced in the correction of LLD.

Significance: The deformity created may affect joint congruity and biomechanics. Further research is necessary to investigate the clinical significance and long term effects of these findings.

Results of Progressive Limb Lengthening in High-Frequency Distraction Mode Associated with Hydroxyapatite-Coated Intramedullary Nailing

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LOE–Therapeutic–Level III

Purpose: The risk of complication in use of external fixation in progressive limb lengthening is high (Koczewski, 2013; Oostenbroek, 2014; Black, 2015). The advancements in pediatric limb lengthening surgery have to reduce these risks and to provide satisfactory anatomical and functional results (Lascombes, 2012; Sabharwal, 2015). We proposed to perform bone lengthening in high-frequency distraction automatic mode using external fixator associated with hydroxyapatite-coated flexible intramedullary nailing (HA-FIN). The aim of the study was to analyze the results of this combined method in lower limb lengthening in children.

Methods: Monofocal femoral lengthening was performed in 21 patients (age range, 6 to 16 y.o.), and 17 children (5 to 16 y.o.) underwent tibial monofocal lengthening. All patients had congenital or posttraumatic lower limb length discrepancy. We applied the high-frequency distraction lengthening with titanium elastic intramedullary nailing in all cases.

Results: Mean lengthening gain was 4.2±2.1 cm for femur and 4.3±1.8 cm for tibia. The average Healing Index was 21.4±0,83 d/cm (congenital femur) *и* 19.0±0.99 days/cm (posttraumatic femur), and 22.5±0.86 days/cm (congenital tibia) and 23.5±0.61 days/cm (posttraumatic tibia). Functional recovery with complete ROM of adjacent joints was observed within 5 to 12 months after frame removal in all patients. Several complications were noted: local sepsis in 14 children (change of wires under GA was required only in two cases), one case of transient common fibular nerve palsy. The HA-FIN allowed to avoid secondary displacement of bone fragments, delayed consolidation, fracture or deformity after frame removal, migration of intramedullary nails. The results assessed in 1 year corresponded to category I (35 cases) and IIa (3 cases) according to Lascombes classification (2012).We did not observe a significant difference regarding HI between actual series and our previous studies where a combined technique associated an external fixator with titanium FIN. On the other hand, the use of HA-FIN prevented any migration of intramedullary nails in contrast to presence of such complication with titanium nails.

Conclusion: HA-FIN adds important advantages to the method of high-frequency limb lengthening: significant decrease of duration of external osteosynthesis, rapid functional recovery after frame removal. This combined technique permits to avoid severe complications and provides low rate of minor complications.

Significance: Level III

Intramedullary Lengthening Nails and MRI Compatability

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LOE–Not Applicable–Level V

Purpose: To evaluate safety concerns of magnetic resonance imaging with the PRECICE® (Nuvasive Specialized Orthopedics, Inc, Aliso Viejo, CA) intramedullary magnetic lengthening nail.

Methods: Using saw bones in air as our model, 6 femoral and 6 tibial PRECICE intramedullary nails were implanted and exposed to MR sequences. A 3-Tesla General Electric scanner was used with routine imaging protocols for the lower extremity. Four parameters were measured: 1. Magnetic forces acting upon the nail in and around the scanner were assessed. 2. Temperature was measured with an infrared laser thermometer through a cortical window that was made at the level of internal magnet located within the PRECICE nail before and immediately after scanning. 3. Implant lengths were measured before and after scanning to evaluate for distraction or compression. 4. Force generation of the device was measured prior to and after scanning to determine if there was any deactivation of the magnet affecting its function as a lengthening device.

Results: The maximal displacement force acting upon the implants placed in various positions in and around the gantry was less than 2 lbs. Average temperature obtained immediately after scanning was 63.3° F, equal to the ambient temperature in the MRI bore. After subjecting the implants to external magnetic fields from the 3 Tesla MR scanner during a typical scanning sequence, there was no measurable difference in length in any of the 12 nails. Prior to MRI each tibial nail had a distraction force of 300 lbs, and after MRI this decreased to 31.2 lbs. The average distraction force present in the femoral nail group was 294 lbs prior to MRI, and after MRI the average was 112.5 lbs.

Conclusion: PRECICE magnetic intramedullary devices do not pose a significant risk to patient safety when subjected to the external magnetic forces generated by 3 tesla MR scanners. However, the magnetic lengthening function of the nails is affected and MR should be avoided if continued function of the nail as a lengthening device is desired.

Significance: The results of this study will allow more accurate assessment of the risks and benefits of performing MRI in patients with magnetic intramedullary implants. This may allow needed imaging studies to be performed in patients with these implants and/or prevent unnecessary hardware removal surgeries.

The Importance of Considering Ultimate Height in the Treatment of Limb Length Discrepancy

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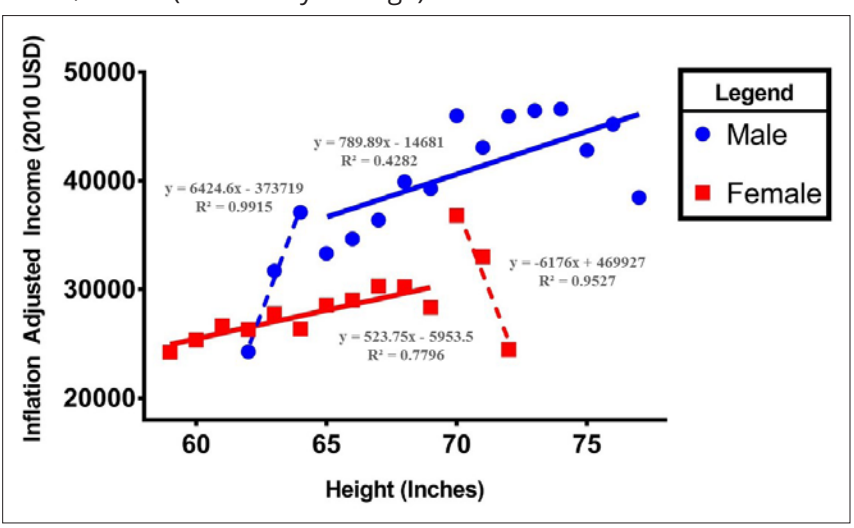
LOE–Economic and Decision Analyses–Level IV

Purpose: Treatment of limb length discrepancy (LLD) requires weighing the risks and benefits of the lower morbidity of epiphyseodesis on a healthy extremity versus correcting the deformity of a growth limited limb and achieving greater ultimate height with limb lengthening. It has been well reported that greater ultimate height is associated with lower rates of depression, suicide, and a variety of other socioeconomic factors. The incremental relationship between height and socioeconomic parameters is poorly defined, but would be useful information for orthopaedic surgeons who can impact final height. Using income as a quantitative marker for overall socioeconomic impact, we sought to better define the height ranges where incremental changes in ultimate height have the largest effect.

Methods: The National Longitudinal Survey of Youth 1979 (NLSY79) was analyzed for an association between participants' height and income. NLSY79 is a large sample of individuals aged 14-22 years old, surveyed annually from 1979-1994, and biennially from 1994-2010. Subjects were excluded if less than 15 subjects reported their given height and if subjects recorded income fewer than 10 times. Income prior to age 18 was excluded.

Results: The study population was 3826 (52%) male and 3561 (48%) female. Heights ranged from 59-77 inches and averaged 64" for females and 70" for males. Overall, each additional inch of height conferred a $1356.80 increase in income (3.9% of study average income, r^2=0.75). For men, each inch from 62-64" correlated with an income increase of $6424.60 per inch (18.2% of study average) while each inch from 65-77" correlated with a $789.89 rise per inch (2.2% of study average). By comparison, women from 59-69" had an increase of $523.75 (1.5% study average) and from 70-72" had a decrease of ($6176.00) per inch (17.5% of study average). Multiple-linear regression analysis was used to factor out patient demographic information, education level and use of financial aid, and confirmed a persistent correlation be-



tween height and income.

Conclusion: For men, height is generally correlated with income, with greater appreciable gains per inch at the lower ends of the height spectrum (62-64”). For women, however, height is positively correlated with income from 59-69” with reversal to a negative correlation from 70-72”.

Significance: This study describes the relationship between greater ultimate adult height and increased income, with greater effects for shorter males and reversal of effects for taller females. Clinicians should consider the socioeconomic impact of height when choosing between contralateral limb epiphyseodesis or ipsilateral limb lengthening for LLD.

Development of a Novel Non-Invasive Growth Plate Ablation Treatment Using Magnetic Resonance Imaging-guided High-Intensity Focused Ultrasound (MR-HIFU)

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Texas Scottish Rite Hospital and Children's National Medical Center, Dallas, Texas and Washington, District of Columbia, United States

LOE–Therapeutic–Level III

Purpose: Current options for epiphysiodesis rely on open or percutaneous surgical techniques to induce physeal destruction. Magnetic Resonance imaging-guided high-intensity focused ultrasound (MR-HIFU) is a novel modality that has been used to non-invasively treat prostate cancer, uterine fibroids, and bone metastases. The technology uses focused ultrasound to ablate tissue and relies on MRI to plan and monitor thermal ablation of precisely-defined targets. The purpose of this study was to evaluate the feasibility of performing epiphysiodesis with MR-HIFU in a pre-clinical large animal model and to assess its side effects.

Methods: Six immature Yorkshire piglets aged 2-5 months underwent MR-guided HIFU of the proximal tibial physis in a research MRI suite with a 3T scanner under general anesthesia. The left proximal physis of the tibia was targeted with a HIFU device which delivered a thermal dose to the physis. The untreated right tibia served as normal controls. The animals were allowed weight-bearing as tolerated and observed daily. One animal was sacrificed at 48-hours post-HIFU treatment to assess acute tissue damage and the rest (n=5) at 10-weeks following MR-HIFU treatment to assess growth inhibition and chronic changes. Tibias were harvested and assessed using radiography for bone length between the proximal and distal physes, histology for growth plate damage, and immunohistochemistry (TUNEL) for the extent of cell death at the site of HIFU application. Statistical analysis used a paired t-test.

Results: All animals recovered quickly and did not exhibit any deficits in gait, weight-bearing, or function during the 10-week observation period. In two animals a slight redness and swelling was observed in the proximal tibial region indicating mild subcutaneous inflammation post-HIFU treatment. Histologic and immunohistochemical assessments of 48-hour post-HIFU specimen revealed extensive cell death in the targeted growth plate cartilage region, adjacent trabecular bone, and marrow space. Measurement of tibial bone length on radiographs showed an average decrease of 3.0±1.3% length in HIFU-treated tibias vs. contralateral untreated tibias (p=0.004). Histologic examination of the HIFU-treated physes revealed localized growth plate damage with replacement of the physis by bony bridge and fibrovascular tissue.

Conclusion: Our findings demonstrate the feasibility of non-invasive ablation of the proximal tibial physis using MR-HIFU in a large animal model.

Significance: This is the first study to evaluate physeal ablation using a MR-HIFU method, a technique that may provide a non-invasive alternative to current surgical treatments for limb-length discrepancy and angular deformity corrections. MR-HIFU has the potential to lower costs and morbidities associated with surgical methods.

An Ex Vivo 3 Dimensional Organotypic Culture Model of the Physis: A First Attempt to Stimulate Endochondral Ossification of the Growth Plate In Vitro

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Medical University of Graz, Graz, Austria

LOE–Therapeutic–Level IV

Purpose: The growth plate is placed between the metaphysis and the epiphysis at each end of a long bone. It is responsible for bone lengthening in children through endochondral ossification, involving a strictly regulated sequence of chondrocyte proliferation and maturation and extracellular matrix changes. Injuries to growth plates may occur either as a result of trauma or after burns and osteomyelitis, which further results in disturbed mobility. Since functional bone tissue grafts can be considered as a potential 3 dimensional model we developed an ex vivo organico typical culture of the growth plate and aimed to investigate the mechanism involved in growth plate modulation. Moreover, upon successful stimulation of fracture lesion we want to evaluate cellular responses and pathways involved in the gap closure of the mechanically induced lesion.

Methods: Femoral organotypic bones slices ranging 300µm-400µm were derived from 4 days old postnatal rats using advanced vibratome. The organotypic slices were cultured in osteogenic conditions for 15 days and were subjected to live confocal imaging, FTIR spectroscopy, histological stainings and morphometric analysis. Immunohistochemical quantifications were performed for Runx2, osteocalcin and collagen II markers to assess the bone and cartilage turnover.

Results: In this study we showed that bone slices were viable up to 22 days with negligible amount of dead cells. Histological evaluations revealed ongoing endochondral ossification corresponding to bone turnover which was further confirmed by increased expression of markers such as Runx2, osteocalcin ($p<0,01$) at day 15. Subsequently, FTIR spectroscopy data confirmed a remarkable increase in hydroxyapatite and bone minerals at day 15 compared to the control samples.

Conclusion: This technique represents the first ex vivo tissue engineering approach that closely mimics the *in vivo* tissue microenvironment of mineralizing bone and cartilage. The strict hirachial achitecture and function of the different zones of the growth plate could be investigated in details. The model can be adapted to stimulate fracture models and investigate growth plate arrest or generally adverse effects on the growth plate induced by toxicological treatments or materials.

Significance: A statistically significant sample size was reached by using $n>6$ samples.

Comparison of Transphyseal Neck-Head Tunneling (TNHT) versus Multiple Epiphyseal Drilling (MED) on Femoral Head Healing Following Ischemic Osteonecrosis

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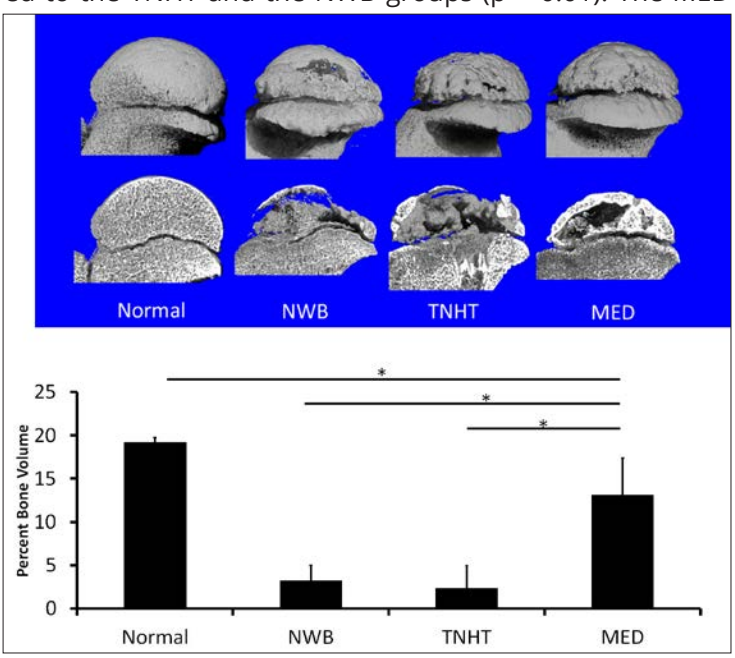
LOE–Therapeutic–Level III

Purpose: Two operative procedures are currently advocated to stimulate the necrotic femoral head healing in patients with Legg-Calve-Perthes Disease (LCPD): transphyseal neck-head tunneling (TNHT) and multiple epiphyseal drilling (MED). The purpose of this study was to compare the bone healing and physeal function after treatment with TNHT or MED in a piglet model of ischemic osteonecrosis.

Methods: Eighteen piglets were induced with osteonecrosis by surgically placing a ligature tightly around the right femoral neck. One week later, the piglets were assigned to one of 3 treatment groups (N=6/group): (1) local non-weight bearing only (NWB), (2) TNHT plus NWB, or (3) MED plus NWB. For TNHT, a cannulated 5-mm drill bit was used to create a transphyseal tunnel from an area below the greater trochanter to the center of the necrotic epiphysis. For MED, 2-mm K-wires were used to create 4 transphyseal channels in each quadrant of the necrotic epiphysis. NWB was instituted postoperatively by above knee amputation. The unoperated left femoral heads were used as normal controls. The animals were sacrificed at 8 weeks post-osteonecrosis induction. Histologic, histomorphometric, radiographic, Micro-CT, and calcein labeling assessments were performed. Statistical analysis included one-way ANOVA.

Results: Micro-CT analyses showed significantly higher femoral head bone volume in the MED group compared to the TNHT and the NWB groups ($p < 0.01$). The MED group had a significantly higher mean trabecular number ($p < 0.001$) and new bone formation based on calcein labeling ($p=0.001$) compared to the TNHT and the NWB groups. In addition, the osteoclast number per bone surface was significantly lower in the MED group compared to the NWB group ($p=0.025$). Histologic and micro-CT assessments of the proximal femoral physis revealed a localized physeal disruption at the site(s) of physeal drilling in the TNHT and



MED groups. However, no significant differences in physeal elongation (p=0.61) and femoral neck length (p=0.31) were observed between the treatment groups.

Conclusion: MED produced a higher bone volume and stimulated greater bone formation than the TNHT or the NWB alone. Both procedures did not produce a significant growth disturbance of the femoral neck during the study period.

Significance: This is the first study to directly compare the bone healing in the necrotic femoral head after treatment with TNHT and MED in combination with postoperative NWB. This study provides evidence that MED produces more favorable bone volume and bone formation results than the TNHT in a large animal model of LCPD.

Effects of Early Anti-inflammatory Cytokine Treatments On Bone Bridge Formation Following Growth Plate Injury

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National University of Singapore, Singapore

LOE–Therapeutic–Level III

Purpose: Injuries to the growth plate may result in growth arrest as a result of bone bridge formation. The resultant deformity and loss in length often requires surgical treatment. Previous studies have shown that the increased secretion of pro-inflammatory cytokines (TNF-α and IL1-β) following growth plate injury might have a role in the molecular mechanisms underlying bone bridge formation. This study aims to evaluate whether biological anti-cytokine treatments administered immediately after a physeal injury would be effective in preventing bone bridge formation and the resultant growth arrest.

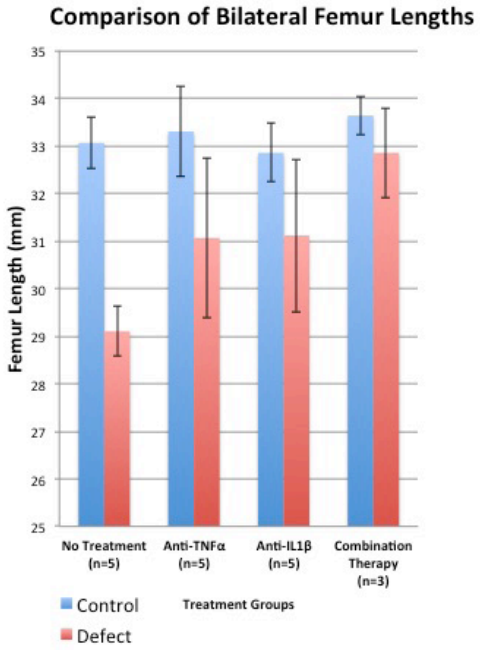
Methods: A 2 x 4 mm sagittal defect was created in the growth plate of the distal femur of 6 week old Sprague-Dawley rats by manual drilling. The contralateral side was left unoperated to serve as a control. Following the surgery animals were intraperitoneally injected either with a single or a combination of monoclonal antibodies as anti-cytokine treatment (Infliximab® for TNF-α and P2D7KK for IL1-β), or saline as control. No further treatments were applied. Whole femurs were harvested at postoperative day 60 for analysis. Bone length measurements were taken and bone bridge formation was assessed using Micro-CT.

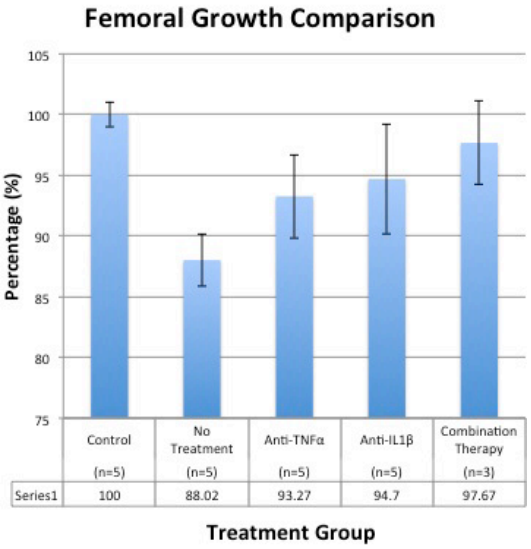
Results: All operated femurs were compared to the contralateral unoperated side to assess the difference between the lengths of the bones. The percentage of bone growth of the operated side compared to the unoperated side was calculated to show the effect of anti-cytokine treatment in salvaging growth in the operated femur. These results were then compared between the groups to assess the treatment efficacy. Both Infliximab® and P2D7KK treatment groups showed a statistically significant improvement in the femoral growth when compared to the untreated group. Treatment with monoclonal antibodies significantly rescued final bone length to a clinically acceptable level.

Conclusion: Our results suggest that the inhibition of pro-inflammatory cytokines during the early period following growth plate injury may help to prevent bone bridge formation by inhibiting the process of bone healing after injury.

Significance: This study provides an alternative method of managing severe physeal injuries with a potential to result in growth arrest by inhibiting the process of bone bridge formation using anti-cytokine treatment. Further studies need to be performed to better understand the molecular mechanisms involved in bone bridge formation and to formulate a treatment strategy.

Femur Growth on Day 60





Are Serum Bone Metabolic Markers Associated with Abnormal BMD and Bone Phenotypes in AIS?

Bobby Ng, MD, *Huanxiong Chen, PhD; Wayne Lee, PhD; Ka-Yee Cheuk; Eric Yu; Fiona Yu; Elisa Tam, PhD; Tsz Ping Lam, MBBS; MD; Alec Lik Hang Hung; Feng Zhu; X. Edward Guo, PhD; Jack Cheng, MD*
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LOE–Prognostic–Level III

Purpose: Low bone mineral density (BMD) and deranged peripheral cortical bone morphology and trabecular bone micro-architecture was found in over 30% of Adolescent Idiopathic Scoliosis (AIS) patients and was recognized as a significant prognostic factor for curve progression. Our previous study also found impaired osteoblasts differentiation and structural and functional abnormal osteocytes lacuno-canalicular system in AIS. In this study we hypothesized that abnormal serum bone metabolic markers are associated with the abnormal bone phenotypes in AIS Vs normal controls.

Methods: This case-control recruited 47 AIS girls and 34 age-, gender- and ethnicity-matched healthy controls with recorded anthropometric data, pubertal maturity and curve severity. Left femoral neck areal BMD was measured with DXA, and volumetric BMD, cortical and trabecular bone phenotypes with HR-pQCT. Plate and rod trabecular configuration was further analyzed with individual trabecula segmentation (ITS) analysis (Figure 1). Serum bone metabolic markers, including osteocalcin, osteopontin, osteoprotegerin, parathyroid hormone (PTH), dickkopf-related protein 1 and sclerostin, were measured with Multiplex array. ANCOVA and partial correlation were performed with adjustment for age (SPSS, v19).

Results: The mean age of AIS and control subjects were 13.6 and 14.2, respectively. Cobb angle of the AIS subjects is 32.8 ± 18.0 degrees. Comparing with controls, AIS had lower body weight and BMI. DXA and HR-pQCT revealed significantly lower aBMD, cortical and trabecular vBMD associated with lower cortical area, cortical thickness and trabecular area in AIS. Advanced ITS analysis showed significantly lower trabecular plate BV/TV and number, and connectivity density in AIS. AIS

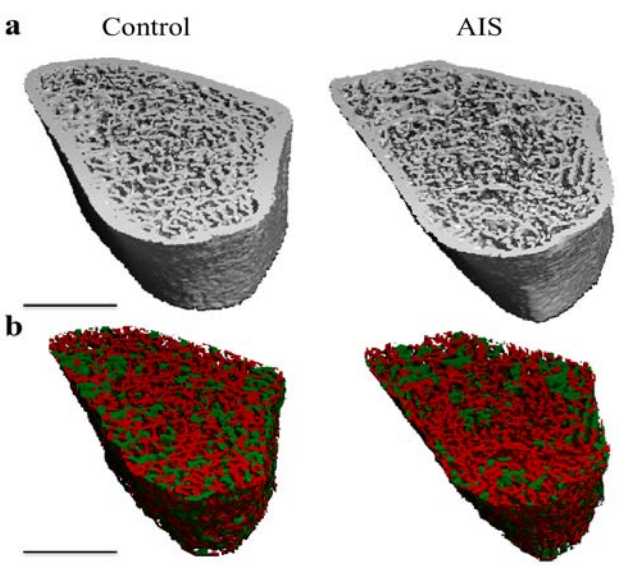

Figure 1 Illustrations of 3D HR-pQCT and ITS images in control and AIS.
(a) Cross-section of the distal radius as assessed with in HR-pQCT, showing cortical and trabecular bone microstructure. The length of the scale bar is 5mm.
(b) Trabecular bone structures with the trabecular type labeled for each voxel. Plate voxels are shown in green, rod voxels in red.

had significantly higher serum osteocalcin level (% difference = 32.9%) than controls. Despite small sample size, the discrepancies in bone phenotypes were consistent to our previous findings. In the control, serum osteocalcin level had significant negative correlation with cortical area and cortical thickness, and serum sclerostin were significantly correlated to rod and plate trabecular BV/TV. But, these distinctive correlation patterns were absent in AIS.

Conclusion: We report for the first time the abnormal relationship between bone phenotypes and serum osteocalcin and sclerostin, and provide additional evidence suggesting abnormal osteoblasts and osteocytes functional activities in AIS patients.

Significance: Considering osteocalcin is secreted by osteoblasts, and sclerostin by osteocytes. This study provides early evidence suggesting aberrant functional activities of these two cells in AIS. Further validation study with larger cohorts with different severities and in depth mechanistic study is warranted.

This study was supported by RGC GRF (14116415).

Genome and Virulence Determinants of Staphylococcus aureus Causing Acute Hematogenous Osteomyelitis

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LOE–Prognostic–Level III

Purpose: Children with acute hematogenous osteomyelitis demonstrate variation in severity of illness, ranging from mild to severe. This study characterizes the composition of the genome of S. aureus with respect to virulence determinants on the basis of clinical phenotypes of the affected children.

Methods: UTSW55, isolated from a 12 year old female with severe osteomyelitis of the proximal femur, was sequenced and analyzed using PacBio HGAP from 6 SMRT Cells. The novel de-novo assembly was used as a reference for comparison with other complete *staphylococcus aureus* sequences from the NCBI GeneBank database. Annotation of candidate virulence genes across all references was performed using blastp similarity identity scores greater than 0.8 and literature review to ensure that predicted protein sequences could be unambiguously assigned to each gene. Genomic DNA was extracted from bacterial isolates of 71 children with osteomyelitis in our community using DNeasy and lysostaphin. Sequencing libraries were prepared using Illumina HiSeq2000 with an average of 6.9 million reads (243-fold coverage). Clinical and laboratory data were used to calculate severity of illness scores for each child (range 0-10). The Kruskal-Wallis rank sum test was used to determine the significance of association between severity of illness scores and presence or absence of genes within each genome. Calculated p-values were adjusted using False Discovery Rate with significance defined as <0.01. Unrooted, radial dendrograms were constructed using PAML comparing the reference strain to the local community isolates and to the 49 GenBank strains for which whole genome sequence data is published.

Results: PacBio assembly identified a single contig of 2,898,306 bp with 2054 assigned ORFs. Gene annotation identified 201 candidate virulence genes within at least one of the GenBank (n=49) and UTSW study isolates (n=71). Severity of illness scores ranged from 0-10 (mean 5.3 $\pm$ 3.7). There were 40 genes (adhesins, immune evasion, protease, toxin, regulatory, and stress resistance) which were significantly associated with severity of illness of the affected chil-

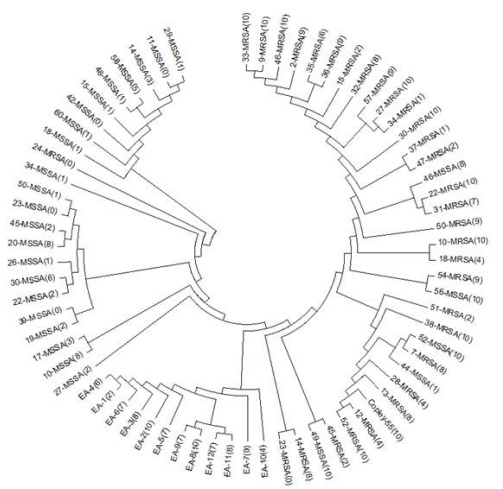

Figure 1. Radial dendrogram of genetic distance between isolates of children with osteomyelitis. Severity of Illness Scores of the affected children (0=mild; 10 =severe) are listed in parentheses.

dren. MRSA isolates were found to encode a significantly larger number of virulence genes than MSSA ($p < 0.0001$). PAML demonstrated the severity relationship of isolates in accordance with the genetic distance between them.

Conclusion: The S. aureus genome contains virulence determinants which are significantly associated with severity of illness among children with osteomyelitis.

Significance: This study introduces a novel reference strain, now publicly available in GenBank, which will guide future genome and transcriptome studies to elucidate the complex pathogenetic mechanisms of S. aureus causing osteomyelitis in children.

Research for Fetal Myelomeningocele Repair

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LOE–Therapeutic–Level IV

Purpose: Development of a translational research for fetal myelomeningocele repair.

Methods: We have developed new surgical procedures for fetal myelomeningocele repair, in three steps.
First step. It includes a gentle coverage of the defect using a patch and a sealant, avoiding aggresive surgeries to the fetus. Experimental study performed in 15 fetal sheep with lumbar myelomeningocele, surgically created on day 75 of gestation. Five foetuses remained untreated. Ten underwent coverage with inert sheeting secured by surgical tissue adhesive without suturing on day 95.
Second step: includes gentle coverage using a fetoscopic approach. Experimental study. A myelomeningocele-like defect was created in 15 fetal sheep on day 75 of gestation. Six remained untreated, whereas 9 underwent fetoscopic coverage of the defect on day 95 of gestation using an inert patch secured with surgical sealant.
Third step: includes regeneration of the bony posterior vertebral arch using regenerative medicine. Stem cells were obtained from the amniotic fluid. Experimental study in 38 fetal sheep with lumbar myelomeningocele, surgically created on day 75 of gestation.

Results: Fist step: gentle coverage of the defect. All untreated animals were unable to walk, had sphincter incontinence, showed an open defect, histological spinal cord damage, and a large Chiari malformation. All covered animals were able to walk, had sphincter continence, showed almost complete closure of the defect with regeneration of several soft tissue layers, and minimum Chiari malformation. Results have been translated to the human being in 10 cases.
Second step: fetoscopy. Four valid newborn lambs were obtained in each group. Mean fetoscopic surgical time was 26.9 (SD = 7.4) min. All untreated animals had an open lumbar defect with cerebrospinal fluid leakage, paraplegia, urinary incontinence, and Chiari malformation. All treated animals had a closed defect and were able to walk; one had weak bladder control, and another mild Chiari malformation. Results have been translated to the human being in 17 cases.
Third step: regenerative medicine. A PLGA scafold was used in 12 cases and fibrine in 10 cases; no bone formation was detected. Sexteen fetuses were repaired using combinations of stem cells, fibrine and demineralized bone; two cases created a bony posterior vertebral arch. No translation to human being has been done so far.

Conclusion: A gentle coverage method using a sealed patch by fetoscopic approach results in satisfactory neural tube closure.
Regenerative medicine could add an incredibly better anatomical result.

Significance: Improving fetal myelomeningocele repair results in less neurological damage and Chiari malformation.

Increased Rate of Malignancy in Children with Syndactyly

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LOE–Prognostic–Level III

Purpose: It is often touted that a better understanding of normal developmental processes improves our ability to understand and therefore diagnose and treat human pathologic conditions, such as syndactyly. Although it is true that aberrations in limb development lead to the congenital limb differences, only genes that are identified in human syndactyly conditions are relevant clinically.

Methods: We identified all genes associated with a syndactyly human phenotype using the Online Mendelian Inheritance of Man database. Identified genes were analyzed using the DAVID functional annotation tool for enriched KEGG functional pathways. The New York Statewide Planning and Research Cooperative System (SPARCS) administrative hospital discharge database was then used to investigate whether the associated clinical conditions were more highly represented in syndactyly patients compared to controls. We selected newborn admissions in New York State between 1997 and 2014 and used ICD-9-CM diagnosis and procedure codes to identify patients with syndactyly (insert codes). Diagnosis codes in subsequent inpatient discharge records for each patient were searched to determine if the patient ever had a diagnosis code for the clinical conditions identified by the functional pathway analysis. A Cox Proportional Hazards regression model was used to evaluate the association of syndactyly with these conditions.

Results: Unexpectedly, the 143 genes that make up the known human syndactyly phenome were most significantly enriched in pathways that cause cancer. Accordingly, we investigated the incidence of a cancer diagnosis in newborns with syndactyly compared to newborns without syndactyly. Of the 4.2 million livebirths identified from 1997 to 2014, there were 3129 (0.075%) patients with congenital syndactyly. Children with syndactyly syndrome were over three times more likely to have a subsequent admission with a diagnosis of malignant cancer than children without syndactyly (Hazard Ratio: 3.40, 95% CI 1.62-7.15, p=0.001).

Conclusion: We have found an unexpected association between syndactyly, the most common congenital difference occurring in the extremities, and childhood malignancies. This approach illustrates the importance of relying on clinically relevant human data when studying human conditions.

Significance: Children born with syndactyly have a greater risk for developing childhood malignancies.

Flexion Supracondylar Humerus Fractures: Ulnar Nerve Deficit is a Risk for Open Reduction

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LOE–Prognostic–Level III

Purpose: The vast majority of pediatric supracondylar humerus fractures (SCFxs) can be treated with closed reduction and percutaneous pinning. Usually, the need for open reduction and internal fixation (ORIF) is not known until the child is anesthetized and positioned and either closed reduction fails, or distal ischemia persists; then urgently, a new set-up or additional equipment is needed for open reduction. For this reason, any injury characteristics that predict the need for open reduction are valuable for pre-operative planning. A few small series have suggested that flexion SCFXs are more likely to require open reduction. From a large consecutive series of SCFxs, we investigated the incidence of flexion SCFxs, the rate of ORIF in flexion SCFxs, and predictors of the need to perform open reduction.

Methods: We developed a database of consecutive operative pediatric SCFxs at a single major pediatric trauma center from 2000 to 2015. Data included age, mechanism of injury, surgeon, associated injuries (including neurovascular), treatment, and fracture type. We reviewed the radiographs of all fractures reported as flexion SCFxs to confirm the pattern. The risk of ORIF associated with flexion-type fracture pattern and ulnar nerve injury at presentation were each assessed by odds ratio (OR) and their corresponding 95% confidence interval (CI).

Results: Of the 2,783 consecutive pediatric SCFxs, 95 were flexion-type (3.4%). Ulnar nerve injury was noted in 10/95 (10.5%). Open injuries were identified at presentation in 3/95 (3.2%) of cases. Among closed fractures, 21/92 (22.8%) flexion-type fractures required open reduction compared to 50/2647 (1.9%) extension-type SCFxs (OR = 15.4, CI, 8.8-27.0, P<0.001). Open reduction was performed in 6/10 (60.0%) closed, flexion fractures with ulnar nerve injury, compared to 15/82 (18.3%) flexion SCFxs without ulnar nerve injury (OR = 6.7, CI, 1.7-26.7, P=0.003).

Conclusion: The flexion pattern of SCFXs is correlated with a 15.4-fold increase in the odds of requiring an open reduction. The presence of an ulnar nerve deficit in those flexion pattern fractures adds a 6.7-fold risk of open reduction compared to flexion SCFxs without signs of ulnar nerve injury.

Significance: In this largest single-institution series of pediatric supracondylar humerus fractures, the flexion pattern was correlated with a 15-fold increase in the odds of requiring an open reduction.

Non-Operative Management of Salter-Harris II Fractures of the Distal Tibia: No Difference in Functional Outcomes Based on Postreduction Displacement

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LOE–Therapeutic–Level II

Purpose: Salter-Harris II (SH II) fractures of the distal tibia are commonly accompanied by premature physeal closure (PPC). The purpose of this study is to assess the functional outcomes in non-operatively managed patients with variable degrees of residual postreduction displacement. We hypothesize that there will be no difference in functional outcomes regardless of postreduction displacement distance.

Methods: All patients with SH II fractures of the distal tibia treated with closed reduction with non-weight-bearing long-leg casts from 2010-2015 were included. Patients were assigned to the following categories based on residual postreduction displacement: < 2 mm, 2-4 mm, and > 4 mm. Patient demographic data, radiographic data, and functional outcome data [lower extremity functional scale (LEFS) score (maximum score of 80 points) administered via telephone survey] were recorded.

Results: A total of 59 patients (32 males, 31 right ankles, 28 accompanied fibular fractures) were identified with a mean age (±SD) at time of injury of 12.0 ± 2.2 years. The average maximum fracture displacement was 6.6 ± 6.5 mm at initial presentation, 2.7 ± 2.0 mm at immediate postreduction, and 0.4 ± 0.7 mm at final radiographic follow-up. There were 23 (39%) patients with <2 mm, 21 (36%) patients with 2-4 mm, and 15 (25%) patients with >4 mm of displacement at immediate postreduction. There were 14 patients with PPC in total with no statistical significant difference between groups (p=0.228). Of the 59 total patients, 18 patients responded to the LEFS telephone survey (administered on average 4.0 ± 2.1 years after injury) with no statistical difference in LEFS scores between groups (p=0.605): 9 patients with a postreduction residual displacement of <2 mm (average LEFS: 76.3 ± 6.0), 4 patients with a postreduction displacement of 2-4 mm (LEFS: 79.9 ± 5.0), and 5 patients with a postreduction residual displacement of > 4 mm (average LEFS: 76.0 ± 8.4).

Conclusion: The overall PPC rate in this series of SH II distal tibia fractures was 24%. Differences in postreduction displacement did not seem to affect the rate of PPCs or the functional outcome of the lower extremity according to the LEFS survey.

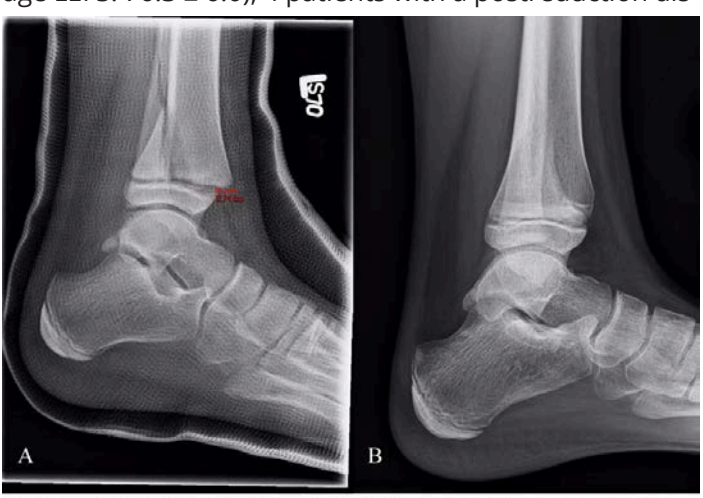

Figure 1. A. 9-year-old male with a 7.4 mm anteriorly displaced Salter Harris II distal tibia fracture immediately after closed reduction and application of long leg cast. **B.** Same patient 5 months later. This patient responded with a Lower Extremity Functional Sacle (LEFS) score of 80 (maximum score is 80) 2 years after initial injury.

Significance: In accordance with this, we recommend non-operative management of these injuries with closed reduction and application of a long leg cast. Operative management with open reduction and internal fixation (ORIF) may not be necessary for these injury types, as most non-operative cases have satisfactory outcomes in terms of PPC rates and function after closed reduction.

Sequential Intravenous High Dose Oral Antibiotics in the Treatment of Osteoarticular Infections in Children – A Randomised Controlled Trial

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LOE–Therapeutic–Level I

Purpose: Children in New Zealand have a high burden of acute osteomyelitis. Prolonged intravenous antibiotics is an effective treatment, however is associated with treatment related complications. Safety and effectiveness of an early switch from intravenous to oral antibiotics have not been examined in a randomised controlled trial in this population.

Methods: From 2009 to 2016, children from 6 months to 14 years with acute haematogenous osteomyelitis were randomised at the point of improvement of acute signs and symptoms and C-reactive protein (CRP), to receive high dose oral cephalexin or continue intravenous (IV) flucloxacillin. Children with resistant organisms, multifocal infection, vertebral osteomyelitis or immunodeficiency were excluded. A minimum of 3 weeks of antibiotics was given with weekly clinical, CRP and compliance monitoring, and until resolution of infection. Children were followed up for 12 months post treatment.

Results: 70 eligible children aged 11 months to 14 years were recruited. 39 children were randomised to the oral group. *Staphylococcus aureus* was identified as the causative organism in 55.7%. 19 surgical procedures were performed in 38 children in the oral group, and 25 procedures in 31 children in the IV group. Median peak CRP in the oral group was 78 and in the IV group 63. The median number of days to clinical improvement was 5 days in both groups and duration of hospitalisation was 8 days in the oral group and 12 days in the IV group. Median antibiotic duration from time of clinical improvement was 26 days and 29 days in the oral and IV group respectively. Treatment failure occurred in 2 children in the oral group and 4 children in the IV group, however there were no late relapse or chronic osteomyelitis. 29% of patients in the IV group developed a peripheral inserted central catheter or antibiotic-related adverse event.

Conclusion: Sequential intravenous high dose oral antibiotic therapy appears to be a well-tolerated, safe and efficacious treatment for this population of children with osteomyelitis. Clinical progress and compliance should be monitored regularly during treatment.

Significance: This randomised controlled trial clearly shows that in mainly cases of osteomyelitis a short course of IV antibiotics followed by a closely monitored course of oral antibiotics is as effective treatment as a prolonged course of IV antibiotics.

A Novel MRI Measurement to Assess Patellar Instability: Width of Patellar Tendon Beyond Lateral Trochlear Ridge

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LOE–Diagnostic–Level II

Purpose: Although measurements of biomechanical alignment, patellar height, trochlear morphology, and soft tissue constraint are currently used to assess patients with patellar instability, it is the resultant end alignment and force vectors that ultimately lead to patellofemoral dislocation. Measurements of each of these factors individually have traditionally been used to assess patients with patellar instability.

However, to better quantify patellar lateralization, we developed a novel measurement quantifying the axial relationship of the patella to the lateral trochlear ridge at the trochlear groove; a distance over which the patella must travel to dislocate. This measurement of the width of the patellar tendon beyond the lateral trochlear ridge may provide more useful information of functional stability of the knee than traditional measurements.

Methods: A consecutive cohort of 200 knees that sustained a patellar dislocation and 73 control knees with no dislocations between 2005 and 2014 were identified. MRIs were retrospectively analyzed by two observers who measured the tangential width of the patellar tendon extending beyond the lateral trochlear ridge apex (Figure). Interobserver reliability was assessed by calculating intraclass correlation coefficient (ICC). Statistical analysis included two-tailed t-tests, sensitivity, specificity, and receiver-operating characteristic (ROC) curves.

Results: For a cohort mean patellar tendon width of 27-29 mm, patients with patellar instability had an average of 9.4 ± 6.3 mm of tendon outside of the lateral aspect of the trochlea whereas patients with a stable tendon had only 1.5 ± 3.5 mm of tendon outside of the trochlea. A patellar tendon width of 5.55 mm beyond lateral femoral condyle is predictive of instability with a specificity of 89.4% and sensitivity of 73.1%. The area under the ROC curve was 0.86 (indicating excellent discrimination) and intrarater reliability was almost perfect (ICC=0.856).

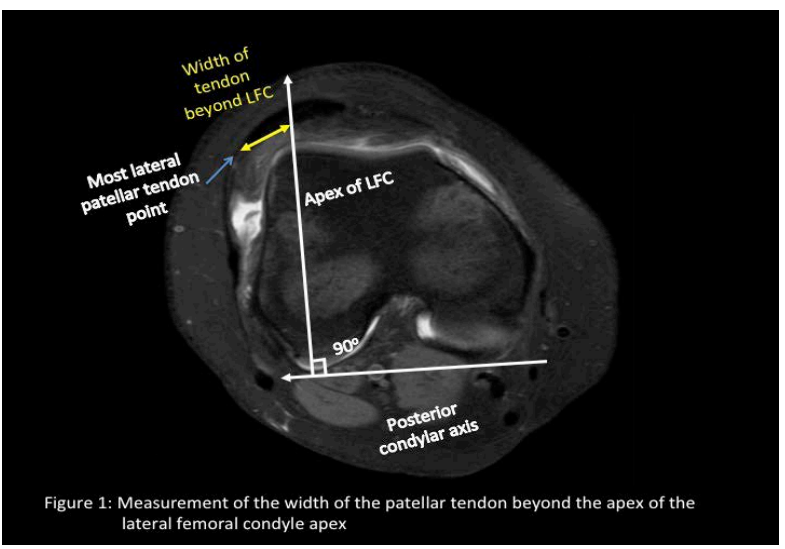

Figure 1: Measurement of the width of the patellar tendon beyond the apex of the lateral femoral condyle apex

Conclusion: Measurement of the width of the patellar tendon beyond the lateral trochlear ridge is reliable and significantly associated with patellar instability, with excel-

lent discrimination including both high sensitivity and specificity.

Significance: The amount of patellar tendon extending beyond the lateral trochlear ridge is a novel MRI radiograph metric taking into account overall alignment and trochlear morphology. It reliably predicts patellar instability with high sensitivity and specificity and thus may be useful to the treating physician when providing activity and treatment-related advice.

Clinical Screening Lowers the Risk of Late Diagnosed Hip Dislocation – Results from 1 Million Children Born in Sweden from 2000 through 2009

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LOE–Therapeutic–Level III

Purpose: Screening for hip dislocation was initiated in Sweden in the 1950s. Up to that time, the minimum frequency of late diagnosed hip dislocation was 0.9 per 1,000 live births. Today, all children born in Sweden are examined neonatally and at child health care centers during their first years. The screening program is mainly based on clinical hip examination. The aim of this study was to examine the epidemiology of late diagnosed hip dislocation in Sweden with the present screening program.

Methods: The Swedish Pediatric Orthopaedic Society instituted a nationwide prospective registry of all cases of hip dislocation in children diagnosed later than 2 weeks from birth, starting in January 2000. Teratogenic and neuromuscular hip dislocations are not included. We have studied the frequency of late diagnosed hip dislocation, the age at diagnosis and treatment start, and the severity of the disease, using the Tönnis radiographic grading system. The study includes all children born in Sweden from 2000 through 2009. The time of observation was through 2014.

Results: The incidence of late diagnosed hip dislocation in Sweden was 0.12 per 1,000 live births (95% CI: 0.10-0.15). The relative risk of having a hip dislocation was 9 in girls, compared to boys. The median age at diagnosis was 7 months. 21 children (17%) had a Tönnis grade 3 or 4 dislocation, and such cases were diagnosed later than less severe dislocations.

Conclusion: Clinical screening for neonatal hip instability at the maternity ward lowers the risk of late diagnosed hip dislocation. Further clinical screening at child health care centers lowers the age at diagnosis, with a resulting decrease in disease severity.

Significance: With unchanged incidence from the pre-screening period, an estimated minimum of 910 children would have presented with late hip dislocations, 790 being high dislocations. Instead, there were 125 cases, 21 of which were Tönnis grade 3 or 4, in the 1 million children born during the study period. Systematic clinical hip examination of infants by well-trained health professionals can be organized in most settings, with the potential for a large positive effect on child health where implemented.

Operative Treatment for Perthes Disease Yields Better Outcomes than Non-operative Treatment at 20 Year Follow-up

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LOE–Therapeutic–Level II

Purpose: The optimal treatment to prevent femoral head deformity in patients with Legg-Calve-Perthes disease (LCPD) remains controversial. Furthermore, prospective studies comparing long-term outcomes of operative and non-operative treatments are non-existent. This is the first prospective, long-term follow-up report comparing operative and non-operative treatment outcomes in LCPD in the third decade of life.

Methods: This is an IRB-approved analysis of patients enrolled in a multicenter study from 1984-1991 who were treated with either a Salter (SO) or femoral osteotomy (FO) for LCPD. Follow-up assessments included a clinical exam, radiographs, the Non-Arthritic Hip Survey (NAHS), and the Iowa Hip Score (IHS). Scores >80 vs <80 were classified as good/excellent or poor/moderate. The outcomes of this operatively treated patient cohort were compared to a lateral pillar and age matched cohort of patients treated non-operatively who returned previously for a long-term follow-up study.

Results: 33 hips in 32 patients (25M/7F; 33.5 ±3.7yrs and average BMI 29.5±13.6 kg/m^2) were treated with either a SO (n=18) or a FO (n=15) at an average follow-up of 25.8 yrs (range, 18.6 – 31.1 yrs). At enrollment, the age at onset was 7.9±1.1yrs with LP classifications: A=2, B=21, B/C=6, C=4. At final follow-up the mean NAHS was 84.9±19.5 and the mean IHS was 77.6±16.6 (max 100). There were no differences in outcome scores between the SO and FO patients. In comparison to the non-operative cohort, the operative patients were older ($p<0.001$) and had longer follow-up (25.8 vs 20.4yrs, $p<0.001$). Matched cohort analysis demonstrated better Stulberg grades (I/II, III, IV/V) in the operative group (75.8, 18.2, 6.1%) compared to the non-operative group (36.4, 43.2. 25.0%; $p=0.003$). The operative group had similar NAHS (84.8 vs 77.2, $p=0.10$) and IHS (77.6 vs 72.6, $p=0.23$), however, 70% of the operative group reported good/excellent outcomes compared to 45.5% in the non-operative group ($p=0.04$). One patient in the operative group (3%) compared to 3 patients (5.2%) in the non-operative group had a total hip arthroplasty.

Conclusion: At a mean follow-up of 25 years, the operative group had significantly better Stulberg radiographic outcome and a greater likelihood of good/excellent patient-reported outcomes than the non-operative group.

Significance: This prospective study demonstrates 75% good Stulberg outcome and 70% good/excellent patient-reported outcomes following operative treatment of LCPD. Careful consideration of operative treatment instead of non-operative treatment may improve the long-term outcome of patients with the onset of LCPD after age 6.

Bracing Idiopathic Scoliosis Greater than 40˚

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LOE–Therapeutic–Level III

Purpose: Due to mixed sentiment in the literature, we analyzed likelihood of progression and treatment outcomes of bracing for idiopathic scoliosis (IS) patients with large curves (>40˚).

Methods: This is a retrospective review identifying 95 IS patients who presented with a Cobb angle >40˚and were treated with a brace, with 72 followed to skeletal maturity. Age, MRI results, Cobb angle, Risser sign, in-brace correction, final curve on follow-up were recorded.

Results: Surgical correction was selected in 43/72 (60%) and 29 (40%) did not have surgery. Children who underwent surgery were younger at diagnosis and initial bracing (10.8 versus 12.7 years p<0.01), and had a greater major curve progression (20˚, p<0.001). For those radiographs with Risser signs visible (62), Risser 0 was most common and underwent fusion most often (33/45, [73%]). Double or triple major curves on presentation existed in 64% of operative curves, compared with 45% of nonoperative curves. For Risser 0 curves, brace treatment lasted an average of 2 years in both operative and non-operative groups. Curve correction in-brace is predictive of non-operative treatment (p=0.008) for those Risser 0. In the operative Risser 0 group, the major curve progressed 19 degrees and brace treatment delayed surgery for 2.5 years. Only 10/27 (37%) of Risser 1-5 curves had surgery, with the major curve progressed 13˚ in the brace. Average surgical Cobb angle was 66˚ versus 46˚ in the nonoperative group (p<0.001). More Lumbar C curves and well balanced double-major or lumbar-main thoracic curves did not have surgery when the curve was >50˚ (86% of nonoperative group >50˚).

Risser	n	surgery (%)	no surgery (%)	no surgery + >50˚	correction >5˚	worsen > 5˚	no change
0	45	33 (73)	12 (27)	5 (11)	4 (9)	34 (76)	5 (11)
1	9	4 (44)	5 (56)	1 (11)	2 (22)	6 (67)	1 (11)
2 or greater	18	6 (33)	12 (67)	5 (28)	2 (11)	12 (67)	3 (17)
total	72	43 (60)	29 (40)	11 (15)	8 (11)	52 (72)	9 (12)

Conclusion: Idiopathic curves >40˚ on presentation can be treated with a brace with over 1/3 not undergoing surgery. Curve correction in the brace does predict who will and will not have surgery. Risks for surgical intervention include Risser 0 at presentation. Lumbar C modifiers and well-balanced double major or lumbar-main thoracic curves are more likely to not have surgery.

Significance: This is the largest series to skeletal maturity of bracing in >40˚ idiopathic scoliosis curves, describing curve patterns that did not have a spinal fusion and identifying risk factors for spinal fusion. In-brace correction does predict success of non-operative treatment, emphasizing the need for close radiographic followup in the brace. There was a larger percentage of non-operative large curves than previously reported. Using the Risser grouping, improved patient education can be done regarding efficacy of brace treatment in large curves.

Radiographic, Pulmonary and Clinical Outcomes with Halo Gravity Traction

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LOE–Therapeutic–Level III

Purpose: Halo gravity traction (HGT) has been proven to be a safe and effective intervention to improve spinal deformity prior to corrective instrumentation of the spine. Severe spinal deformity has been correlated with poor pulmonary function and improved thoracic height afforded by HGT has the theoretical potential to improve pulmonary function prior to spinal deformity surgery. This study aims to (1) report on a large series of patients undergoing HGT, (2) demonstrate correlation between thoracic height improvement and pulmonary function, and (3) evaluate the efficacy of nutritional assessment and intervention while in HGT for these often malnourished or nutritionally-compromised patients.

Methods: Single center retrospective chart review: 107 patients who underwent HGT for severe spinal deformity from 2007- 2013 with ≥2 years follow-up. Major coronal and sagittal Cobb angles; coronal balance; and T1–T12 ht were collected pre-HGT, during HGT, immediate postop, and 2 years postop. Pulmonary function tests (PFTs) recorded Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 second (FEV1). Nutritional interventions such as formal nutrition consult while admitted for HGT, resulting nutritional supplementation, or interventions were recorded.

Results: HGT was used on average 11.5 (1.0-68.3) weeks with mean traction weight of 13.6kg (4.0-35.0) or 49.5% (16.1-107.1) of body wt. Mean coronal and sagittal major Cobb angles improved respectively by 27% and 25% in traction, and 49% and 35% from pre-op to post op. There was an 18% increase in T1-T12 height in traction and 23% overall. 19 patients had preoperative and 2 year postoperative PFTs. Improvement in PFTs correlated to improvement in T1-T12 height but not Cobb angle correction. Nutritionally, patients who preoperatively had a weight-for-age Z-score which was 2 SD below the mean improved from baseline (mean -4.3 Z score) by 2 standard deviations towards mean weight-for-age.

Conclusion: HGT successfully and safely obtains 55%, 69% and 78% of total correction of coronal, sagittal, and T1-T12 height prior to final surgical correction. We demonstrate a significant correlation between improvement in PFTs and increase in thoracic height, the first time this has been shown. Patients who are underweight benefit from traction and nutritional consult reflected in average weight gains of 2SDs. Future studies assessing non-radiographic benefits of HGT such as nutritional support and pulmonary function improvement will benefit prospectively from assessment of patients' pulmonary and nutritional status.

Significance: HGT provides significant correction of spinal deformity, leads to improvement in PFTs correlating with increased thoracic height, and allows significant improvement in nutritionally at-risk patients.

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Early Anterior Tibial Tendon Transfer for Clubfoot Patients

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LOE–Therapeutic–Level I

Purpose: To evaluate the influence of early Tibialis anterior tendon transfer (TATT) applied in the treatment of clubfoot on the foot function and children quality of life.

Methods: Because braces noncompliance are the main cause of clubfoot relapses, thus we proposed a hypothesis that early TATT–might be an effective and safe procedure, allowing achievement of similar outcomes comparable with the conservative Ponseti method, ensuring long-term brace wear avoidance and long-term foot correction. A prospective randomised study was performed. 39 children (55 clubfeet) were randomly allocated into one of two groups according to the applied treatment method (Ponseti (n=28 feet) vs early TATT (n=27 feet). The clinical data and children quality of life (using Pediatric quality of life inventory (Peds QL)) were evaluated. The final follow-up was at age of 2 years.

Results: The severity of deformity according to Pirani in both groups was ≤3.5 points in all cases, while according to Dimeglio, moderate deformity was observed in 32.14% in Ponseti and in 14.81% in TATT group, but no statistically significant difference regarding Pirani and Dimeglio scale among the groups was observed. Statistically significantly lower dorsal flexion ($p=0.03$) was observed in TATT group, although the mean motion amplitude in Ponseti group (18.21°±4.26) and TATT group (15.56°±4.78) corresponded the normal values. Other clinical parameters did not differ between groups. The analysis of Peds QL demonstrated a statistically significant difference in the mean score between both groups on the general psychosocial (PSFS) ($p=0.03$) and emotional functional scale (EFS), ($p<0.001$). The score was greater in TATT group, which means that psychosocial and especially emotional functioning were better evaluated by parents of TATT group. Physical ($p=0.26$), social ($p=0.17$) and school functioning ($p=0.9$) were similarly evaluated in both groups. Each question on the parent survey was analysed separately and was evaluated in relation to other questions of the same scale. Assessing the EFS, statistically significant difference between the groups was observed in two survey questions. Both "feeling angry" ($F=4.27$; $df=1$; $p=0.046$) and "trouble sleeping" ($F=18.38$, $df=1$, $p<0.001$) were statistically significantly more frequently indicated by the parents of Ponseti group.

Conclusion: Clinical results in both groups corresponded to the normal values indicated in the literature. Parents of patients for whom early TATT was performed, evaluated psychosocial health and emotional condition of their children better than in the Ponseti group.

Significance: An early TATT allows a significant reduction in the brace wear duration and achieves the same outcomes as using the Ponseti method.

A 13 Year Follow-up of Split Tendon Transfers for Equinovarus Deformity Secondary to Cerebral Palsy

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LOE–Therapeutic–Level III

Purpose: Equinovarus (EV) foot deformity is commonly seen in ambulatory patients with cerebral palsy (CP) and interferes with stability in stance, pre-positioning the foot in terminal stance, and clearance in swing during gait. Soft tissue surgeries such as a split anterior (SPLATT) and/or posterior (SPOTT) tibial tendon transfer are indicated to balance coronal and transverse plane torque throughout the foot. Limited long-term reports on outcomes had variable results. The purpose of this study was to examine the long-term outcomes of these procedures.

Methods: Ten participants (average age 22y 10m; 4M, 6F; 5 hemiplegia, 4 diplegia, and 1 triplegia involvement; Gross Motor Functional Classification System (GMFCS) I n=7 and GMFCS II n=3) who had EV corrective surgery at an average of 9y 2m, were seen for a follow up visit in the Motion Analysis Lab an average of 13y 6m post-surgery. Outcomes included multi-segment foot and ankle gait kinematics using the Milwaukee Foot Model, visual analog pain assessment, ambulatory ability, static foot alignment based on Kling criteria, and hindfoot score based on Chang. Surgeries included four SPLATT and nine SPOTT procedures. Five participants had follow-up surgery.

Results: Gait kinematics demonstrated that the Equinovarus Group presented with mild residual equinus (hindfoot plantar flexion and decreased forefoot plantar flexion), hindfoot valgus, and forefoot varus (Figure 1). Residual/recurrent transverse plane foot deformity was not appreciated. Average pain score in the foot was 2.5 out of 10. Nine participants ambulated community distances and one was a short community ambulator. All wore regular shoes, and five participants had callouses at their great toe. Using the Kling foot positioning criteria, there were six excellent and four good results. In contrast to hindfoot kinematics, the Chang hindfoot grading criteria results showed seven neutral, one mild varus and two mild valgus feet after correction.

Conclusion: Overall, surgical results were maintained 13 year post-operatively. Corrections were maintained in most subjects' hindfoot and forefoot coronal plane alignment and overall foot gait kinematics; however mild residual equinus did persist. Pain and callouses were minimal and all subjects now fit into regular shoes and attend school/work full time.

Significance: Findings support the use of split tendon transfers to treat equinovarus foot deformities. The results also illustrate the importance of objective gait kinematics as observational-based tools did not detect residual, recurrent hindfoot valgus.

Acknowledgments: We would like to acknowledge the Helen Kay Charitable Trust grant for funding this study.

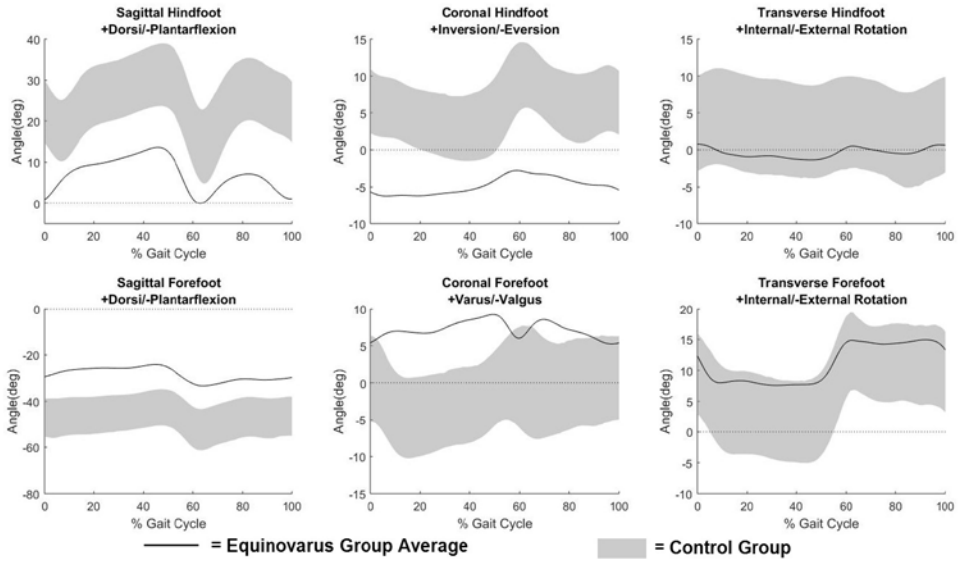

Figure 1. Multi-segment kinematics of the Control Group (Grey band: Mean +/- 1 SD) and the Equinovarus Group (Black line: Mean)

Normalization of Foot Motion after Tibialis Anterior Tendon Transfer for Clubfoot Recurrence

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LOE–Therapeutic–Level II

Purpose: The tibialis anterior tendon transfer (TATT) is part of the Ponseti method for the treatment of children with dynamic clubfoot recurrence. However, changes in foot motion compared to the preoperative findings and compared to healthy children have not been described in detail. Our aim was to evaluate the difference of foot motion after TATT compared to a healthy control group using 3D gait analysis including the Oxford foot model. Preliminary results of this prospective study are presented.

Methods: Patients older than three years with idiopathic clubfoot treated with the Ponseti method at our center and with a TATT were included. Exclusion criteria were prior bone or joint invasive clubfoot surgery and associated syndrome or neurological disease. The indication for TATT was dynamic clubfoot recurrence with foot adduction and supination during swing. Postoperative gait analysis was performed six months after surgery and compared to preoperative gait analysis and to a healthy age-matched control group. A total of 63 children underwent tibialis anterior tendon transfer between 2011 and 2015; 30 patients met the inclusion criteria.

Results: The full set of data was available for 10 children (6 bilateral, 4 unilateral) with 16 clubfeet with a mean age at time of surgery of 7 (5-9) years. Additional surgical procedures were Achilles tenotomy in 6 feet, plantar fasciotomy in 2 feet and abductor hallucis release in one foot. The control group consisted of 16 children (=32 feet).
Gait analysis showed significantly increased dorsiflexion of the ankle (p=0.001) and increased range of motion of the hindfoot in relation to tibia (p=0.006). The forefoot supination and adduction was reduced compared to preoperative data.
Compared to the healthy control group the ankle dorsiflexion was slightly increased (p=0.09). The forefoot plantarflexion in relation to the hindfoot and tibia was decreased (p=0.001). The supination of the forefoot during swing was normalized (p=0.5). The adduction of the forefoot in relation to the hindfoot was reduced during the whole gait cycle (p=0.01).

Conclusion: Gait analysis including the Oxford foot model showed improved foot motion after TATT in children with clubfoot recurrence. While the forefoot supination was normal, the forefoot seemed to be slightly abducted compared to the control group. Therefore, the postoperative data shows that TATT can effectively correct dynamic clubfoot recurrence.

Significance: Our results confirm the good outcome reported in previous studies and give additional information on foot motion after TATT. However, further evaluations of larger cohorts with a longer follow up are needed.

Ponseti Treatment of Clubfeet Results in Less Foot Size Asymmetry than Comprehensive Surgical Releases

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LOE–Therapeutic–Level III

Purpose: The clubfoot, regardless of treatment, is usually smaller and wider than normal and may require different size shoes. Ponseti management has demonstrated improved outcomes over comprehensive surgical release (CSR) with less pain, greater flexibility, function, and patient satisfaction. Our purpose was to assess the impact of treatment on the growth of the clubfoot. Our hypothesis was that Ponseti treatment would result in improved growth of the clubfoot compared to comprehensive surgical releases.

Methods: Using a pedobarographic database of 10,015 studies, an IRB-approved review revealed 299 studies of unilateral idiopathic clubfeet treated with Ponseti management (casting +/- Achilles tenotomy or anterior tibialis tendon transfer) and 381 studies of unilateral idiopathic clubfeet treated with CSR (+/- prior casting). All patients who had bony procedures were excluded. From this, we were able to obtain age and height matched cohorts of 40 children treated with Ponseti and 40 treated with CSR. All pedobarographic studies were performed using a Novel EMED-X foot pressure plate (Novel, Germany, 2015). Representative trials were evaluated using a 10 area mask.

Results: Mean age at assessment of the treatment groups were 10.5(±0.6) years for Ponseti and 10.8(±0.6) years for CSR patients. Ages and heights of the 2 treatment groups were not statistically different ($p>0.05$).
Clubfeet versus Unaffected Feet:
The Ponseti feet were significantly different in length between the affected (22.5cm) and unaffected (23.6cm) sides ($p=0.001$). This equates to an average of 1.2 shoe sizes smaller. The CSR feet were significantly different between the affected (21.5cm) and unaffected (23.4cm) sides ($p<0.001$). This is a mean difference of 1.9 shoe sizes.

Ponseti versus CSR Treated Clubfeet:
Ponseti feet were 95.0% of the unaffected foot length and the CSR feet were 91.7% of the unaffected foot length.($p=0.005$) The Ponseti treated foot was significantly longer than the CSR treated foot. (22.5cm vs. 21.5cm respectively, $p=0.015$) This is an average 0.95 shoe size difference between the treatment groups. The Ponseti and CSR unaffected foot lengths were not significantly different (23.6cm and 23.4cm, respectively $p=0.36$).

Conclusion: Regardless of treatment, the affected clubfoot was smaller than the unaffected foot. However, Ponseti treated feet were significantly longer and more symmetrical than the CSR treated feet.

Significance: This is the first cohort matched study comparing foot size asymmetry between Ponseti and comprehensive surgical release treated clubfeet. In addition to the other benefits, Ponseti, treatment results in a longer and more symmetrical foot than one treated by CSR.

Community Ambulatory Activity and Gross Motor Function Following Treatment for Clubfoot at Age 10 Years

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LOE–Therapeutic–Level II

Purpose: The purpose of this study was to assess objective functional outcome measures (community ambulatory activity, ankle strength and Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) following nonsurgical and surgical treatment for idiopathic clubfoot.

Methods: Ninety children with clubfoot (43 surgical [SX], 47 nonoperative [NO]) wore an accelerometer at age 10 years for a minimum of 1 week and reported their physical activity for that week. Ambulatory activity variables included average daily total steps (steps), total ambulatory time (TAT; minutes), intensity (*Easy*/*Moderate*; % of TAT) and duration (*Short*, *Intermediate*, *Long*; % of TAT). Isokinetic plantarflexion strength was reported and the BOT-2 (gross motor function) was completed in a subgroup of 68 patients. BOT-2 scores included running speed/agility and strength. 42 age-matched controls were used for comparison.

Results: There were no statistically significant differences in ambulatory activity or in BOT-2 scores between NO and SX patients. SX patients had significantly less plantarflexion strength than NO patients (p=0.006). 62% of clubfoot patients reported participation in sports during a typical week. Compared to controls, clubfoot patients took significantly fewer steps (p=0.027) and spent significantly less time in ambulatory activity (p=0.004). Clubfoot patients with higher BMIs spent less time participating in *Long* duration activities (rho=-0.21, p=0.047). SX patients with weaker plantarflexors spent more time in *Short* duration activities (rho=-0.32, p=0.035) and less time in *Moderate* Intensity/*Long* Duration activities (rho=0.33, p=0.029).

On the BOT-2, 90% (n=61) and 87% (n=59) of clubfoot patients scored average or above average on running speed/agility and strength, respectively. Clubfoot patients with lower BOT-2 strength scores had weaker plantarflexion strength (rho=0.28, p=0.023), spent less time in *Long* duration activity (rho=0.26, p=0.036) and had a higher BMI (rho=-0.28, p=0.022). Clubfoot patients with lower running speed/agility scores took significantly fewer steps (rho=0.32, p=0.008) and had less ambulatory time (rho=0.31, p=0.010) with greater steps at *Easy* Intensity/*Short* duration (rho=-0.28, p=0.021).

Conclusion: Clubfoot patients at age 10 years spend significantly less time in community ambulatory activity when compared to their peers. No significant differences in activity and BOT-2 scores were found between patients treated with and without surgery. The majority of patients scored average or above average on BOT-2 strength and agility. Weak but significant correlations were found between ambulatory activity and BOT-2 scores.

Significance: Ten year old children with clubfeet have less ambulatory activity with correlations seen between the intensity and duration of activity and gross motor function.

Motor Skills in 191 School Children with Idiopathic Clubfoot

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LOE–Not Applicable–Level II

Purpose: The aim of the study was to examine motor abilities in children treated for idiopathic clubfoot.

Methods: The children were all assessed with the Movement Assessment Battery for Children (MABC-2). It evaluates motor performance according to hand function, ball skills static and dynamic balance. The MABC-2 age band 7-10 years was used. The same specialized physiotherapist tested all the children. The children were recruited from a Norwegian multicenter study and health age- and gender-matched individuals were recruited from a school nearby the hospital.

Results: 97 children with idiopathic clubfoot treated a.m. Ponseti, mean age 8.8 (7-10) years were assessed. 94 children treated *before* the Ponseti method was introduced in Norway, mean age 9.0 (7-10) years, were also assessed. 45 healthy children were also tested. 70 and 67 percent were boys in the treatment groups and there were 51 and 36 percent bilateral ceses respectively. The children treated a.m. Ponseti had had serial castings (3-13 casts) starting a few days after birth. 80 percent of them had tenotomy of the Achilles after an average of 7 castings. One fourth of the cases had minor surgeries like open lengthening of Achilles within the first 7 years of their life. 1/10 of the cases had more extensive surgeries like posteromedial release. The pre-Ponseti group had traditional serial castings from a few days after birth, posterior release or other surgeries if needed. All had abduction braces for 4 years thereafter but compliance was not recorded. In the control group 96 percent had normal motor function and 4 percent had motor problems. In the treatment groups, Ponseti and pre-Ponseti, 67 percent and 65 percent respectively had normal motor function, 18 and 14 percent were categorized as having clumsiness and 15 and 17 percent respectively had motor problems.

Conclusion: 1/3 of children with idiopathic clubfeet treated a.m. Ponseti or treated in the pre-Ponseti era had inferior motor function compared with their peers in early school age according to MABC-2. The identified children with motor problems suggest more comprehensive physiotherapeutic follow-up.

Significance: This study suggests that a closer follow-up concerning motor skills should be considered for patients with idiopathic clubfoot in pre-school age.

The Outcome of the Ponseti Method at a Minimum of 5 Years: What Have We Learned?

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LOE–Therapeutic–Level I

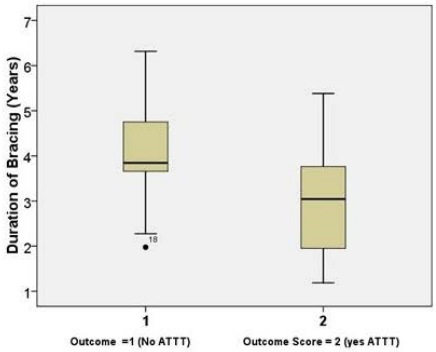
Purpose: As the Ponseti technique was developed at the University of Iowa in the 1950s, long-term outcome studies of this method have almost exclusively come from this single institution. The goal of this study was to report the outcome of patients followed to mid-childhood – at a minimum of 5 years of age – whose feet were managed using the Ponseti method to see if comparable results could be obtained to those reported from Iowa.

Methods: Since July 2006, all families of infants seen in our clinic diagnosed with idiopathic clubfoot were prospectively invited to participate in our IRB-approved study. All patients who had received no prior outside treatment and were followed for a minimum of 5 years were included. Demographic, treatment, and outcome data was collected. Outcomes were assessed using both the Dallas criteria and the Roye Disease Specific Instrument (DSI).

Results: Ninety-two patients met the inclusion criteria. The mean length of follow-up was 74.8 months (SD 14.3). The mean Dimeglio score at initial presentation was 13 (SD 2). Sixty-two percent of patients experienced one or more relapses, and 33% of patients required an ATTT. Using the Dallas criteria, 67% of patients were rated good, 33% of patients were rated fair; no patient was rated poor. Importantly, patients who had a good outcome wore the brace for a mean of 4.1 years (median 3.8, range 2.0-6.3), whereas patients who had a fair outcome, wore the brace for a mean of 3.0 years (median 3.1, range 1.2-5.4) ($p<0.01$). Based on the DSI, most families were satisfied with the function and appearance of the feet.

Conclusion: Based on the Dallas criteria, good results were achieved in a high percentage of patients. Based on the DSI, most parents were highly satisfied with the appearance and function of the feet. On average, patients who wore the brace for 4 years had better outcomes than those who wore the brace for 3 years. The rate of relapse and the need for anterior tibial tendon transfer in our patients was comparable to that reported by the Iowa group.

Significance: At a minimum follow-up of 5 years, satisfactory outcomes were achieved using the Ponseti method. The results indicate that bracing should continue to at least 4 years of age to improve outcome. Despite a better understanding of the Ponseti method, including longer post-corrective brace use, the need for anterior tibial tendon transfer remains an important adjunct to the Ponseti method.



Roye DSI

#	Question				
		Very Satisfied	Somewhat Satisfied	Somewhat dissatisfied	Very dissatisfied
1	How satisfied with foot?	78.3%	16.3%	0.0%	5.4%
2	Appearance?	71.7%	21.7%	2.2%	4.3%
		Never	Sometimes	Usually	Always
3	Child teased b/c of foot?	84.8%	13.0%	0.0%	2.2%
4	Problems finding shoes that fit?	64.1%	23.9%	6.5%	5.4%
5	Problems finding shoes that they like?	73.6%	14.3%	6.6%	5.5%
9	Complain of pain during heavy exercise	53.3%	42.4%	4.3%	0.0%
10	Complain of pain during moderate exerci	70.7%	28.3%	1.1%	0.0%
		No	Yes		
6	Child ever complains?	59.8%	40.2%		
		Not at all limited	Somewhat limited	Moderately limited	Very limited
7	Ability to walk?	82.6%	15.2%	1.1%	1.1%
8	Ability to run?	73.9%	22.8%	2.2%	1.1%

Treatment of Neuromuscular and Syndromic (Non-idiopathic) Clubfeet Using the Ponseti Method

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LOE–Therapeutic–Level III

Purpose: The Ponseti method has revolutionized the treatment of clubfeet patients. Non-idiopathic clubfeet due to their neurogenic /syndromic causes are typically thought to be resistant to non-operative management.
The purpose of this study was to analyze the outcomes of the Ponseti method of treatment in patients with non-idiopathic clubfeet as compared to idiopathic clubfeet.

Methods: All patients from our dedicated clubfoot clinic were reviewed between July 2011 to August 2015. Out of 374 patients, 284 had idiopathic clubfoot (group I) and 90 (24%) children had non-idiopathic clubfeet. 31/90 patients were lost to follow up. 59 patients (96 feet)-group NI were finally analysed. Outcomes evaluated included number of casts, tenotomy rate, recurrence rate, failure rate and need for secondary procedures. Results were compared between both groups for the same period.

Results: The mean follow-up in Group NI was 32 months (6 months- 4 years). Mean presentation age was 7.8 months (6 days - 4.7 years). 18 patients had arthrogryposis, 5 had menigocoele & 36 patients had various syndromes. Mean pre-treatment Pirani score was 5.08 (1 - 6) and mean post-treatment Pirani score was 0.23 (0 - 3). Mean number of casts was 6.9 (1 - 20); per-cutaneous Tendo- Achilles tenotomy was performed in 55 patients (93%). Only 5/59 patients (8%) failed to respond to the Ponseti method and required surgery, showing an initial success rate of 92%. Recurrence was seen in 32/59 patients (33%) needing either re-casting, repeat Tendo-Achilles tenotomy, open releases or external fixator. Nine /59 patients underwent surgery (15%). 4 patients had complications viz. 1 sore,1 rocker bottom foot and 2 heel varus. In group I (284 patients)mean follow up was 33 months (6 months – 4 years),mean age 9 months(7 days-10 yrs), mean pre op Pirani score was 5.6(4-6) and post treatment score was 0(0-0.5).The mean number of casts were 5.6 (1-14).per-cutaneous tenotomy rate was 94%.recurrence was seen in 21/284 patients (8%).On early results comparison significant correlation was seen in successful rate of final correction 92% (NI)v/s 98% I ,significant relapse rate group NI 33% v/s 18% (0.002). More casts were required for group NI as compared to Group I. Total casts did not correlate with either age of presentation / initial severity.

Conclusion: Despite a high recurrence rate (33%), most syndromic clubfeet (92%) respond well to the Ponseti method of treatment. The benefits of non-operative treatment outweigh the morbidity of surgery.

Significance: Paper highlights successful early results with Ponseti even in syndromic feet not frequently reported.

Mid-term Results of the Ponseti Method for Treatment of Clubfoot in Patients with Spina Bifida

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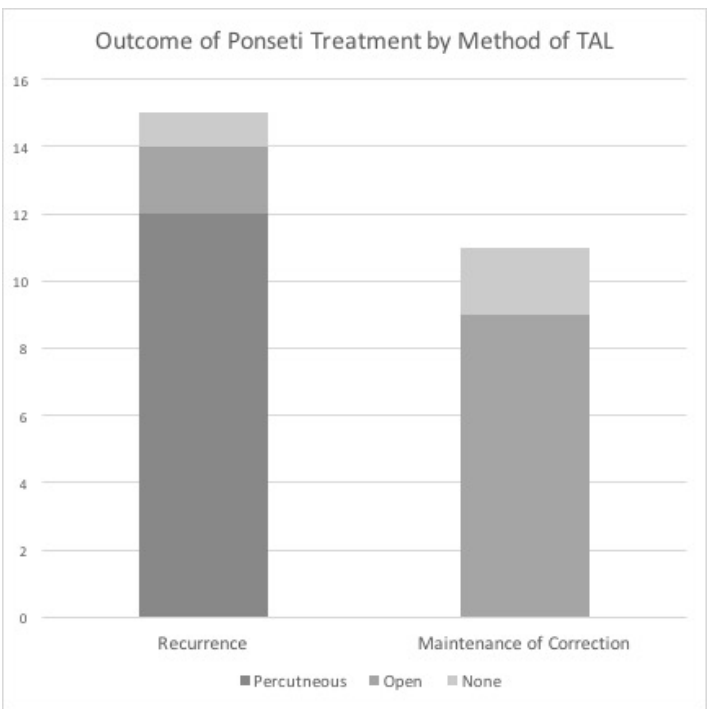
LOE–Therapeutic–Level III

Purpose: Clubfoot is present in 30-50% of pediatric patients with spina bifida. The Ponseti serial casting method has changed the treatment of idiopathic clubfoot to a primarily non-operative regimen. The Ponseti method is now widely applied to patients with clubfoot associated with spina bifida, however, few studies have reported treatment outcomes. Most available studies include heterogeneous diagnoses or report short-term results. The purpose of this study is to report mid-term outcomes in patients with spina bifida who were treated for clubfoot using the Ponseti method.

Methods: This is an IRB-approved retrospective chart review of 16 consecutive patients (26 feet) less than one year of age with spina bifida treated with the Ponseti method. Patient charts were reviewed to identify the age at treatment initiation, total number of casts required, surgeries performed, recurrence of clubfoot deformity, and further treatments. The primary outcome was recurrence of the clubfoot deformity requiring further treatment. Data was analyzed using t-tests for means and chi square tests for categorical data.

Results: Initial correction was achieved in 26/26 feet. 23/26 feet underwent TAL at an average age of 105 days, 12 percutaneous and 11 open excision. At an average follow-up of 5 years (1.8 – 7.5 years), 11 feet (42.3%) in 7 patients were successfully treated with the Ponseti method. Of the 15 feet (57.7%) with recurrence, 8 required posterior releases, 6 posterior-medial-lateral releases and one tendon transfers. Average age at further treatment was 1.5 years (0.9 – 3.1 years). Those with recurrence required more casts prior to TAL (7.2 vs 5.3, p=0.017). All patients (12/12) who underwent percutaneous TAL had recurrence of deformity requiring further treatment, compared to 18% (2/11) of patients who underwent open excision (p<0.0005).



Conclusion: Mid-term evaluation of the Ponseti

method for clubfoot associated with spina bifida shows a successful outcome in 42.3% of patients. Recurrence in those who underwent open Achilles excision was significantly lower than percutaneous TAL and also substantially lower than previously published recurrence rates in spina bifida (33.3-68%).

Significance: The Ponseti method leads to reliable initial correction of clubfoot associated with spina bifida and is useful to decrease the need for extensive soft-tissue releases. To decrease risk of recurrence, an open excision of the Achilles should be performed. Families should be counseled prior to initiation of treatment about realistic expectations regarding the high risk of recurrence and potential need for further treatment.

Can Repeated Ponseti Management for Relapsed Clubfeet Produce the Outcome Comparable to the Case Without Relapse?
A Clinical Study in Term of Gait Analysis

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LOE–Therapeutic–Level III

Purpose: Clinical efficacy of repeated Ponseti method has been poorly reported in term of gait analysis. This study aims to evaluate the clinical outcome of relapsed clubfeet treated with repeated Ponseti method in comparison with the case without relapse by means of gait assessment.

Methods: Thirty-seven patients were retrospectively reviewed from our database according to the inclusion and exclusion criteria. Of the 37 patients with 53 clubfeet, 17 cases with 25 relapsed clubfeet were assigned to Group I, while 20 cases with 28 clubfeet, which did not relapse in term of physical assessment, were assigned to Group II. Physical assessment and gait analysis were employed. The kinematic gait deviation criteria from TSRH were used for evaluation

Results: Foot length, stride length and single limb support time (SLST, %GC) were found to be significantly different between these two groups. No statistical difference was found in kinematic parameters of total hip, knee and ankle excursion, peak knee and ankle flexion and extension and internal foot progression angle. There was no statistical difference in peak hip, knee and ankle flex moment, peak knee valgus moment and peak ankle power. No significant difference was found in equinus and calcaneus gait, increased ankle dorsiflexion, foot drop, and internal foot progression.

Conclusion: From the findings of this study, it is demonstrated that repeated management of relapsed clubfeet using Ponseti method can yield good or excellent clinical outcome. We strongly recommend repeated Ponseti method be the first choice of treatment for relapsed clubfeet at the early stage of relapse.

Significance: Repeated management of relapsed clubfoot using Ponseti method is of excellent or good clinical efficacy in term of functional assessment and should be considered for clinical application as soon as the relapse occurs.

Gait Analysis in Children in Middle Childhood with Clubfoot: Posterior-Only Release versus Ponseti Method

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LOE–Therapeutic–Level III

Purpose: The overall purpose of this study is to evaluate clinical progress in children in middle childhood (7- 12 years old) with clubfoot treated with Ponseti method versus posterior-only release and compare their results to a control group with 4 testing modules(physical examination,gait study,radiographic measurements and questionnaires).

Methods: Retrospective study approved by the Ethics Committee.
Inclusion criteria: diagnosis of idiopathic clubfoot treated between 2004-2009 in one centre.
Group1: 28 patients (39 clubfeet) treated with the posterior-only release.
Group2: 18 patients (31 clubfeet) treated with the Ponseti method.
Group3: 25 control subjects with no known musculoskeletal or neurologic abnormalities.

Gait
An 8-camera KINESCAN/IBV system was used to gather kinematic and kinetic data.

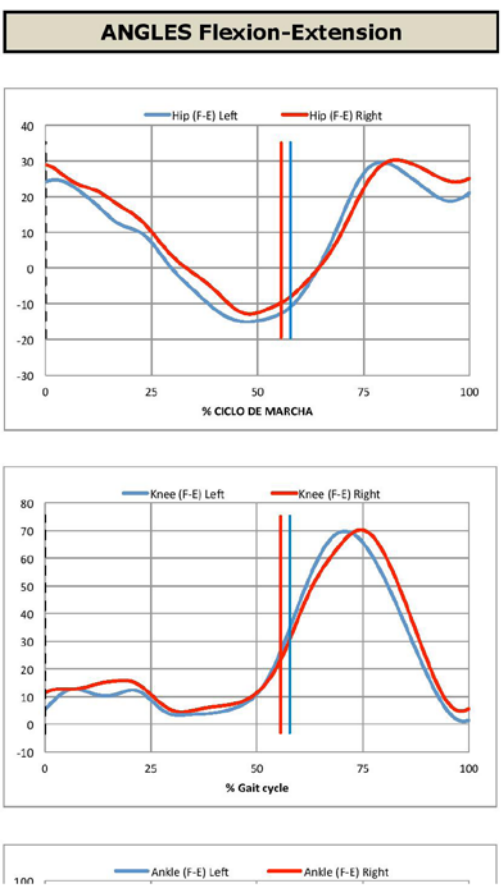
Physical exam
Physical examination measurements evaluated passive ROM,flexibility and strength.

Questionnaires
Parents completed the Pediatric Outcomes Data Collection Instrument(PODCI),Foot and Ankle Disability Index Score(FADI) and Foot and Ankle Outcome Score(FAOS).

Radiographs
Standing AP/LAT radiographs of the feet were made.

Results:
Physical exam:
Treatment groups showed reduced dorsiflexion,plantar flexion,inversion and eversion compared with control group.

Radiographic examination:
No differences in angles measured and osteoarthritis was observed between



treatment groups.

Gait:
No differences were found between treatment groups for temporal or spatial parameters. No differences were found in kinematic and kinetic data between treatment groups although the Ponseti group more closely resembled the control group. Rotational alignment analysis revealed no differences in residual internal rotation between treatment groups. Only 14 feet(45%) of Ponseti group and 17 feet(44%) Posterior-release group had normal gait (p=.42).

Questionnaires:
No differences were found in FADI and FAOS questionnaires. PODCI scores were higher in Ponseti group subjects in physical functioning section but were not statistically significant.

Conclusion: Our study showed that patients in the Ponseti and posterior group remained functional with high quality of life. Slight differences were observed in ROM and specific gait parameters favouring the Ponseti method group however they were not statistically significant. With these results,we still believe that the Ponseti method should be the method of choice(less costs and same results without having the need of surgery) however we can also send a message to those parents whose children were treated with posterior-release that functional outcome in their children is acceptable.

Significance: To the best of our knowledge,this is the first study to perform a complete gait analysis in patients treated with one surgical technique(posterior-only release, excluding other surgeries) in a specific age group(middle childhood) and compare their results to children treated with the Ponseti method and control group.

Surgical Management of Idiopathic Clubfoot in the United States from 1997-2012: An Analysis of 11,940 Discharges

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LOE–Economic and Decision Analyses–Level II

Purpose: With the introduction of the Ponseti Method in the late 1990's, rates of operative intervention of clubfoot within the first year of life have significantly declined. However, operative procedures for clubfoot continue to be routinely performed in the United States. Our purpose was to analyze trends in the operative management of clubfoot in the US, including total costs from 1997-2012.

Methods: The HCUP KIDS' Inpatient Database was used to identify discharges associated with idiopathic clubfoot (ICD-9-CM diagnosis codes 754.70 and 754.51) and one or more of 28 corrective surgeries between 1997-2012. Patients were divided into subgroups of ages 0 to <1 and 1 to 18. Variables analyzed included number of operative procedures, hospital charges, and length of stay.

Results: There were 11,940 discharges (~65% Male) with a clubfoot diagnosis and clubfoot procedures identified in the study period. In the first year of life, total procedures decreased approximately 92% from 1997-2012 (2153.6±205.6 to 177.2±27.7, p=0.0067) (Figure 1). Total number of procedures remained steady in the 1-18 age group (2644.5±285.4 to 1923.9±203.2, p=0.0969) from 1997-2012. Eighty-six percent of all procedures were done after the first year of life. The average number of clubfoot procedures per patient ages 0-<1 did not significantly decrease from 1997 (1.26±0.04) to2012 (1.17±0.05, p=0.2095). The average number of clubfoot procedures per patient ages 1-18 significantly increased from 1.61±0.04 in 1997 to 1.74±0.03 in 2012(p=0.0005). Over the same time period, the number of hospital stays for clubfoot procedures decreased in both age groups (both p<0.05). Average hospital length of stay increased from 1.98+0.17 to 3.01+0.45 (p=0.016) from 1997 to 2012. Mean hospital charges increased on average $5802.6±744.7 every three years (p<0.0001) totaling $46,826.0±5,800.3 per hospitalization in 2012.

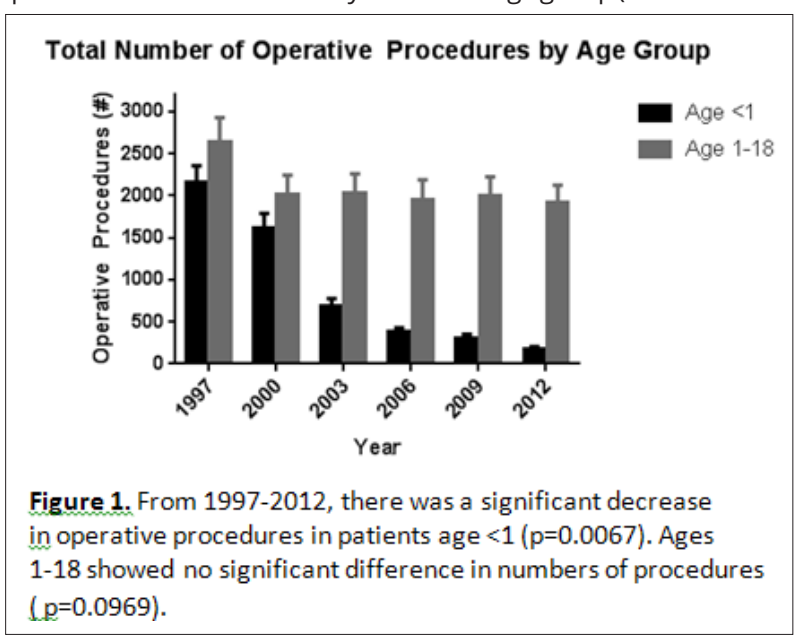

Figure 1. From 1997-2012, there was a significant decrease in operative procedures in patients age <1 (p=0.0067). Ages 1-18 showed no significant difference in numbers of procedures (p=0.0969).

Conclusion: Over the 15-year period analyzed, there was a significant decrease in clubfoot operative procedures in the first year of life. In contrast, the average number of per patient club foot procedures increased and total procedures remain steady in the 1-18 age group. Mean charges for operative clubfoot procedures have increased totalling nearly 700 million from 1997-2012. These data suggest a break from the Ponseti Method after the first year of life and a trend towards operative preference in management of clubfoot in patients ages 1-18.

Significance: This study highlights the trend for continued operative management and increasing total costs in the treatment of idiopathic clubfoot.

Health-Related Quality of Life in Early-Onset Scoliosis Patients Treated Surgically: EOSQ Scores in Traditional Growing Rod versus Magnetically-Controlled Growing Rods

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LOE–Therapeutic–Level III

Purpose: The treatment of early-onset scoliosis is currently undergoing a paradigm shift with the introduction and acceptance of the magnetically-controlled growing rod (MCGR). This new implant attempts to decrease surgical sessions and obtain more natural growth with more frequent lengthenings. This study aims to compare quality of life and caregiver burden in traditional growing rod (TGR) and MCGR patients utilizing a previously validated tool, the Early-Onset Scoliosis Questionnaire (EOSQ)-24.

Methods: Inclusion criteria: 10 years or younger at the time of index surgery, pre-operative major curve more than 40°, radiographic thoracic height T1-T12<22cm, no previous spine surgery, and minimum 12-month postoperative follow-up. Pre- and post-distraction radiographs were taken for all patients to confirm that rods had been lengthened. The previously validated Early Onset Scoliosis Questionnaire (EOSQ) was utilized to assess health-related quality of life. T-test was utilized to test for significant differences in scores between TGR and MCGR patients.

Results: 44 children with a mean age of 6.7(SD2.0) MCGR, 6.1(SD2.0) TGR were included. Children in MCGR and TGR groups were similar in terms of gender, age, major Cobb angles and complications. The mean length of follow-up was 31.1(SD19.1) months in MCGR, 98.3(SD29.3) months in TGR($p<0.001$). The mean number of distractions per patient was 5.6(SD2.8) in MCGR 9.2(SD3.4), in TGR($p<0.001$). The mean unplanned surgery number was 0.3(SD0.7) in MCGR and 0.8(SD1.2) in TGR($p=0.15$). Mean EOSQ values and domain values of groups are listed in table 1. Univariate analysis revealed that children in the MCGR group scored significantly higher in the domains of Economic Burden and Overall Satisfaction. When patient groups were controlled statistically for length of follow-up (analysis of covariance), physical activity scores became significantly superior in the MCGR group as well.

Conclusion: This study reveals that health-related quality of life outcomes are superior in the MCGR group in the domains of Financial Burden and Overall Satisfaction when compared to a TGR group with significantly longer follow-up. Number of unplanned surgeries is not statistically significant. More studies are required to better delineate the impact of early-onset scoliosis treatment modalities on the day-to-day lives of these children and their families.

Significance: HQRL data obtained from MCGR and TGR reveal superior outcomes in the financial burden and patient satisfaction, and, when controlled for length of follow-up, physical activity. However, in all other domains and average number of unplanned surgeries, both treatments remain similar, indicating that the TGR is far from being obsolete as of yet.

Table: EOSQ values and domain values of groups

(adjusted lengthening count with analysis of covariance [ANCOVA] models)

Mean (95% CI)	MCGR(n=19)	TGR (n=25)	p
General health	60.8 (53.2 - 68.4)	57.3 (50.7 - 63.9)	0.495
Pain/Discomfort	73.9 (63.5 - 84.3)	74.9 (65.9 - 83.9)	0.889
Pulmonary functions	86.8 (77.1 - 96.5)	86.5 (78.1 - 94.9)	0.968
Transfer	62.2 (46.8 - 77.6)	53.7 (40.4 - 67.1)	0.418
Physical function	73.9 (60.8 - 87.0)	55.8 (44.5 - 67.2)	***0.046***
Daily living	50.6 (33.8 - 67.4)	61.1 (46.5 - 75.6)	0.355
Fatigue/energy level	71.6 (60.1 - 83.1)	76.6 (66.6 - 86.6)	0.520
Emotion	60.9 (49.3 - 72.5)	52.2 (42.2 - 62.3)	0.273
Parenteral burden	53.3 (42.0 - 64.6)	46.1 (36.3 - 55.9)	0.345
Financial burden	61.7 (50.2 - 73.3)	38.1 (28.1 - 48.1)	***0.004***
Satisfaction	82.7 (73.5 - 91.9)	67.6 (59.7 - 75.6)	***0.018***
Mean	67.1 (60.2 - 74)	60.9 (54.9 - 66.9)	0.186

Shilla Growth Guidance-Evolution of a New Procedure: Rate of Complications in the First Two Years Following Implantation in the First 80 Patients

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LOETherapeutic–Level IV

Purpose: To determine the complication rate of Shilla patients in the first 2 years following implantation.

Methods: Using the patient population for the GSSG database a retrospective review of the first 40 patients (Group A) undergoing the Shilla growth guidance procedure was compared with the next 40 patients (Group B). The groups were reviewed for number and type of complications occurring within the first 2 years after insertion. All surgeries were performed by a single surgeon in one institution.

Results: Group A had 4 patients that either died from their underlying disease, were lost to follow up, or had definitive procedures prior to two years after index procedure, leaving 36 patients for review (15 male, 21 female). Diagnoses were idiopathic 8, neuromuscular 12, syndromic 13, kyphosis 1, tumor 1, congenital 1. Age at surgery ranged from 1+11 years to 11+9 years. These patients had 42 additional surgeries (1-6 per patient) involving 20 patients, a complication rate of 54% in the first 2 years after surgery. The reasons for surgery were infection 7 and implant related 35.
Group B had 6 patients who either died from underlying disease, were lost to follow up or did not have 2 year follow up leaving 34 patients for review (17 male, 17 female). Diagnoses were idiopathic 9, neuromuscular 11, syndromic 13, and congenital 1. These patients had 19 additional surgeries (1-3 per patient) which involved 12 patients, a complication rate of 35% in the first 2 years. The reason for surgery was infection 9 and implant related 10.

Conclusion: A considerable drop in the number of surgeries was seen in Group B (19 in Group B, 42 in Group A) with both groups being comprised of the same type and severity of patients. This drop can only be explained as a learning curve. 12 of the 34 patients (35%) in Group B had a return to surgery within the first two years versus 20 of the 36 patients (54%) in Group A. Some patients in both groups had more than one surgery. It leads us to conclude that improved insertion techniques, such as deeper screw placement with larger diameter screws, better rod contouring, and larger rods resulted in diminished implant problems.

Significance: As the Shilla growth guidance technique has evolved, progression along the learning curve has resulted in fewer implant related complications and fewer returns to surgery.

Limiting Pre-incision Instrument Uncovered Time via Quality Practice Intervention Decreases VEPTR Implantation Surgical Site Infections

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LOE–Therapeutic–Level III

Purpose: Increased preoperative instrument exposure has been hypothesized to contribute to a greater risk of postoperative surgical site infection (SSI) in adult spine surgery. Often, the preoperative instruments uncovered time is equivalent to the anesthesia ready time (ART). As such, a quality practice intervention (QPI) was implemented to reduce the instruments uncovered time (IUT) for VEPTR implantation in the pediatric population. The relationship between IUT, ART, and other variables remains unexplored in VEPTR implantations, which often require prolonged ART for line placement. The purpose of this study was to examine the effect of a QPI to minimize IUT and the impact on postoperative SSIs.

Methods: A consecutive series of 187 VEPTR implant procedures performed between February 2007 and September 2015 were identified, with QPI beginning in August 2013. Patient demographics, hospital length of stay, underlying diagnoses, ART, IUT, and perioperative variables were collected via retrospective registry review. The primary outcome measure was the presence of postoperative culture proven SSI based on CDC criteria. A Student's t-test was performed to assess changes in IUT and ART following the QPI. Chi-squared and binary logistic regression analysis were used to identify significant risk factors for SSIs.

Results: A total of 16 procedures (8.6%) resulted in SSIs. Patients' mean IUT decreased from 120 to 42 minutes following the QPI ($p<0.001$), while the mean ART did not change significantly ($p=0.422$). The post-QPI infection rate was 3.2%/procedure compared to the pre-QPI incidence of 11.3%. Number-needed-to-treat (NNT) to prevent 1 infection was 12.3. Age, syndromic diagnosis, and IUT were significantly associated with the development of SSIs via bivariate analysis. In a logistic regression model incorporating these variables, only IUT (OR=1.01,95%CI=1.00-1.02,$p=0.021$) and syndromic diagnosis (OR=3.25,95% CI=1.07-9.86,$p=0.038$) remained significantly predictive of SSIs. An IUT exceeding 100 minutes was associated with 8.5 times the odds of developing an SSI.

Conclusion: IUT was an independent, modifiable risk factor for developing SSIs in VEPTR implantation. Decreasing instruments uncovered time by a quality practice intervention may reduce the incidence of surgical site infections in VEPTR implantation.

Significance: Infection prevention and control remains an important issue in pediatric spine surgery. Reducing the preoperative instruments uncovered time by way of a quality practice intervention can significantly reduce post-operative SSIs in pediatric VEPTR implant surgeries. This research can serve as a basis for institutions to guide their best practices for infection prevention in VEPTR implant surgery.

Determinants of Effective Control of Curve Progression Using Calcium and Vitamin D Supplementation in Adolescent Idiopathic Scoliosis – In-depth Analysis of a Randomized Double-blinded Placebo-controlled Trial

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LOE–Therapeutic–Level I

Purpose: Adolescent Idiopathic Scoliosis (AIS) is associated with low bone mass. This study aimed at evaluating the therapeutic effect and its determinants of Ca+Vit-D supplementation in improving bone strength and preventing curve progression in AIS.

Methods: This was a randomized double-blinded placebo-controlled trial recruiting AIS girls (11-14 years old, Tanner stage<IV) with femoral neck bone mineral density Z-scores<0 and Cobb angle>15°. 330 subjects were randomized to Group1 (placebo), Group2 (600mg Calcium+400 IU Vit-D_3/day) or Group3 (600mg Calcium+800 IU Vit-D_3/day) for 2-year treatment. Investigations at baseline and 24-month included: (1) Finite Element Analysis (FEA) on High-resolution Peripheral Quantitative Computed Tomography at distal radius, (2) serum 25(OH)Vit-D assay and (3) dietary calcium intake. The SRS guideline for scoliosis outcome study was followed for the Latest Follow-up analysis on curve progression defined as increase in Cobb angle≥6°. Chi-square, ANOVA, logistic regression model and ANCOVA were used for statistical analyses. P value<0.05 was considered statistically significant.

Results: 270 (81.8%) subjects completed the study. At 24-month, the increases in serum 25(OH)Vit-D and FEA parameters including stiffness (kN/mm), failure load (N) and apparent modulus (MPa) were significantly greater in the Treatment Group3 than Group1 (Figure1).
The Latest Follow-up (N=132) showed that 21·7% in Group3 and 24·4% in Group2 had curve progression as compared with 46·7% in Group1. Within-group logistic regression analysis showed in Group3, increase in FEA parameters of failure load and apparent modulus were significant protective factors against curve progression (p=0.043 and 0.034 respectively).
Using the same logistic regression model, subgroup analysis for baseline serum 25(OH)Vit-D≤50nmol/L (N=103) showed that the adjusted odds ratio for curve progression was 0·242 when Group3 was compared with Group1 (p=0·015), with 16.2% having curve progression in Group3 and 48.6% in Group1 (p=0.003). For those with 25(OH)Vit-D>50nmol/L (N=29), no between-group difference was noted on curve progression.
As for baseline dietary calcium intake levels in the combined Treatment Group (2 & 3), 17.6% progressed when baseline dietary calcium intake≤1000mg/day as compared with 53.8% progressed when baseline dietary calcium intake>1000mg/day (p=0.009).

Conclusion: The results of this study provide strong evidences that calcium+Vit-D supplementation can improve bone strength and its therapeutic effect of preventing curve progression in AIS is correlated with increase in FEA parameters in the Treatment Group, low baseline 25(OH)Vit-D level and low baseline dietary calcium intake.

Significance: This study provides the evidence-based justification for a new therapeutic approach for AIS to prevent curve from progression especially for those with low 25(OH)Vit-D or low dietary calcium intake levels.

Figure 2

Proportion of Vit-D insufficiency and mean changes in serum 25(OH)Vit-D and Finite Element Analysis (FEA) parameters from baseline to 24-month time-point for Group 1, Group 2 and Group 3[§]

		Gp 1 N=91	Gp 2 N=91	Gp 3 N=88	p-value	
					Gp 1 Vs Gp 2	Gp 1 Vs Gp 3
Proportion with Vit-D insufficiency	Baseline (N=330) [#]	74.5%	70.0%	75.5%	0.274	0.500
	24-month time-point (N=270) [#]	62.6%	30.8%	19.3%	<0.001^	<0.001^
	p-value for within-group comparison between Baseline Vs 24-month time-point [##]	0.035^	<0.001^	<0.001^		
		Changes from baseline to 24-month time-point[§] mean ± SD			p	
		Gp 1 N=91	Gp 2 N=91	Gp 3 N=88	Gp 1 Vs Gp 2	Gp 1 Vs Gp 3
Serum 25(OH)VitD (nmol/L) [###]		6.3 ± 15.3	20.4 ± 19.6	28.0 ± 23.3	<0.001^	<0.001^
		Gp 1 N=83	Gp 2 N=78	Gp 3 N=72		
FEA: stiffness (kN/mm) [###]		13455 ± 4670	15786 ± 5701	16520 ± 5563	0.048^	0.001^
FEA: failure load (N) [###]		533 ± 193	622 ± 243	658 ± 252	0.094	0.002^
FEA: apparent modulus (MPa) [###]		465 ± 220	591 ± 353	588 ± 289	0.020^	0.028^

[§]: Changes from baseline to 24-month time-point refers to the parameter at 24-month minus that at baseline
[#]: p-value from Chi-square for between-group comparison
[##]: p-value from McNemar test for within-group comparison on the Vit-D status between baseline and 24-month time-point for the 270 subjects who have completed the 2-year treatment
[###]: p-value from ANCOVA
^: p-value < 0.05

Alternatively Repetitive Cast/Brace Treatment without General Anesthesia for Early Onset Scoliosis

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LOE–Therapeutic–Level IV

Purpose: The Risser-Cotrel cast (RCC) has been reevaluated for the treatment of early onset scoliosis (EOS) and becoming common treatment method again. However, to our knowledge, most casting procedures for children younger than 5 years are conducted under general anesthesia. We have been utilizing RCC without general anesthesia since 1995 in combination with brace treatment. The protocol is as follows: casting for 2 weeks, followed by brace for 2-4 months. This is repeated depending on patients' curve control (alternatively repetitive cast/brace treatment, ARCB). The purpose of this study was to evaluate the effect of ARCB in terms of how long we can save the time prior to surgery.

Methods: This was a retrospective cohort study. Inclusion criteria were as follows; 1) ARCB at the age younger than 6 years, 2) surgical treatment following ARCB, 3) minimum follow-up of 2 years. 69 patients met these criteria. The time when to switch to surgery was 1) uncontrollable progression, 2) age older than at least 6 years or taller than 100 cm in height, 3) if indicated for short fusion and/or 4) thoracolumbar angular kyphosis. Diagnosis includes infantile IS (13), congenital scoliosis (31), and syndromic scoliosis (25).

Results: The age at the 1st casting was 3 years with scoliosis magnitude of 58°. Most of the patients completely shifted ARCB to brace treatment without casting due to lower compliance except five. The magnitude of scoliosis at this time was 59°. The age at the surgical intervention was 8 years with scoliosis of 69°. The casting was applied 6 times (1-18) prior to surgery. Seven patients were casted only once because of lower compliance of casting without general anesthesia (3), switch to short fusion after one casting (2), progressive dystrophic change due to NF-1 (1) and migration to another country (1). Of 69 patients, 27 were performed growth-friendly surgery and 23 had combined anterior and posterior correction/fusion. Scoliosis was corrected to 31° and maintained at final follow-up.

Conclusion: ARCB without general anesthesia was well-tolerated with 96% acceptance while approximately 90% of patients hoped to switch to brace treatment only due to starting primary school. This study found that ARCB suppressed scoliosis progression effectively and could save four years prior to surgical intervention in EOS.

Significance: ARCB without general anesthesia was accepted for approximately 90% of patients and by their families without any problems. ARCB can potentially save four years prior to surgery with significant suppression of scoliosis progression in EOS.

Clinical Impact of Corrective Cast Treatment for Early Onset Scoliosis: Is It Worthwhile Doing to Suppress Scoliosis Progression Prior to Surgical Intervention?

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LOE–Therapeutic–Level III

Purpose: To our knowledge, no studies have reported how clinically meaningful the corrective cast (CC) was in comparison to brace treatment without CC (BT) in early onset scoliosis (EOS). The purpose of this study was to investigate the effect of CC in terms of suppression of scoliosis progression prior to surgery.

Methods: This was a retrospective comparative study that involved a comparison of patients treated at two spine institutions differing in treating methods (one: mainly CC with brace, the other: BT). 58 patients met the following criteria; 1) age at the first visit ≤6 years, 2) scoliosis ≥45°, 3) follow-up beyond surgical intervention. Patients with congenital scoliosis were excluded in this study. 58 patients were divided into two groups; cast/brace group (C/B-G) and BT group (B-G).

Results: There were no significant differences of diagnosis (p=0.1773), sex (p=0.0670), age at the first visit (C/B-G: 3.1 years, B-G: 3.9 years., p=0.1437), scoliosis magnitude (C/B-G: 65°, B-G: 59°, p=0.1980), and duration for conservative treatment prior to surgery (C/B-G: 49 months, B-G: 50 months, p=0,2578) between two groups. Scoliosis was well corrected maximally from 65° to 29° in the C/B-G and from 59° to 37° in the B-G. A significant difference existed between two groups (p= 0.0104) with greater correction seen in C/B-G. Most of the patients who were treated with CC with brace, were switched to BT due to lower compliance for CC after the age of 7 years. The magnitude of scoliosis was maintained at this time (65°) in comparison to first visit values. However, preoperative magnitude of scoliosis was 77° in the C/B-G and 79° in the B-G (p=0.2578), resulting in overall progression of 13° in the C/B-G and 20° in the B-G (p=0.0385) during four years of conservative treatment.

Conclusion: In this study, no bias of surgeons affected on the results in terms of choice of conservative treatment for each patient with EOS because two institutions that joined this study had completely different conservative strategy (one was cast/brace and the other was BT). This study showed that cast/brace treatment had a significant impact on suppression of scoliosis progression compared with BT in EOS. However, the termination of casting and the switch to BT may be still a clinical question considering the time to surgical intervention.

Significance: The corrective cast treatment had a significant impact on suppression of scoliosis progression compared with BT for time-spared prior to surgical intervention in EOS.

Effect of Curve Type in Brace Success in Patients with Idiopathic Scoliosis

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LOE––Therapeutic–Level III

Purpose: Curve magnitude and skeletal maturity are drivers in determining the efficacy of bracing in AIS, but curve morphology may also affect brace success. The purpose of this study was to determine the influence of morphology on AIS treated with orthoses.

Methods: An IRB-approved retrospective review of patients treated with orthoses for AIS who were prospectively enrolled at brace initiation and followed through brace completion or surgery was completed. Inclusion criteria were main curves measuring between 25-45° and Risser 0-2 at brace prescription. Compliance was measured using thermochrons. Radiographs at brace initiation, cessation and final follow-up were retrospectively categorized by the modified Lenke (mLenke) classification and more broadly as main-thoracic or main-lumbar. The effect of morphology on outcome was evaluated using chi-square and Fisher exact tests.

Results: 169 patients were included. There was no difference in curve magnitude at brace initiation (p=0.23) or average brace wear (p=0.29) between groups. The incidence of surgery or progression ≥ 50° was 34.5% (29/84) in mLenke I, 54.5% (6/11) in mLenke II, 27.3% (9/33) in mLenke III, 17.6% (3/17) in mLenke V and 13.6% (3/22) in mLenke VI. There were no mLenke IV at presentation. The incidence of surgery or progression ≥ 50° was 34.4% (44/128) in the combined thoracic and only 15.4% (6/39) in the combined lumbar group (p=0.0176). In brace-compliant patients (>12.9hours/day), the incidence of surgery or progression was 31.8% (20/66) in main thoracic curves and 5.3% (1/19) in main lumbar curves (p=0.0192). One-tenth of curves changed morphology during bracing. The incidence of surgery or progression was 35.8% (43/120) in fixed main thoracic curves, 20% (6/30) in fixed main lumbar, 12.5% (1/8) in main thoracic that became main lumbar and 0% (0/9) in main lumbar that became main thoracic (p=0.0262).

Conclusion: Thoracic curves are at greater risk for brace treatment failure than main-lumbar curves despite similar initial curve magnitudes and average brace wear. Further, the effect of bracing is more profound in main lumbar curves than in main thoracic curves in compliant patients specifically. A change in curve pattern may imply flexibility and is associated with brace success. Patients with main thoracic curves, specifically thoracic curves that remain thoracic throughout the course of treatment, should be counseled accordingly.

Significance: This information, in conjunction with previously-established risk factors for brace failure, will hopefully guide future practices and help predict individual brace efficacy at brace initiation.

Even if Bracing Fails to Prevent Surgery, It May Benefit the Lumbar Spine in Adolescent Idiopathic Scoliosis

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LOE–Therapeutic–Level III

Purpose: Bracing decreases curve progression in adolescent idiopathic scoliosis (AIS). We hypothesized that even if curves progressed to surgical range, patients compliant with bracing regimens would have decreased lumbar curve magnitudes, less severe lumbar involvement by Lenke types, and fewer levels of lumbar fusion compared to un-braced patients. The purpose of this study was to compare the distribution of Lenke types between braced and un-braced patients, specifically examining bracing's effects on lumbar curvature.

Methods: This is a retrospective review of surgical AIS patients seen by one surgeon from 2005-2015. Patients were categorized into two groups: braced vs. un-braced. Patients were included in the braced group if they met Scoliosis Research Society criteria. Both groups were subdivided based on Lenke classification and the distribution was compared. The distribution of lumbar modifiers (A, B, and C: representing increasing lumbar curve severity) were examined between groups in Lenke types 1, 2, and 3. Additionally, braced patients were matched for age, Lenke type, and preoperative thoracic Cobb angle degree (+/- 5°), with un-braced patients to determine the difference in lumbar curve magnitude.

Results: 432 patients were studied (83% un-braced vs. 17% braced). The un-braced group (n=357) averaged 11 months from time of first presentation to surgery, while the braced group (n=75) averaged 29 months ($p < 0.001$). The distribution of Lenke types were significantly different, with a higher proportion of Lenke 1 patients in the braced group and a higher proportion of Lenke 3 and 6 patients in the un-braced group (Table 1).

After conducting a 1:1 randomized thoracic matching, the un-braced patients had a 10° (95%CI: 6°-14°) larger lumbar curve compared to braced patients (44° vs. 34°, $p<0.001$) at time of surgery. Comparing modifiers in Lenke 1 patients yielded a statistically significant difference in the proportion of Lenke 1A (81% vs. 39%, $p<0.001$) and 1B (14% vs. 39%, $p=0.002$) patients between the braced and un-braced groups, respectively. Compared to braced patients, un-braced patients had a 2.3 (95%CI: 1.2-4.5,

Table 1. Preoperative Patient Demographics for 432 Braced and Un-Braced Adolescent Idiopathic Patients

	Braced	Un-Braced	*P*
Mean Age (yr) (Presentation) ± SD	12.7 ± 1.5	14.2 ± 1.9	<0.001‡
Mean Age (yr) (Preoperative) ± SD	15.3 ± 2.0	15.4 ± 2.5	0.889‡
Female (%)	73.9	76.0	0.712‡
Lenke Curve Type % (N)			
1	69.3 (52)	40.1 (143)	<0.001†
2	4.0 (3)	7.3 (26)	0.317†
3	5.3 (3)	19.9 (71)	0.003†
4	0.0 (0)	4.8 (17)	0.057†
5	14.7 (11)	12.6 (45)	0.617†
6	6.7 (5)	15.4 (55)	0.046†
Mean Major Curve Magnitude ± SD (°)	54.5 ± 9.4	61.3 ± 13.1	<0.001‡

Chi-squared tests†, and student independent t-tests ‡ were performed, appropriately, with statistical significance set to $p<0.05$. A Bonferoni adjustment was made for multiple tests with statistical significance set to $p<0.004$ for the Chi-squared test. SD = standard deviation; yr = year.

p=0.02) times higher odds of having a posterior spinal fusion that extended distal to the L1 vertebral level.

Conclusion: Even if bracing may not prevent surgery, it can improve the lumbar spine. This is highlighted by the difference in distribution of Lenke types, smaller preoperative lumbar curves when matched for thoracic curve, and fewer fused lumbar vertebra among braced patients.

Significance: We demonstrate an unrecognized benefit in bracing the lumbar spine that extends beyond its traditional purpose of preventing surgery.

Ultralow Dose Radiation 3D Intraoperative Imaging: How Low Can We Go? An O-Arm, CT Scan, Cadaveric Study

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LOE–Diagnostic–Level IV

Purpose: Pedicle screw misplacement rates vary from surgeon to surgeon. Intraoperative guidance technology, such as O-arm®, helps to increase pedicle screw safety and accuracy. However, the radiation exposure with its use is considerably high. Purpose is to determine reliability of intraoperative O-arm® at low, very low and ultra-low doses. We found O-arm® imaging at ultra-low and very-low doses can safely be used for intraoperative evaluation.

Methods: 8 cadavers were instrumented with 6.0 x 30mm and 6.0x40mm screws bilaterally from T1 to S1. Screws were randomly placed using O-arm® navigation into 3 positions: contained within the bone, OUT-anterior/lateral, Out-medial. O-arm® images obtained at 3 dosage settings: low-dose (kvp120/mAs125-lowest manufacturer recommended), very-low dose (kvp120/mAs63) and ultralow dose (kvp120/mAs39). CT scan was performed using institution's lowdose protocol (kvp100/mAs50) and gross dissection to identify screw positions. All images were reviewed by observers.

Results: Overall accuracy of O-arm (all doses) and CT compared to gross dissection was 82%(+/-). Sensitivity was 84% (+/-6), specificity 82% (+/-9), positive predictive value 72% (+/-7) and negative predictive value 91% (+/-4). There was moderate to substantial interobserver agreement (k=0.54-0.73). Radiation effective doseses for low-dose O-arm® scan is 2.16 msV, very-low dose 1.08 mSv, ultra-low 0.68 mSv and our CT protocol is 1.05 mSv. In comparison, a standard scoliosis XR is 1.00 msV, equivalent to 5 months of background radiation in the US.

Conclusion: Accuracy of pedicle screw placement is similar for O-arm® at all doses and CT compared to gross dissection. Ultra-low and very-low doses can be safely used for intraop navigation and evaluation purposes. Inter-observer reliability was substantial for very-low dose and CT.

Significance: Intraoperative O-Arm® imaging at very-low and ultra-low doses can significantly increase the accuracy of pedicle screw placement. This low-dose technique can reduce radiation burden to near negligible levels in spine surgery and also reduce the need for subsequent surgeries. All of these advantages tremendously improve patient safety.

Prospective Evaluation of Outcomes After Selective and "Non-selective" Fusions of C Type Curves in AIS

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LOE–Therapeutic–Level II

Purpose: Lenke lumbar C modifier idiopathic scoliotic curves do not require fusion into the lumbar spine. These non-instrumented lumbar curves remain stable long-term. The clinical significance, if any, of improving Cobb angle correction with longer fusions is not known. Eliminating motion segments by extending fusion into the lumbar spine may have unforeseen long-term consequences. Validated, patient-related outcomes on a large cohort of patients treated with selective vs. non-selective fusion is lacking. We hypothesized that in a prospectively collected cohort of adolescent idiopathic scoliosis (AIS) patients with Lenke 1C, 2C, and 3C curves, fusion below L1 would allow greater lumbar Cobb correction without improvement in SRS-22 scores at 2 year follow-up as compared to fusion ending at or above L1.

Methods: 191 patients with AIS and Lenke 1C, 2C, and 3C curves treated with a posterior spinal fusion (PSF) were identified from a prospectively collected database. All patients had a minimum of 2 years of clinical and radiographic follow-up. The selective fusion group comprised 105 patients in whom the lowest instrumented vertebra (LIV) was at or above L1. The non-selective fusion group included the remaining 86 patients in whom the LIV was distal to L1. Cobb angles, rib hump, trunk shift, forward and side bending motion, and SRS-22 scores were recorded pre-operatively and at 6 month, 1 year, and 2 year follow-up. Analysis of variance was used to compare the groups.

Results: The selective and non-selective cohorts were similar in demographics and preoperative radiographic parameters. Fusion with LIV below L1 significantly lowered the lumbar Cobb angle at final follow-up (16.9° vs. 23.79°, $p < 0.001$). In all patients, PSF improved rib hump, trunk shift, and SRS-22 scores. Statistically significant, but likely clinically insignificant, differences of < 5° in forward and side bending motion existed between the study groups. No significant differences in trunk shift, total SRS-22 scores (4.42 vs. 4.41, $p > 0.82$) or individual SRS-22 domain scores were seen.

Conclusion: Fusion of Lenke 1C, 2C, and 3C curves below L1 lead to significantly better lumbar curve correction at final evaluation. Improved radiographs did not translate into clinical improvement. SRS-22 outcomes were equivalent regardless of whether or not the lumbar spine was included in the fusion.

Significance: Longer term prospective analysis of patients with Lumbar C modifier curves treated operatively with an emphasis on functional measures may elucidate which patients would benefit from longer fusion and provide more objective guidelines for spinal deformity surgeons.

Can Surgical Innovation Decrease Operative Time, Surgeon Variability and Surgical Morbidity in AIS Surgery: A Study of Operative Efficiency

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LOE–Therapeutic–Level III

Purpose: Operative time associated with Adolescent Idiopathic Scoliosis (AIS) surgery impacts blood loss, infection rates, and cost. The purpose of this study was to identify the relative portion of time spent in performing various segments of the operation for AIS and to evaluate surgeon variability and change in operative efficiency after alterations in surgical technique.

Methods: A multi-center multi-surgeon study of operative time in posterior fusion (PSF) for AIS for 14 sub-steps of the procedure was performed in 2013 and in 2015. Absolute as well as normalized values (per level and Cobb magnitude) of the operative time of each sub-step were evaluated. Variability between surgeons in each operative step was compared using ANOVA. Improvement in operative efficiency over 2 years was evaluated using the t-test.

Results: A total of 77 consecutive PSF cases were collected (surgeon 1 n=30; surgeon 2 n=27 and surgeon 3 n=20) in the two time periods. Exposure (19.2%), screw insertion (23.4%), rod maneuvers (14.1%) and closure (16.2%) are the four major segments of the surgical procedure accounting for 73% of the total operative time, and were consistent over time. Differences in age at surgery (16.4, 14.1 vs. 15.2yr; p=0.0073), # of osteotomies (4.2, 5.9 vs. 4.5; p=0.0006), # screws (16.9, 20.9 vs 20.3 p=0.0071) and anchor densities (1.7, 1.9 vs. 1.9; p<0.0001) were observed between the 3 surgeons. Significant differences between surgeons were observed in all 4 major steps in addition to several others. Improvements in operative efficiency (normalized) were made in EBL (50%), total operative time (14%), rod maneuver and subcutaneous closure (See Table).

Conclusion: Exposure, screw insertion, rod maneuver and wound closure are the 4 major steps in AIS surgery with significant surgeon variability noted. EBL was decreased by 50% and operative time decreased by 14% over 2 years. Opportunities for improved efficiency and decrease in variability remain.

Significance: Operative time in AIS surgery impacts blood loss, infection rates and cost. Exposure, screw insertion, rod maneuver and wound closure account for 73% of total operative time. Improvements in EBL and efficiency in various aspects of the AIS operative procedure were observed over a 2-year period. Opportunities for improved efficiency and procedural innovation remain.

	2013	2015	p-value
EBL (ml)	912.90	492.07	0.0026
EBL/level	101.71	51.20	0.0002
Total Operative Time (min)	212.87	206.67	0.6142
Op time/level	25.41	21.84	0.0160
Exposure (min)	40.68	44.87	0.2430
Exposure/level	4.74	4.60	0.6298
Facetectomy (min)	17.16	17.29	0.9505
Facetectomy/level	2.00	1.80	0.3849
Osteotomy (min)	15.92	14.98	0.6061
Osteotomy/#osteotomy	3.81	3.30	0.2436
Screw Insertion (min)	45.52	57.63	0.0131
Screw Insertion/screw	2.72	2.92	0.4018
Screw Imaging (min)	6.32	6.39	0.9351
Screw Imaging/ screw	0.36	0.33	0.5938
Screw stimulation (min)	6.23	6.70	0.7819
Stimulation/ screw	0.38	0.32	0.4497
Rod Maneuver (min)	34.29	29.80	0.0843
Rod Maneuver/level	4.07	3.12	0.0004
Final Tightening (min)	2.53	1.91	0.0423
Tightening/level	0.29	0.22	0.1290
Wound Cleansing (min)	2.67	2.74	0.8038
Cleansing/level	0.32	0.29	0.4054
Decortication/Graft (min)	5.68	5.74	0.9078
Decortication/level	0.68	0.61	0.2870
Total Closure (min)	36.23	36.74	0.8887
Total Closure/level	4.35	4.01	0.5019
Fascia Closure	12.39	13.96	0.2959
Fascia/level	1.48	1.56	0.6939
Subcutaneous Closure	14.77	11.51	0.0789
Subcutaneous/level	1.79	1.26	0.0189
Skin Closure	10.96	12.36	0.3778
Skin/level	1.27	1.28	0.9555
Final Radiograph (min)	6.05	3.65	0.0288
Final Radiograph/level	0.68	0.47	0.1277

Is It Surgical Volume, Surgeon's Experience, or the Number of Surgeons That Determine Safety, Efficacy, and Efficiency?

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LOE–Therapeutic–Level III

Purpose: Recent literature suggests that utilizing two surgeons for scoliosis correction surgery can improve perioperative outcomes. However, the surgeon's experience and surgical volume are likely as important. This study seeks to evaluate effect of these factors for scoliosis correction through posterior spinal fusion (PSF).

Methods: A retrospective chart and x-ray review of all pediatric scoliosis patients who underwent PSF correction from 2013-2016 was performed. Patient's demographics, x-rays, and perioperative measurements were collected. Analyses were executed for single vs. dual attending surgeons, surgical experience (<,> 10 years), and surgical volume (<,> 70 cases/yr.). Median values, Wilcoxon Rank Sums test, and Fisher's exact test were utilized.

Results: 137 cases, performed by four attending surgeons, had complete records. Two surgeons were highly experienced, one of whom is also high volume. These two surgeon's most recent cases were available. 74/137 surgeries were performed by highly experienced surgeons. 51/74 were performed by the high volume surgeon, 34 of which were performed independently. All other cases were performed by dual surgeons. Estimated blood loss ($p < .001$), levels fused ($p = .004$), operative time ($p = 0.013$), and anesthesia time ($p = 0.017$) were significant between all groups. EBL was significantly lower for the highly experienced surgeons compared to the less experienced surgeons (450 vs. 600, $p = .024$). Operative time (4.4 vs. 4.6, $p = 0.488$), levels fused (12 vs. 12, $p = 0.105$), and anesthesia time (6.7 vs. 6.4, $p = 0.760$) had similar results when comparing highly and less experienced surgeons. The high volume surgeon had significantly lower EBL (350 vs. 600, $p < 0.001$), fewer levels fused (11.5 vs. 13, $p = 0.004$), shorter operative time (4.1 vs. 4.8, $p = .003$) and shorter anesthesia time (6.2 vs. 6.9, $p = .030$). When the high volume surgeon operated with another attending, there were no significant changes in outcomes.

Conclusion: When looking for better surgical outcomes, dual surgeon approach can be considered favorable. However, it is important to consider surgical volume and experience. A high experience, high volume surgeon does not benefit from the dual surgeon approach. Less experienced, lower volume surgeons using the dual surgeon approach have comparable results to experienced surgeons.

Significance: Less experienced, lower volume surgeons should use the dual surgeon approach for scoliosis correction surgery. High experience, high volume surgeons do not benefit from the dual surgeon approach, therefore it is not necessary.

The Safety and Feasibility of Magnetic Resonance Guided High Intensity Focused Ultrasound to Treat Symptomatic Osteoid Osteoma

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LOE–Therapeutic–Level III

Purpose: The standard treatment of osteoid osteoma (OO) refractory to medical therapy has evolved from surgical excision to CT-guided radiofrequency ablation (RFA). While RFA is effective, it does require an invasive approach and exposure to ionizing radiation. Magnetic resonance imaging-guided high intensity focused ultrasound (MR-HIFU) is a novel noninvasive technology that uses focused ultrasound waves to ablate tissue without radiation. The purpose of this study was to determine the feasibility, safety, and clinical response of MR-HIFU to treat symptomatic OO in a cohort of pediatric patients.

Methods: A prospective study using MR-HIFU ablation to treat OO was performed. Feasibility was assessed by ability to successfully complete the planned treatment. Safety and adverse events were assessed using the NIH CTCAE scale v4.0. Clinical response was assessed using Visual Analog Pain Scale (VAS) scores and decrease in medication use at seven and 28 days post-op. Complete response to treatment was defined as total resolution of pain and cessation of all pain medication while partial response was defined as a decrease in pain and mediation use.

Results: Nine patients were treated with MR-HIFU, from 25 patients screened. The mean age was 16±6 y, mean BMI: 19.7 (range 14.4-27.3) and the mean OO lesion volume was 0.82cm^2 (range 0.4-0.8). Ablation was performed without any serious adverse events attributable to the treatment. Overall, 8 patients had a complete treatment response and 1 patent had a partial treatment response. The total cohort showed a statistically significant decrease in mean VAS pain score (6 vs 0, p=0.0004) between pre-op and 28 days post-op (figure 1). Additionally, 8 of the 9 patients with complete pain relief were no longer taking any medications by 28 days post op.

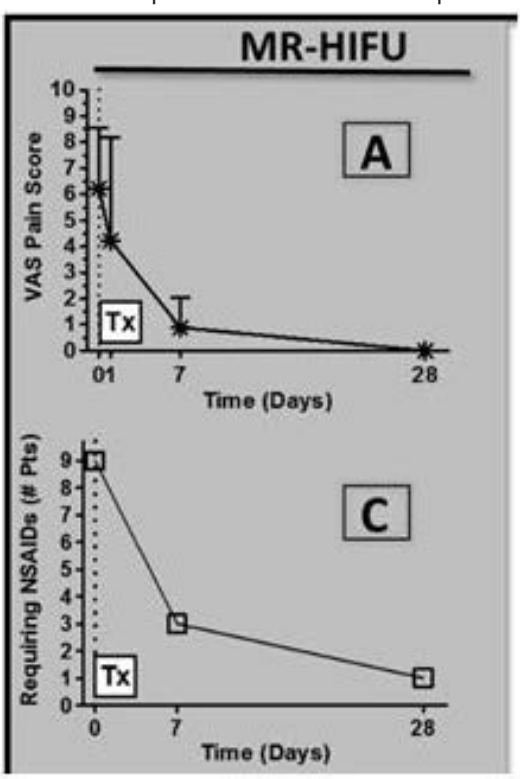

Figure 1. Pre-op and Follow-up VAS pain scores and # patients requiring pain medications.

Conclusion: The use of MR-HIFU ablation appears to be a clinically safe and feasible treatment option for pediatric patients with OO refractory to medical therapy. This new technology offers a

non-invasive alternative therapy that eliminates use of ionizing radiation during treatment. Further assessment to define optimal patient and lesion characteristics for MR-HIFU treatment is warranted.

Significance: MR-HIFU appears to be a safe and clinically feasible method of tissue ablation that eliminates the need for ionizing radiation and need for an invasive approach. A trial to directly compare its clinical efficacy to radiofrequency ablation in the treatment of osteoid osteoma is planned.

Surgical Treatment of Active or Aggressive Aneurysmal Bone Cysts in Children-Revisited

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LOE–Therapeutic–Level IV

Purpose: The treatment of ABC usually is surgical The objective of this study was to evaluate functional and radiological results, tumor control and complications of the surgical treatment of ABCs in children, by extended curettage with use of a mechanical burr and cauterization, grafting and internal fixation in specific locations.

Methods: One hundred and ten children [68 male, 42 female; the median age = 10 years (range, 5-18 years)] with active or aggressive ABCs of long and flat bones had a median follow-up of 62 months (range, 26-160 months) following surgical treatment. Pathological fracture rate was 72%. A standard protocol was performed in 105 patients (95.4%) including biopsy with frozen section, extended curettage with high-speed burring and cauterization, bone grafting and internal fixation when required (48.5%). Local adjuvants were not used in any case. En-bloc resection occasionally (5 patients = 4.6%) was used for aggressive lesions in expandable bones or for recurrent lesions.

Results: The pathological fractures were healed successfully in 8 to 12 weeks. The median MSTS score at last follow-up was 95% (range, 55-100%). Treatment failure (partial healing/recurrence) and complication rates following extended curettage were 7.2% and 4.5% respectively. Statistically, the only parameter affecting partial healing and local recurrence was proximity of the lesion to growth plate ($p = 0.011$).

Conclusion: Extended curettage with use of a mechanical burr and cauterization, grafting and internal fixation in specific locations can promote healing in most cases of ABC, with low recurrence and complication rates.

Significance: Lack of understanding about its origin and growth makes treatment of ABCs empirical. We tried to develop a standard treatment protocol with high healing and low recurrence and complication rates.

Mid-Term Radiological and Functional Results of Biological Reconstructions of Extremity-Located Bone Sarcomas In Children and Young Adults

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LOE–Therapeutic–Level IV

Purpose: Biological reconstruction is a useful option for reconstruction following bone sarcoma resection in children. The mid-term functional and radiological outcomes of biological reconstructions after resection of bone sarcomas in children are presented in this study.

Methods: Forty-eight patients [average age 12.5 (range, 4-22 years)] with primary sarcomas of long bones and pelvis underwent wide surgical resection and biological reconstruction. The bone defects were managed by intercalary (32), osteoarticular (12) reconstructions and arthrodesis (4) with vascularized fibular graft (VFG). VFG was combined with massive allograft or recycling bone in 19 lower extremity reconstructions. The average follow-up was 43 months (range, 25-105 months).

Results: Graft union and graft hypertrophy was observed in 45 (93.7%) patients at 12 months. VFG and allograft/recycling bone osteointegration rate was 100% at 24 months. Average final follow-up MSTS scores for lower and upper extremity reconstructions were 78% (range, 66.6 to 90%) and 82% (range, 56.6 to 100%), respectively. Nine (18.7%) complications, including nonunion (2), implant failure (2), infection (2) and wound problem (3) required re-operation. The disease relapsed in 14 (29%) patients in terms of distant metastasis and/or local recurrence. Defect size and VFG length did not correlate with MSTS scores and radiological parameters ($p > 0.05$).

Conclusion: Biological reconstruction with VFG can provide permenant stability and progressively increasing functional and radiological results. The success of VFG transfer, however, requires microvascular expertise and adherence to sound orthopaedic principles for bone healing, including stable internal fixation, maximal bone-to-bone coaptation, and appropriate postoperative management regarding joint mobilization and weight-bearing.

Significance: Free VFG is frequently indicated for reconstruction of massive bone defects following oncologic resections in children and young adults. In this series, massive bone defects were reconstructed with various applications of VFG, and gradually increasing radiological and functional results were obtained. These results strongly supported the previous series, which had shown the effectiveness of biological reconstructions in the management of bone sarcomas.

Bedside Aspiration in Children with Septic Arthritis of the Hip Joint. Should We Still Do Arthrotomy?

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LOE–Therapeutic–Level IV

Purpose: Septic hip in children is an orthopedic emergency and left untreated associated with myriad of complications. Currently hip arthrotomy is still considered the standard method of treatment; however, it might be associated with significant surgical morbidity. During the last 7 years we treated septic hip by aspiration only. The purpose of this study was to describe the clinical course of patients treated with bedside aspiration under sedation.

Methods: All patients diagnosed with septic hip during the years 2008-2015 were included. The diagnosis was established based on joint fluid laboratory findings: positive cultures or PCR or WBC count of more than 50000/ml. All patients had hip sonography followed by bedside aspiration under sedation. No image control and no irrigation were performed during the aspiration procedure. Repeated sonographic examinations were performed daily during the first week and recurrent aspirations done as needed.

Results: Nineteen children with septic arthritis of the hip were subjects of this study. The mean age was 4.5 years (median 3 years, interquartile range [IQR] 1-8) and male to female ratio 11:8. Mean number of hip aspiration was 1.9 (median 2, IQR 1-3). Pathogen was detected in 12 children. Mean length of antibiotic treatment was 29 days (median 28, IQR 22-39). All patients had normal hip joint function upon discharge from the hospital, and all patients returned to their normal activities within a mean of 27 days (median 21, IQR 14-36). In a mean follow-up period of 3.8 years (median 4, IQR 2-5) No clinical or radiographic complication was recorded.

Conclusion: All patients with septic hip were treated with hip aspiration and no hip arthrotomy or irrigation was performed during the last 7 years. Based on our experience hip aspiration is an effective treatment and performed safely as a bedside procedure.

Significance: Bedside hip joint aspiration might be an alternative to hip arthrotomy with less surgical morbidity.

Septic Arthritis of the Hip in the Newborn and Young Child

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LOE–Prognostic–Level IV

Purpose: Neonatal septic arthritis (NSA) of the hip is rare condition with the potential for severe long-term complications. Severity of residual hip deformity has been previously correlated with age at presentation and time to diagnosis. Little is known about what factors may be associated with late sequelae and need for further surgery. The purpose of this study is to characterize NSA of the hip in our population seen in the last thirty years.

Methods: A single center tertiary-care departmental database was queried for patients treated for NSA of the hip who were less than twelve months at presentation between 1984 and 2014. Patients were excluded if there were initially treated at an outside institution. Clinical data were collected.

Results: Thirty-four children (65% male, mean age 135 days) met inclusion criteria. Forty eight percent of the children were premature (gestational age <37 weeks at birth), with mean gestational age of 32 weeks. Most common initial symptoms included "irritability" (85%), fever (71%), and pseudoparalysis of the limb (59%). Ultrasound was performed in 30 of 34 patients, and was positive for effusion in all but one case (97%). Fluid cultures from hip aspirate were positive in 46% of cases, with Staphylococcus Aureus the most common causative organism. All patients underwent hip irrigation and debridement via anterior approach. In those children in whom time to surgery data was available, 33% were operated on less than 12 hours from onset of symptoms, 42% were operated on between 12 and 24 hours, and 25% were operated on more than 24 hours after symptom onset. Post-septic arthritis instability was diagnosed in 17% of patients. The most common complications were proximal femoral or trochanteric growth disturbance (52%), radiographic joint space narrowing (50%), acetabular dysplasia (48%), and avascular necrosis (43%). Secondary surgical intervention was necessary in 36% of patients to address one or more of these complications. Univariate and multivariate analysis identified gestational age as the only risk factor associated with secondary surgical intervention. No factors were found to be associated with a risk of complication.

Conclusion: NSA of the hip has a high rate of late sequelae and need for additional surgical procedures. Gestational age was the only risk factor found to be associated with the need for further surgery due to one or more complications.

Significance: NSA is a rare, but potentially devastating condition that can lead to long-term functional sequelae. Prompt diagnosis and treatment is critical to avoid these issues.

Septic Arthritis of the Hip - Who Needs a Second Look?

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LOE–Therapeutic–Level III

Purpose: Septic arthritis of the hip (SAH) is a common condition encountered by pediatric orthopedic surgeons, and is generally treated with arthrotomy and irrigation. Depending on associated conditions and the response to initial treatment, some patients require operative treatment beyond the index procedure. The purpose of this study is to investigate risk factors for repeat operative intervention after initial arthrotomy for presumed SAH.

Methods: A multi-center retrospective review of all patients aged 0-18 years who underwent operative arthrotomy for presumed SAH over a ten-year period was conducted. Variables queried included: demographics, clinical presentation, laboratory parameters, radiographs/advanced imaging, infecting organism, presence of concomitant osteomyelitis, and surgical interventions performed. Logistic regression was used to predict risk of a second procedure with independent predictors. Chi square was used to compare patients that required further surgery and those that did not.

Results: One hundred and forty-one patients qualified for inclusion. Average age at initial surgery was 5.1 years (range 0-15.7), and 67% of the patients were male. Concomitant osteomyelitis was diagnosed in 50 cases (35%). An infecting organism was identified from 85 (60%) index intraoperative cultures, with Methicillin-resistant and Methicillin-sensitive Staph aureus (MRSA: 30 cases, MSSA: 26 cases) being the most frequent cases. Fifty-six (40%) patients required subsequent operative intervention, at an average of 3.9 days (range 2-41) from index procedure. Independent risk factors for repeat operative procedures included presenting C-reactive protein (CRP) > 10 (p=0.011) and presenting erythrocyte sedimentation rate (ESR) > 40 (p=0.011). The odds of repeat surgical intervention were significantly increased by the presence of concomitant osteomyelitis (OR 3.5, p=0.001) and positive index intraoperative cultures for MRSA (OR 5.97, p=0.001).

Conclusion: Forty percent of children in this multi-center cohort required at least one repeat operative procedure after the index arthrotomy for management of presumed SAH. Risk factors for return to the operating room include elevated ESR and CRP, infection with MRSA, and presence of osteomyelitis.

Significance: Surgeons treating these patients should consider these risk factors when developing operative plans and when counseling families regarding the possibility of multiple operative procedures.

Improved Diagnosis and Treatment of Pediatric Bone and Joint Infections Using an Evidence-based Treatment Guideline

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LOE–Prognostic–Level IV

Purpose: Historically, diagnosis of pediatric acute hematogenous osteomyelitis (AHO) and septic arthritis (SA) relied on varying imaging and laboratory diagnostics. With limited definitive data, empiric treatment with long-term intravenous (IV) therapy was recommended. In 2013, our hospital created an evidence-based multidisciplinary diagnosis and treatment algorithm for pediatric bone and joint infections. This is a report of outcomes following implementation.

Methods: This is a retrospective cohort study of patients age 6 months-18 years hospitalized between January 2009 and July 2016 with a diagnosis of AHO or SA qualifying for the algorithm. Cohorts were categorized: pre and post algorithm. Exclusion criteria consisted of: symptoms >14 days, multi focal involvement, hemodynamic instability, or history of immune deficiency.

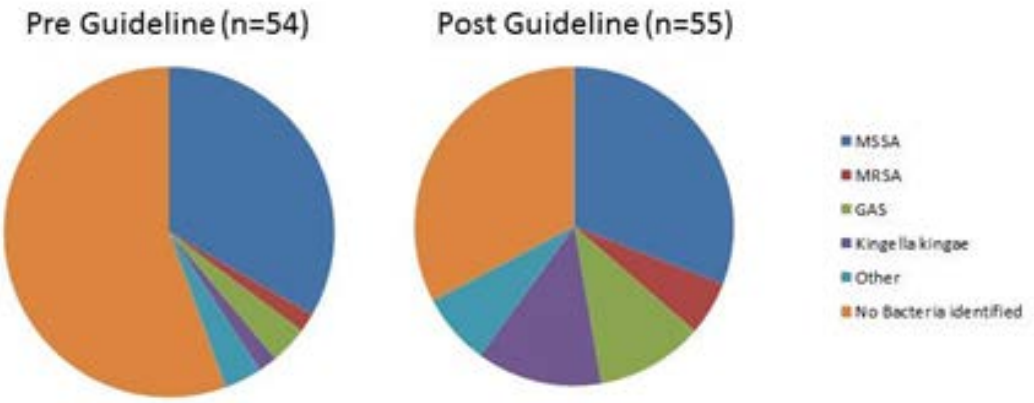
The algorithm calls for orthopedic consultation on admission, specific admission labs, standardized 6AM MRI scheduling and focal aspiration for positive MRI findings. Specimens are sent for routine cultures and drainage procedures are performed when indicated. Polymerase chain reaction (PCR) testing for *Staphylococcus aureus* and *Kingella kingae* is added in the presence of negative cultures. Patients are transitioned to oral antibiotics upon symptom improvement and 50% decrease in CRP value.

Results: 109 patients qualified for the algorithm and were included in this report; 54 pre and 55 post algorithm. After implementing the algorithm, we found a significant increase in the identification of bacterial etiology. We also significantly decreased the length of IV antibiotics and peripherally inserted central catheter (PICC) line utilization without affecting length of stay. Further results and demographics are in Table 1.

Table 1. Patient Demographics and Algorithm Outcomes

	Pre-Algorithm (n-54)	Post-Algorithm (n=55)	p-value
Age (median years)	6.2	5.9	0.904
Sex (% male)	63% (34)	55% (30)	0.485
Length of Stay (median)	4.5	4.9	0.089
MRI done within 24 hours	67% (36)	82% (45)	0.116
Bacterial identification by culture or PCR	44% (24)	65% (36)	0.044
IV antibiotic Days (median)	22	5	<0.001
Oral Antibiotic Days (median)	14	21	<0.001
PICC Utilization	91% (49)	45% (25)	<0.001

Figure 1. Bacterial Organisms Identified Pre and Post Algorithm



Conclusion: The use of a treatment algorithm with a standardized timing for MRI and focal aspiration with the addition of PCR testing increased the identification of bacteria in patients with AHO and SA. The greatest increase in bacterial identification was among cases of *Kingella kingae.* Increased bacterial identification allows for early, focused oral antibiotic therapy, reducing the need for PICC lines.

Significance: Utilizing an AHO algorithm can lead to improved bacterial diagnosis and decreased burden of treatment through early oral antibiotic use.

Does Pre-Culture Antibiotic Administration Lead to Non-Diagnostic Bone and Joint Culture Results in Pediatric Osteomyelitis and Septic Arthritis: A 12-Year Retrospective Review

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LOE–Diagnostic–Level III

Purpose: Pediatric musculoskeletal infections can be devastating, with ramifications that can cause lasting morbidity. Children often receive antibiotics in various clinical settings prior to having cultures obtained. A commonly held notion is that administration of antibiotics prior to obtaining a sample from the involved musculoskeletal site will result in negative cultures.
The purpose of our study was to evaluate whether or not culture results for children receiving antibiotics prior to obtaining cultures for suspected septic arthritis and/or osteomyelitis is negatively affected. We hypothesize that antibiotic administration prior to bone and/or joint culture in children with suspected osteomyelitis or septic arthritis would result in a greater number of negative cultures.

Methods: A retrospective chart review of 135 patients was performed at a single institution. Children age < 18 years with suspected osteomyelitis or septic arthritis that received antibiotic administration (oral or intravenous) within seven days of obtaining a formal culture were included. Comparison based on pre-sample antibiotic administration and final culture results were made as well as the recording of frequency and type of antibiotic, organisms isolated, diagnoses, location of infection, age, sex, fever, WBC, ESR, and CRP.

Results: 107 children, with an average age of 8.2 years old (range: 6 weeks-16 years) 76 male, 31 female were included**.** 59/107 (55%) patients received antibiotics prior to culture. In those who had bone and/or joint culture obtained after receiving antibiotics, 47 had positive cultures and 12 had negative cultures. Of those who did not receive antibiotics prior to culture 30 (62.5%) had positive cultures and 18 (37.5%) had negative cultures. Patients who received antibiotics prior to obtaining a sample were more likely to have positive results ($p = 0.049$). Children with positive blood cultures regardless of timing to antibiotic administration had a higher maximum fever than those with negative cultures ($p = 0.007$).

Conclusion: Receiving antibiotics prior to obtaining a bone, joint or blood culture in suspected osteomyelitis or septic arthritis did not lead to a statistically significant number of negative cultures. Contrary to our hypothesis patients who received antibiotics prior to tissue/joint sample were actually more likely to have positive cultures.

Significance: Further larger cohort multi-center trials are needed to investigate the necessity of delaying antibiotics until cultures are obtained. In our study delaying antibiotic treatment until formal samples were obtained demonstrates no benefit for diagnostic purposes.

Wash, Rinse, Repeat: Which Patients Require Serial Joint Irrigation in Pediatric Septic Hip Arthritis?

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LOE–Prognostic–Level III

Purpose: Pediatric septic hip arthritis can be a devastating condition if not immediately recognized and treated with prompt operative joint irrigation and culture specific antibiotics. Occasionally patients require further workup, imaging, and repeat washouts to clear their infection. The purpose of this study is to identify what risk factors are associated with need for repeat surgical irrigation in the setting of pediatric septic hip arthritis.

Methods: A retrospective case-control study was performed. Patients were identified from an internal database at a single tertiary care children's hospital. Patients who had 2 or more washouts (cases) were compared with those who had only 1 washout (controls). Demographic, clinical, laboratory, microbial, and magnetic resonance imaging (MRI) data were compared between cases and controls. Cases and controls were compared with respect to categorical factors using Fisher's exact test. Symmetric and non-symmetric variables were analyzed using the two-sample t-test or the two-sample Wilcoxon test, respectively. Two-sided tests were used throughout, with $p<0.05$ considered significant.

Results: We identified 26 patients (cases) between 1994-2015 who required at least 2 washouts for septic hip arthritis, and 63 control patients. Twenty-two patients had 2 washouts, 3 had 4 washouts, 1 had 5 washouts. Median number of days between first and second washout was 5 (IQR 4-8). For the 26 cases, there was often more than one clinical reason for repeat washout, the most common being persistent fever (N=21), followed by persistently elevated lab values (N=13), abnormal MRI findings (N=12), and continued pain (N=12). Cases demonstrated a higher peak temperature prior to surgery ($p<0.001$), and more often had a misdiagnosis prior to diagnosis of septic hip arthritis ($p=0.002$), despite a shorter average time from symptom onset to surgery ($p=0.02$). Laboratory values in cases showed higher C-reactive protein (CRP) ($p=0.003$), and more frequent left shift ($p=0.03$) at presentation. Cases more often had positive cultures ($p<0.001$) and were more likely to have MRIs with findings of soft tissue abscess ($p<0.001$) or osteomyelitis ($p=0.001$). Postoperatively, cases had higher temperatures ($p<0.001$), more frequent wound drainage ($p=0.02$) and surgical complications ($p=0.001$).

Conclusion: Cases of repeat irrigation for pediatric septic arthritis are associated with a more aggressive infection and robust inflammatory response. Despite the impressive nature of presentation, initial misdiagnosis was common in the repeat washout group.

Significance: This study helps to identify factors that may guide physician and patient expectations for the treatment course for septic arthritis of the hip in children.

Functional Outcome after Pediatric Osteomyelitis Treated with a Multidisciplinary Evidence-Based Clinical Practice Guideline: 2 Year Follow-up

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LOE–Prognostic–Level II

Purpose: Osteomyelitis has a highly variable clinical course in children. The disease can range from a mild clinical illness with rapid resolution to a severe and complicated disease with permanent sequelae. Unfortunately there is a lack literature to describe how initial disease characteristics relate to risk of long term sequelae or health related quality of life. Here we describe the 2 year outcomes of children treated for osteomyelitis.

Methods: Affected children were consecutively enrolled and prospectively studied from 2012-2014. These were cared for by a multidisciplinary team according to evidence-based clinical practice guidelines. Clinical and radiographic follow-up as well as Pediatric Outcomes Data Collection Instrument (PODCI) and Pediatric Quality of Life Inventory (PedsQL) survey data were obtained at 2 years. Mann-Whitney U test was used to compare means.

Results: There were 90 (53%) children out of 170 enrolled who returned for follow-up. Mean age at diagnosis was 7.8 years (range 1 month-18years). 46% of children presented with associated abscess or pyomyositis and 25% had associated septic arthritis. MSSA was the most common organism (48%) followed by MRSA (38%). Mean LOS was 7.5 days (Range 0-51 days). Mean SIS was 3.1 (95%CI 2.3-3.9). Clinical and radiographic outcome was favorable for 86 (95.5%) children. Persistently visible physeal abnormalities at 2 years occurred in 8 children (8.8%). However, in 4 cases a small central physeal growth arrest affected radiographic appearance but not longitudinal growth or function. One child had complete growth arrest and AVN of the proximal humerus. Another had persistent angular deformity of the tibia related to healed pathologic fracture. There were two children (2.7%) with AVN of the femoral head both associated with septic arthritis of the hip. The 4 children with persistent clinically significant skeletal abnormalities were found to have worse presenting SIS (than the rest of the cohort: 6.7 (95%CI 3.3-10.1) vs 2.8 (95%CI 2.0-3.5) (p=0.0171) and worse overall PODCI global function

Scoring Parameter	Criteria	Points	Total
Initial CRP (mg/dL)	>15	2	0-2
	10 to 15	1	
	<10	0	
CRP hospital day 4-5 (mg/dL)	>10	2	0-2
	5 to 10	1	
	<5	0	
CRP hospital day 2-3 (mg/dL)	>10	2	0-2
	5 to 10	1	
	<5	0	
Band percentage of WBC	≥ 1.5%	1	0-1
	<1.5%	0	
Febrile days on anbiotic	≥2	1	0-1
	<2	0	
ICU Admission	Yes	1	0-1
	No	0	
Disseminated Disease*	Yes	1	0-1
	No	0	
Total			0-10

*DVT, septic pulmonary embolism, pneumonia, endocarditis, multi-focal

Figure 1. Modified severity of illness scoring system for AHO

scores at 2 years 89.8 (95%CI 94.0-97.5) vs 95.7 (95%CI 82.9-96.8) (p=0.0268).

Conclusion: Long term sequelae among children with osteomyelitis requiring ongoing orthopaedic surveillance is rare and may be anticipated by initial severity of illness. The majority of children with this condition do not require long term follow-up beyond the initial treatment period.

Significance: This is the first study to prospectively track long term functional and radiographic outcomes of children osteomyelitis. This data should serve as a benchmark for future understanding of those children who are at risk for sequelae of osteomyelitis.

Kingella Kingae the Commonest Cause of Paediatric Septic Arthritis in a Prospective Cohort

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LOE–Diagnostic–Level III

Purpose: Acute paediatric monoarthritis poses an important diagnostic quandary. Septic arthritis is considered the main concern acutely, but often difficult to fully exclude. Increasing recognition of emerging pathogens such as *Kingella kingae* adds an extra dimension to the diagnostic process.

Methods: A 16-month prospective observational study of all children (ages 0 to 18 years) presenting with an acute monoarthritis at a tertiary children's hospital was conducted. Demographic data, and key clinical features at presentation were captured on a pro-forma completed during initial emergency department assessment. Hospital records were reviewed at minimum 6-months following presentation to identify delayed re-presentations or clarify final diagnoses following outpatient review. The main diagnostic groups of interest were transient synovitis (TS), juvenile idiopathic arthritis (JIA), and septic arthritis(SA). All synovial fluid samples underwent PCR testing for *Kingella kingae.* Cases were excluded if traumatic or other causes of joint pain were identified. Diagnosis of transient synovitis was based on self-limiting monoarthritis in the absence of any other identifiable cause.

Results: Between August 2014-December 2015, 229 cases of acute monoarthritis presented, with 196 (85.6%) cases categorised into the main study diagnostic groups. Mean age was 5.3 years (range 1 month-16.8 years), with 138 (60.3%) males. No significant difference in age was observed between diagnostic groups. The mean temperature at presentation was 36.6°C (SD 0.7), and symptom duration 4.7 days (SD 16.6). Final diagnoses were TS 167 (72.9%); SA 21 (9.2%); JIA 8 (3.5%). Significant difference in ESR (TS 13.5mm/hr, JIA 17.6mm/hr, SA 49.4mm/hr; $p<0.001$) and CRP (TS 4.9mg/L, JIA 6.8mg/L, SA 45.4mg/L; $p<0.001$) were observed between the diagnostic groups. Anti-Nuclear Antibody(ANA) titres were performed in 140 (73.6%) cases. Positive ANA was observed across all groups (TS 25 cases (21.0%); JIA 5 cases (62.5%); SA 3 cases (18.8%)). Positive microbiology was identified in 17 (79.0%) cases of septic arthritis. *Kingella kingae* was the most commonly identified pathogen (12 cases, 57.1%) followed by S*taphylococcus* 3 (14.3%).

Conclusion: This study confirms acute monoarthritis as a relatively common childhood presentation, although the vast majority are self-limiting in nature. Although JIA should be considered a differential, it was uncommon in our cohort and additional blood investigations may not aid diagnosis at initial presentation. *Kingella kingae* was the commonest pathogen cultured in septic arthritis.

Significance: In this prospective study, at an institution routinely using *Kingella kingae* PCR analysis, *Kingella kingae* was the commonest cause of paediatric septic arthritis, and the commonest cause of monoarthritis in cases that aren't self-limiting.

Does Staphylococcus Nasal Decontamination Affect the Rate of Early Surgical Site Infections in Adolescent Idiopathic Scoliosis Surgery?

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LOE–Therapeutic–Level IV

Purpose: Nasal colonization with *Staphylococcus aureus* is a risk factor for developing nosocomial infections in adolescent idiopathic scoliosis (AIS) surgery. However, the exact rate of healthy carrier remains unknown in the adolescent population. This study aims to report the efficacy of a preoperative nasal decontamination program on early surgical site infections (SSI) after AIS posterior surgery.

Methods: Between 2014 and 2016, all AIS patients were screened preoperatively with nasal swabs and decontaminated if positive 5 days before surgery. Early SSI were prospectively identified and microorganisms findings were compared to a previously published series before the decontamination program.

Results: Among the 270 AIS posterior procedures performed during the study period, the incidence of positive nasal swab was 21 %. The overall infection rate was not significantly reduced by the decontamination program, and 26 early SSI (9.5%) were reported, among which 31% had been preoperatively decontaminated for positive nasal swabs. *Propionibacterium acnes* was the most frequent pathogen (58%). *Staphylococcus aureus* was only found in 6 cases (23 %), while it represented 61% of the SSI before the decontamination program. One patient with *Staphylococcus Aureus* SSI had been decontaminated preoperatively, while 33% of the patients who developed *Propionibacterium Acnes* SSI had preoperative positive nasal swabs.

Conclusion: Nasal decontamination divided by 3 the incidence of *Staphylococcus aureus* SSI, without developing Methicillin-resistant pathogen. However, the influence of the program on the emergence of *Propionibacterium acnes*, which is a commensal skin bacteria, needs to be further studied. In addition, the SSI rate remains very high and is currently addressed by a multifactorial approach.

Significance: Nasal decontamination reduces the risk of *Staphylococcus aureus* early SSI in AIS.

Interrater Reliability and Age-Based Normative Values for Radiographic Indices of Syndesmosis and Deltoid Ligament Stability in Children

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LOE–Diagnostic–Level III

Purpose: While recent research has investigated the normative values, discriminative capacity, and interrater reliability of x-ray indices for evaluating the syndesmosis in adults, no such data exists in children. The purpose of this study was to determine the interrater reliability and establish age-based normative values in children of common radiographic measures of syndesmosis and deltoid ligament competency.

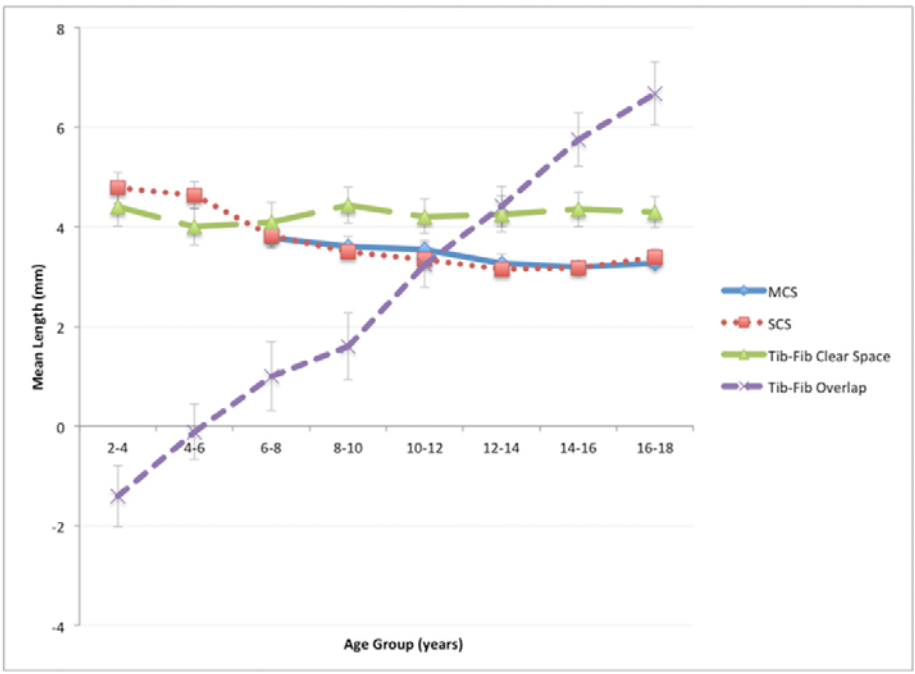
Methods: Consecutive patient radiographs from a level-I pediatric trauma center were identified and used to create an age- and sex-balanced cohort of 282 patients. Subjects between 2 and 18 years of age were randomly selected from a pool of patients who had a complete three-view radiographic ankle series (AP, lateral, and mortise) and a final diagnosis without bony or ligamentous injury. Eight age and sex-balanced groups were created for analysis. Three independent raters evaluated all radiographs and recorded radiographic indices commonly used in ankle trauma evaluation: width of the medial clear space (MCS) and superior clear space (SCS), tibiofibular clear space (TFCS), tibiofibular overlap (TF), and MCS/SCS ratios. Interrater reliability was calculated using the intraclass correlation coefficient (ICC); means and standard deviations were used to report age-group normative values.

Results: 282 patients (mean age 9.61±4.6 years) were analyzed. SCS and TF were characterized by excellent interrater reliability (ICC=0.915 and ICC=0.964, respectively). MCS and TFCS resulted in substantial agreement (ICC=0.656 and ICC=0.635, respectively) while the MCS/SCS ratio had moderate agreement (ICC=0.418). The MCS could not be reliably measured until age 8 due to insufficient ossification of the medial malleolus. TF demonstrated a linear increase over time, ranging from -1.4mm at 2-4 years old to 6.7mm for children aged 16-18 (R^2=0.995) (Figure 1). Normative values varied by age and sex.

Conclusion: The MCS and MCS/SCS could not be reliably assessed for children under 8 years old and were thus characterized by suboptimal interrater reliability. TF had excellent interrater agreement, changed predictably with skeletal growth, and may be useful in the assessment of pediatric ankle injuries to guide clinical decision-making.

Significance: This is the first study to report a comprehensive array of normal syndesmosis measurements in the pediatric population using radiographic imaging. Since radiographic evaluation is an essential component in the diagnosis and intraoperative assessment of pediatric syndesmosis injury, the establishment of normative ankle indices in children is an essential first step to guiding treatment in this population at increased risk for negative long-term sequelae.

Relationship between the mean width of the measured radiographic indices and patient age



Tib-Fib overlap increased predictably over the period of skeletal growth in a linear fashion. SCS width was largest in the youngest patients (2-4 years of age), while Tib-Fib clear space remained constant throughout the age groups. MCS could not be reliably measured for patients younger than 8 years due to the ossification pattern of the medial malleolus.

Innovative Treatment for Pes Cavo Varus

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LOE–Therapeutic–Level II

Purpose: To present the preliminary results of a new mini-invasive surgical technique, using growth guidance as a treatment for the pes cavo varus deformity from an early age.

Methods: Prospective study with the following admision criteriae: Pes cavovarus with coleman +, and patient skeletally immature
Fifteen patients (10 girls, 5 males) and 26 feet were included in this study. Ages ranged from 7.3 to 13.16 with a median age for boys of 11.6 and, for girls of 10.1 years. Nine patients had underlying neurological disease, the rest had no underlying aetiology.
The surgical procedure consisted in a hemiepiphysiodesis with a 2 hole-plate and screws at the 1st metatarsal dorsal surface, associated in most of the cases with a percutaneous plantar release.
Clinical assessment of results comprised hindfoot deformity measured by clinical pictures and presence of callosities in the preoperative and final check-up. Radiological measurements included Meary angle, Calcaneal Pitch and 1st MTT-Talus angle on standing x-Rays.
Additionally, at final follow-up, a foot child questionnaire was distributed to assess the different domains of satisfaction.

Results: The median follow-up ranged from 12-32 moths, mean of 18 (SD 5.92)
Clinically, there was an obvious improvement in heel position from a mean of 6º varus to 8º valgus post-operatively and all feet were fully mobile at final check up. Ten patients had callosities before surgery, which disappeared in all patients except for one case where surgery failed.
The Meary angle improved in most cases from an average preoperative in males from 7º to 1.7º post-procedure, and in girls from 10.4º to 2º. The calcaneal pitch did not show significant changes despite the plantar release.
The most common complication was the misplacement of the plate (3 cases), which in 1 case went undetected and resulted in a poor outcome. Another case of ruptured plate was spotted timely and was exchanged. Moreover, two feet had overcorrection, one of which is pending treatment.

There was a clear correlation between skeletal maturity and the degree of correction achieved.
The questionnaires, except for the failed case, revealed a high degree of satisfaction with the procedure.

Conclusion: Cavovarus deformity at an early age could be treated by minimally invasive surgery, preventing its progression and resulting in a mobile, close to normal foot shape by the end of growth.

Significance: This treatment may alter the natural history of pes cavovarus in young children, and probably diminish the amount of surgery needed.

One-stage Correction of Brachymetatarsias Involving the Greater Toe

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LOE–Therapeutic–Level III

Purpose: To introduce a novel technique including one-stage step-cut lengthening osteotomy of the first metatarsal and shortening and/or lengthening of neighboring rays with internal fixation, for the treatment of brachymetatarsias involving the greater toe.

Methods: We treated 24 feet (15 patients) with first ray brachymetatarsia. Patients were classified into 3 groups based on how the adjacent rays were affected and on how they were treated: (Group A) only the 1st ray were involved (7 feet in 5 patients), which was treated by one-stage step-cut lengthening; (Group B) the 1st ray and other metatarsal(s) were involved (11 feet in 7 patients), treated by one-stage step-cut lengthening in the 1st ray and shortening and/or lengthening of other metatarsal(s) and/or proximal phalange(s); (Group C) the 1st ray and other metatarsal(s) were involved but 1st ray was not treated, and only the neighboring metatarsals were lengthened or shortened (6 feet in 3 patients). Osteotomies were fixed internally. The mean age at the time of the surgery was 15.9 years and the mean follow up period was 16.7 months. All patients had short leg cast for 6 weeks and then partial weight bearing was permitted. Length gain (mm) and percent increase (%) were evaluated for each group. The American Orthopaedic Foot and Ankle Society Score (AOFAS) was used for clinical evaluation.

Results: The mean length gain and percent increase of the first ray were as follows: 8.4 mm and 22 % in group A; and 8.1 mm and 25 % in group B. For group C, an indirect (relative) effect of 8.6 mm and 23 % in the 1st ray was achieved. All patients showed bony union and no complications occurred. In all cases, smooth parabolas at the level of the metatarsal heads and at the toe tips were restored. Mean postoperative AOFAS score at the last follow up was 82.1 for all patients.

Conclusion: Combined one-stage step-cut lengthening of the first metatarsal and shortening and/or lengthening of the adjacent metatarsal and phalangeal bones provides excellent cosmetic and functional results.

Significance: One-stage lengthening with an interpositional bone graft, and gradual lengthening by callotasis, are the two techniques most widely used in the treatment of brachymetatarsia. In both techniques, common problems are mainly related to excessive lengthening. Therefore combined adjustment of the adjacent metatarsals and/or phalanges is one option to minimize the amount of lengthening required of the affected metatarsal. (400)

Resection of Tarsal Coalition and Surgical Correction of the Hindfoot Deformity in One Step

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LOE–Therapeutic–Level IV

Purpose: The calcaneonavicular (CNC) and the talocalcaneal (TCC) coalitions are the most common cause of rigid flatfoot in children. Arthrodesis or resection are the options reported in literature for symptomatic flatfeet. After resection, the correction of the most frequent valgus–hind foot deformity usually requires further surgery. We report the results of patients treated with resection, interposition of fat graft and subtalar extra-articular screw arthroereisis (SESA) in one step.

Methods: During the period 2008 and 2015 data was collected of 17 (12 m, 5 f) patients affected by CNC (n=13) and TCC (n=7) all with rigid symptomatic flatfeet (n = 20 feet, 3 bilateral). The overall average age at surgery was 12.3 years ± 1.1 SD (min 9,8- max 14,4) All patients underwent resection and interposition of fat graft while 17 of them underwent at the same time subtalar extra-articular screw arthroereisis for correction of the hind foot valgus and flat foot. The average follow-up was 36 months (12-108). Pre- and post-operative weight-bearing x-rays angles were evaluated and all patients had an postoperative American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score.

Results: Pre- and post-operative weight-bearing lateral x-ray angles were respectively: pre-operatively Talo-calcaneal angle average 142,6° ± 7,1 (SD) ; talar declination angle average 30,2° ± 5,5 (SD). Post-operatively : Talo-calcaneal angle 130,0° ± 6,0 (SD) ; lateral declination angle average 20,4° ±2,8 (SD). The average AOFAS Ankle-Hindfoot score obtained was 94,46 (SD 9,7) out of 100 (excellent). None of the patients had additional surgery or recurrence.

Conclusion: Symptomatic rigid flatfeet affected by CNC and TCC can be treated with resection, interposition of fat graft and a mini-invasive subtalar extra-articular screw arthroereisis for correction of Hindfoot Valgus in one step and achieve good to excellent results in 88.2% of patients. Further surgery to correct malalignement is avoided.

Significance: Rigid symptomatic flatfoot in tarsal coalitions with valgus hindfoot deformity can be treated successfully with a one-step technique, involving mini-invasive SESA, and avoiding further surgeries.

Arthroscopic Calcaneonavicular Coalition and Too-long Anterior Process of the Calcaneus Resection in Children

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LOE–Therapeutic–Level IV

Purpose: The purpose of our study is to present the results and outcomes of arthroscopic resection of CNC and TLAP in pediatric patients.

Methods: Prospective study of 31 consecutive persistently symptomatic feet with CNC (n=12) or TLAP (n=19) in 30 children, arthroscopically resected between 2009 and 2013. Mean age was 12.4; mean follow-up 55.2 months. Preoperative and postoperative examination, imaging studies, AOFAS Ankle-Hindfoot scale and pain were evaluated, as well as patient satisfaction.

Results: In all patients the arthroscopic approach allowed a complete visualization and resection of CNC or TLAP. All patients showed a statistically significant improvement in pain after surgery, with the exception of one patient who developed a complex regional pain syndrome (CRPS) (p<0.001). Mean preoperative AOFAS score was 78.9; postoperatively it was 93.1, revealing a statistically significant increase (p<0.001).

Conclusion: Although arthroscopic CNC or TLAP resection is a demanding technique, it allows for precise coalition resection through a less invasive approach which may ultimately lead to faster recovery and improved outcomes.

Significance: Minimally invasive approach to CNC

Calcaneal Lengthening Using Ipsilateral Fibula Autograft in the Treatment of Adolescent Symptomatic Pes Valgus

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LOE–Therapeutic–Level IV

Purpose: Calcaneal lengthening has been a solution in the treatment of symptomatic pes valgus for years. The graft selection include autologous iliac bone graft (AIBG) or allograft. The disadvantages are donor site morbidity for AIBG and higher cost and lower union rate for allograft. Ipsilateral fibula graft could be a better choice than AIBG and allograft.

Methods: From June 2014 to July 2016, 25 patients with 40 feet between 10 to 18 years old with symptomatic pes valgus after at least one year conservative treatment were included in the study. All patients received calcaneal lengthening using ipsilateral fibula autograft. Additional procedures include accessory naviculum excision, tibialis posterior tendon tightening and gastrocnemius lengthening. Short leg splint was applied post-operatively for four weeks and partial weight bearing were allowed. The clinical and radiographic outcomes were evaluated preoperatively, two and six months, 12 months postoperatively using ankle hind foot score published by American Orthopaedic Foot and Ankle Society (AOFAS). T-test was used to evaluate the functional score and radiographic parameters preoperatively and postoperatively.

Results: The follow up period was at least one year (12 months~24 months).The average of AOFAS scores was 72.8 preoperatively and significantly improved to 93.5 two months postoperatively and 99 one year postoperatively. Radiographic parameters including Meary angle, calcaneal pitch had significant postoperatively. All grafts were united two months postoperatively. No graft collapse or migration was found. No patients had donor site morbidity. One patient had superficial wound infection due to stitch abscess. All patients were satisfied with the results.

Conclusion: Calcaneal lengthening using ipsilateral fibula autograft in the treatment of symptomatic pes valgus could have comparable result with using iliac autograft or allograft. It has the advantages of AIBG and lower donor site morbidity. It could be an alternative choice in resouce limited countries and area where the allograft is unavailable.

Significance: Calcaneal lengthening using ipsilateral fibula autograft in the treatment of symptomatic pes valgus could have comparable result with using iliac autograft or allograft. It has the advantages of AIBG and lower donor site morbidity. It could be an alternative choice in resouce limited countries and area where the allograft is unavailable .

Structural Hydroxyapatite Tricalciumphosphate Graft versus Tricortical Iliac Crest Autograft in Paediatric Calcaneal Lengthening Osteotomies. Results from a Randomised Controlled Noninferiority Trial

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LOE–Therapeutic–Level II

Purpose: To compare the structural durability of hydroxyapatite-tricalcium phosphate (HATCP) to autologous iliac crest bone graft in calcaneal lengthening osteotomy (CLO) for pes planovalgus in childhood.

Methods: We present the interim results of 11 patients (HATCP, n = 6 and autograft, n = 5) with a mean age of 11.5 years (8.2 to 14.2) from a randomised controlled non-inferiority trial with six months follow-up. The primary outcome was the stability of the osteotomy as measured by radiostereometric analysis. A non-inferiority margin of ≤ 2 mm osteotomy compression was set. Final results with complete one year follow-up are expected to be presented at the time of the conference.

Results: At six months the data showed that the osteotomy had been compressed by a mean 1.97mm (99.8% confidence interval: -1.65 to 5.60) more in the HATCP group than in the autograft group. Migration of the CLO grafted with HATCP stabilised at six months rather than at six weeks with autograft.

Conclusion: This is the first randomised trial to compare the efficacy of HATCP graft with autograft in terms of stability of CLO in children. Because of problems with the HATCP the trial was stopped. We do not recommend HATCP graft in its current structure for use in an unfixed CLOs.

Significance: This is the first randomised trial to compare the efficacy of HATCP graft with autograft in terms of stability of CLO in children. The brittle nature of the HATCP material does not make it viable as a structural bone graft substitute in calcaneal lengthening osteotomies. RSA is feasible to indicate osseointegration in calcaneal osteotomies in children.

Acute Correction of Congenital Brachymetatarsia in Adolescent and Young Adults

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LOE–Therapeutic–Level IV

Purpose: Brachymetatarsia is a relatively rare abnormal shortening of the metatarsal bone with female predominance, which most commonly involves the fourth metatarsal. Patients usually complain on pain due to transfer metatarsalgia, callosities, problems with shoe fitting and cosmetic appearance of the foot. No consensus exists as of the ideal treatment of this condition. Common present treatment options are gradual lengthening using external fixation and acute one stage lengthening .The purpose of the current study is to evaluate the results of acute lengthening using iliac bone graft.

Methods: During 12 years we operated 11 patients (10 females and one male) with a mean age of 17.4 years (range 13-23 years).All patients achieved skeletal maturity at time of operation. Treatment protocol included distal metatarsal osteotomy, lengthening of extensor tendon and percutaneous tenotomy of the flexor tendon at the level of affected MP joint. Autologous iliac bone graft was inserted after acute distraction of the osteotomy site and fixation of the graft was done by Kirshner wire. Below knee non walking cast was applied for 6 weeks.

Results: All patients achieved uneventful union. Mean lengthening was 13 mm (range 11-15 mm).One patient had bilateral metatarsal lengthening. Metatarsal parabola was restored in 8 patients. 10 patients were satisfied with the cosmetic appearance of the foot.

Conclusion: Based on our experience acute metatarsal lengthening using iliac bone graft is a reliable and effective treatment for brachymetatarsia.

Significance: Acute one stage lengthening provide excellent cosmetic results with minimal morbidity and short learning curve compared to gradual lengthening using external fixator.

Hemiepiphysiodesis for the Correction of Juvenile Hallux Valgus

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LOE–Therapeutic–Level IV

Purpose: Juvenile Hallux Valgus (JAV) is a complex surgical condition. The growth plates, the association with high recurrence rates and ligament laxity distinguishes JAV from the adult form of disease.
The surgical indication in JAV is reserved to pain and progressive deformities. It should be delayed until bone maturity. Multiple techniques are described with its inherent risks and complications, including: osteotomies , bunionectomy, release of soft tissue and metatarsal hemiepiphysiodesis.

Methods: This retrospective study reports results of lateral percutaneous hemiepiphysiodesis of the base of the 1st metatarsal bone, treated between 2009-2014. Radiographic evaluation measures included pre and post operative intermetatarsal angle (IMA), hallux valgus angle (HVA), DMAA and metatarsal length. It was also assessed additional procedures performed, the subsequent need for further surgery and complications.

Results: Eleven female were included in the study, with a total of 21 feet, and a mean age of 10 years. Mean follow-up was 2 years.
Beyond the lateral hemiepiphysiodesis of the base of the 1st metatarsal , 4 feet were submitted to additional procedures.
Seventeen cases (80%) showed improvement of IMA angle (average of 2.4 degrees).
Thirteen cases (62%) showed an improvement in HVA angle, (average of 3.46 degrees).
One case had radiological worsening of IMA and in 7 cases had worsening of HVA.
None complications noticed in the immediate postoperative period. Eight cases (38%) are on the waiting list for surgical correction (maintenance of complaints and significant deformity).

Conclusion: JAV raises many controversies regarding the correct approach (surgical indication, surgical options and timing).
Lateral hemiepiphysiodesis of the base of the 1st metatarsal is a technique described but with few reported studies. While some report high rates of bad results, others report results short follow-up. One study with a mean follow-up of 4 years, showed that this technique applied to patients from 9 to 11 years prevented the progression of deformity with improved IMA, and HVA angles in 50% of cases.
In our series although there is an improvement of the IMA around 80% of cases and HVA in 62%, this is not sufficient for definitive treatment of deformity. However, it is likely that prevents deformity progression, facilitating future procedures, but it is necessary comparisons.

Significance: We consider it to be a possible alternative for the initial treatment of juvenile hallux valgus delaying the progression and reducing the symptoms, because it is a minimally invasive surgical technique which could theoretically model the growth without altering joint mobility.

Does Pseudarthrosis of the Fibula After Lower Limb Lengthening Predispose Patients to Increase of Ankle Valgus?

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LOE–Prognostic–Level IV

Purpose: Pseudarthrosis of the fibula after lower limb lengthening is occasionally noted; this could be a cause of developmental ankle valgus due to the proximal migration of the lateral malleolus. However, this has rarely been discussed. The purpose of this study is to investigate how often pseudarthrosis of the fibula was seen following lower limb lengthening and its condition as a risk factor of ankle valgus.

Methods: In this study, 61 limbs in 54 patients who underwent lower limb lengthening using a circular device (Ilizarov or Taylor frame) were reviewed retrospectively. Distal and proximal tibio-fibular fixations with wire during the distraction were performed in all cases. The average age at surgery was 11.3 years (range: 3.0 -16.6) and the average duration of the follow up was 3.9 years (range: 2.0-6.5). To evaluate the proximal migration of the fibula, malleolar tip distance was measured and to evaluate the ankle valgus, the tibio-talar angles (TTA) from the standing anteroposterior radiographs at preoperative, immediate removal of external fixator, and final visits were used.

Results: The average tibial length gain was 46.4 mm (range: 28-85), and the average healing index was 46.5 days/cm (range: 28.3-78.0). All lengthening was performed by monofocal lengthening, and all osteotomies of the fibula were performed in the middle third portion. Mean gap distance of the fibular osteotomy site at immediately post-surgery was 3.9 mm (range: 0.5-20). Pseudarthrosis of the fibula was seen in 14 (23.0%) of the 61 limbs; these 14 had a mean proximal migration of the lateral malleolus of 4.9 mm (range: 1-9mm) between before surgery and final presentation. A high rate of pseudarthrosis (67%; 6 of 9 limbs) was noted in patients with fibular hemimelia (FH), and these 6 showed a significant increase in ankle valgus (average 11.3º, range: 7-15). In the other 8 patients with fibular non-union, 2 (25%) presented

with ankle valgus (increase of TTA > 5 º), while the remaining 6 showed no progression of ankle valgus.

Conclusion: In patients with FH, pseudarthrosis of the fibula after limb lengthening was frequent, and once nonunion occurs, it predisposes patients to a significant increase in ankle valgus deformity. In patients with other underlying conditions, pseudarthrosis of the fibula may relatively predispose them to ankle valgus.

Significance: We should consider the risk of developmental ankle valgus due to the proximal migration of lateral malleolus following pseudarthrosis of the fibula after limb lengthening especially in the patient with FH.

Are Two Radiographic Views as Good as Three Views to Diagnose Ankle Fractures in Children and Adolescents?

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LOE–Diagnostic–Level III

Purpose: Ankle radiographs are among the most commonly obtained trauma images in the pediatric population, with the standard three views (AP/Mortise/Lateral) routinely ordered in the Emergency Department (ED). These account for up to 10% of all x-rays requested in the ED, yet it is estimated that only 12-20% of the children with ankle injuries seen in an emergency setting have an ankle fracture. The purpose of this study was to estimate the diagnostic accuracy, sensitivity and specificity of sets of two views (AP/Lateral or Mortise/Lateral) using the standard three views as the reference, with the goal of reducing radiation exposure for children and decreasing healthcare costs.

Methods: One hundred and twenty sets of ankle radiographs of skeletally immature patients obtained in the ED of a level 1 pediatric trauma center were used. All common pediatric ankle fracture patterns, as well as a subset of radiographs with no identifiable fracture, were represented. Sets of three and two views were reviewed by pairs of pediatric trained orthopedic surgeons, radiologists and emergency physicians. Each reviewer completed three randomized viewing sessions where all possible combinations for each set of radiographs were reviewed. Diagnoses for the three sets of views were compared for accuracy, sensitivity and specificity.

Results: Overall accuracy, sensitivity and specificity for all reviewers were as follows: AP/Mortise/Lateral - 74%, 94%, 90%, AP/Lateral - 71%, 90%, 94%, Mortise/Lateral - 69%, 90%, 91%. P-values for accuracy, sensitivity and specificity of AP/Lateral compared with three views were 0.34, 0.04, 0.52, while those of Mortise/Lateral compared with three views were 0.04, 0.004, 1.0, respectively. Common fracture patterns missed/misdiagnosed on limited views included medial malleolus avulsion, tillaux, triplane, SH3/SH4 medial malleolus, distal fibula SH3, distal tibia metaphyseal buckle, distal fibula metaphyseal/diaphyseal, and talar osteochondral fractures.

Conclusion: In skeletally immature patients, statistically significant differences in accuracy were obtained when comparing the standard three AP/Mortise/Lateral views with more limited Mortise/Lateral views, suggesting that this set of two views is not as accurate. Conversely, differences in accuracy between the standard three views and AP/Lateral views were not statistically significant. Differences in sensitivity of limited views were also statistically significant.

Significance: While more limited AP/lateral views may be comparable in accuracy and specificity, and lead to dramatically decreased radiation and costs, this can be at the expense of increased risk of misdiagnosing or missing certain fracture patterns and less diagnostic sensitivity.

Short Leg Cast Immobilization of Distal Tibial Physeal Fractures

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LOE–Therapeutic–Level IV

Purpose: Distal tibial physeal injuries are one of the most commonly reported fractures in children. Although various treatment algorithms exist, historically these physeal injuries have been treated in a long leg cast if less than 2mm of displacement is present after closed reduction. The purpose of this study was to evaluate the efficacy of short leg cast immobilization in the closed treatment of distal tibial physeal fractures.

Methods: We performed a retrospective review of 123 pediatric patients who were treated with short leg cast immobilization for a distal tibial physeal fracture at a tertiary care facility between January 2002 and September 2015. Radiographs were analyzed for displacement and angulation at the time of injury, after closed reduction and/or casting, and at final follow up. Demographic data, mechanism of injury, and fracture classification were also recorded. The primary outcome was to assess for loss of reduction following short leg cast immobilization of both displaced (>2mm) and non-displaced (<2mm) distal tibial physeal fractures undergoing closed treatment.

Results: In total, 123 patients with an average age of 12.2 years that underwent closed treatment of a distal tibial physeal fracture via short leg cast immobilization were included in the study with an average follow-up of nine months. Of these, there were 3 SH I (2.44%), 64 SH II (52.03%), 21 SH III (17.07%), 11 SHIV (8.94%), 20 Triplane (16.26%), and 4 Tillaux (3.25%) fractures. Forty-three percent of fractures were displaced (>2mm) and underwent closed reduction and short leg cast immobilization for at least 4 weeks. The remaining fractures were non-displaced (<2mm) and were treated in a SLC without a formal closed reduction. Forty-six percent of fractures were intra-articular. The average initial displacement was 3mm (range 0-21.95mm) with 79% of these fractures achieving less than 2mm of displacement after closed reduction. At final follow-up all fractures achieved or maintained less than 2mm of displacement and there were no instances of loss of reduction including increased gap or angulation as well as any evidence of premature physeal closure.

Conclusion: Short leg cast immobilization is an effective alternative in the closed treatment of both non-displaced and displaced distal tibial physeal fractures that were previously considered appropriate for treatment in a long leg cast.

Significance: This finding is significant because short leg cast immobilization likely represents a more cost effective treatment option and one that would interfere less in the daily activities of patients.

Brace Treatment Can Result in Improved Acetabular Indicies in Infantile Dislocated Hips

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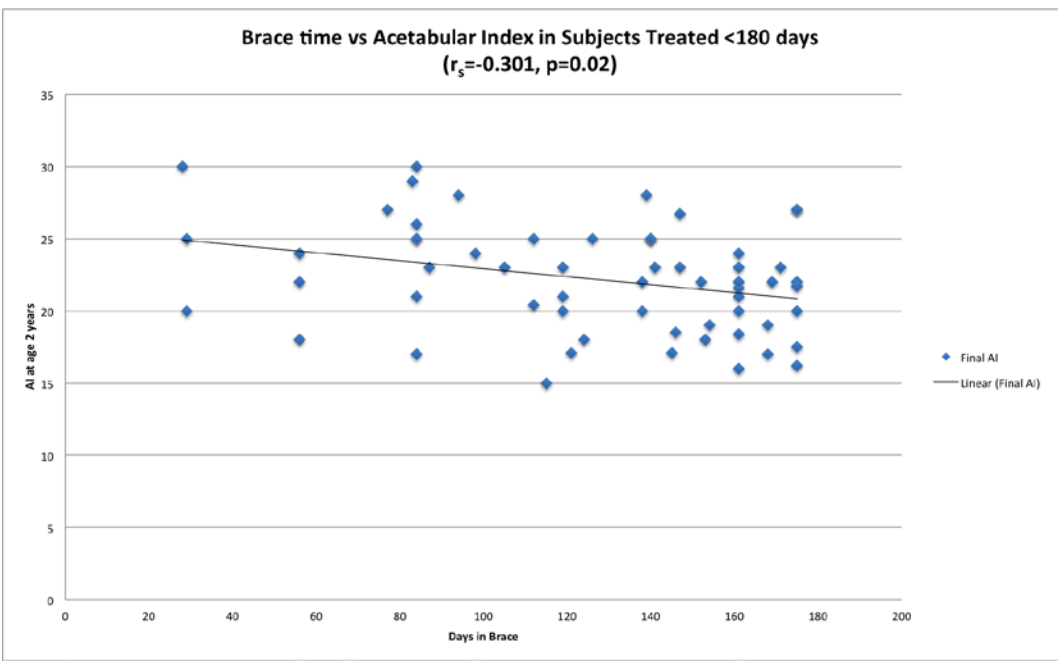
LOE–Therapeutic–Level II

Purpose: The Pavlik harness (PH) is most commonly used to treat infantile dislocated hips. However, variability exists in the duration of brace treatment for hips that are dislocated yet reducible (Ortolani positive). Our aim was to evaluate the effect of prescribed time in brace on the acetabular index (AI) at two years of age using a prospective, international, multicenter database.

Methods: We studied: enrolled infants that had an Ortolani positive hip at initial presentation, successfully treated with a PH, and had a recorded AI at age two years (n=111 hips). Hip dislocation was defined as less than 30% femoral head coverage at rest on the pre-treatment ultrasound or IHDI grade III or IV on the pre-treatment radiograph. Time in brace was evaluated as a continuous variable and was correlated with the AI. In order to minimize the effect of age on the AI, we only used radiographic data obtained between 24 months and 36 months of age.

Results: Eighty hips met our inclusion criteria. Average age at brace initiation was 40±38 days with average total time in brace of 172±127 days (range: 28 to 708 days). In looking at the entire cohort, there was no correlation between time in brace and AI (p=0.28). However, in patients who were treated in a brace for 180 days or less, there was a moderate yet statistically significant correlation with time in brace and improved AI (r_s=-0.301, p=0.02) (Figure 1). This correlation was absent in subjects treated longer



than 6 months (p=0.163). Subjects weaned from full time (FT) to part time brace wear were treated longer (weaned: 194±127 days versus FT only: 133±120 days, p<0.001) and had a lower AI (weaned: 21±3˚ versus FT only: 24±3˚, p=0.002) at age two years.

Conclusion: Up to six months of brace treatment was found to have a positive impact on the AI as measured on radiographs at age two years. Weaning the brace from full time to part time may increase the ultimate time in brace and resulted in improved AI in this study. Brace compliance depended on parent reported compliance to our treatment recommendations.

Significance: Secondary goals of treating a dislocated hip, after obtaining/maintaining reduction, are to maximize acetabular remodeling and minimize the risk of residual dysplasia. Our data suggests that continued use of the harness for up to six months may accomplish these goals. We therefor recommend Pavlik harness duration for a minimum of six months.

Open Reduction for Developmental Dysplasia of the Hip: Early Outcomes from A Multi-Centre, International Prospective Cohort Study

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LOE–Therapeutic–Level III

Purpose: Open reduction (OR) is typically used in developmental dysplasia of the hip (DDH) to treat older infants, more severe dislocations, and dislocations that have failed closed reduction (CR). However, little data on outcomes and complications of OR have been prospectively collected. The purpose of this observational, prospective multi-centre study was to examine early outcomes and complications of OR.

Methods: A multi-centre, prospective database of infants diagnosed with DDH 0-18 months of age was analyzed from 2010 to 2015 for patients treated by OR. Demographics, clinical exam, radiographic/ultrasonographic data and history of previous orthosis or surgical treatment (CR) were assessed. At minimum one year follow-up, incidence of avascular necrosis (AVN, Salter criteria) and location of the femoral head (IHDI Grade) were assessed.

Results: A total of 69 ORs (69 hips) were performed on 62 patients with a median age at diagnosis of 8 months (range 0-18) and a median age at OR of 12 months (range 3-25). Acetabular and/or femoral osteotomies were concomitantly performed on 16 (23%) hips. Time between diagnosis and OR was 3 months (range 0-14). At diagnosis, 38/69 hips (55%) were irreducible, and 37/69 (54%) were left hips. At OR, 23/69 hips (33%) had received prior brace treatment and 18/69 hips (26%) had undergone CR. Pre-operatively, 41% of hips were IHDI Grade IV and mean pre-operative acetabular index (AI) was 39°. One hip required a second OR to reduce. At most recent follow-up (median 23 months, range 12-57), 60/69 hips (88%) were IHDI Grade I while 7/69 hips (11%) were IHDI Grade II. 18/69 hips (26%) developed AVN. AVN developed in 12/43 (28%) hips with an ossific nucleus at time of OR, and 6/26 (23%) hips without an ossific nucleus. During follow-up, 3/69 hips (4%) underwent further corrective surgery (FCS) for residual dysplasia.

Conclusion: At a median 23 months following OR, 99% of hips remained reduced; however, 11% had some degree of subluxation (IHDI Grade II). Development of AVN occurred in 26% of hips, and did not seem to be impacted by presence/absence of ossific nucleus.

Significance: Early outcomes from this cohort suggest that OR is successful in achieving and maintaining hip reduction. However, AVN remains an important complication, and is comparable to the AVN rate found with closed reduction. Although numbers are too small to accurately assess risk factors for AVN, there appears to be no difference in AVN rate whether the ossific nucleus is present or absent.

Efficacy of Maintaining the Ligamentum Teres in Medial Open Reduction for DDH: A Comparative Study of Shortening/Reattachment versus Excision

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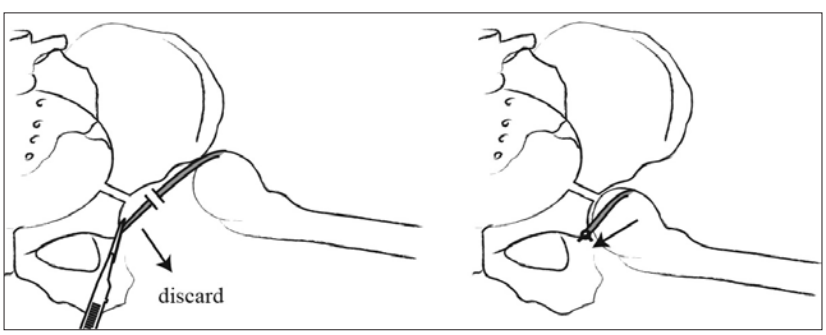
LOE–Therapeutic–Level III

Purpose: Open reduction of infantile hip dislocation is indicated when the hip is irreducible using closed methods. Medial open reduction (MOR) is typically used in patients under 18 months, enabling a direct approach to the common obstacles to reduction. Studies cite a 5-14% rate of repeat subluxation or dislocation. Ligamentum teres preservation and transfer has a potential role in providing additional stability (Figure 1). We retrospectively compare results from MOR surgeries, with and without ligamentum teres maintenance (LTM), to determine if this additional stability results in improved outcomes.

Methods: After institutional approval, charts of all patients who underwent MOR at our institution since 1996 were reviewed. Exclusion criteria included a diagnosis of neuromuscular disease, and less than one year of follow-up. Clinical outcome was rated using the modified McKay criteria. Repeat subluxation/dislocation and additional surgeries were recorded. Radiographic outcomes were determined using the Severin score. Avascular necrosis (AVN) was assessed using the Kalamchi criteria. Statistical analysis was done with chi-squared tests for nominal variables, t-tests for continuous, with a p-value of 0.05 denoting significance.

Results: The majority of patients who underwent MOR during the study period underwent LTM. There were 20 patients in the LTM group (26 hips, median age: 6.5 months) and 6 patients in the excision group (7 hips, median age: 6.2 months). Average follow up was 5 years, 4 months. There were no repeat dislocations in the LTR group, compared to 3 of 7 in the excision group (p=0.006). All patients had excellent or good clinical outcomes using the modified McKay criteria, although the excision group had two patients with a limp at final follow-up (28.6% vs 0%, p=0.04). Radiographically, most hips had excellent or good Severin scores (LTM group, 91.3%; excision group, 83.3%). In the LTM group, 34.6% of hips needed additional surgery, and the AVN rate was 11.5%. Neither of these were different between groups.



Conclusion: Our results demonstrate equivalent clinical and radiographic outcomes between the two groups. However, the LTM group had no recurrent dislocations, and fewer gait abnormalities at final follow up compared to the excision group.

Significance: Traditionally considered a block to reduction, the ligamentum teres has mechanical properties that may be valuable in tethering the femoral head to the acetabulum. Maintaining the ligamentum is beneficial in reducing re-dislocation rates and has become standard practice in our hospital. Ligamentum transfer during MOR surgery is a safe and effective tool that provides additional stability in congenitally dislocated hips.

Intermediate Results of the Bernese Periacetabular Osteotomy for the Treatment of Hip Instability in Patients with Down Syndrome

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LOE–Therapeutic–Level IV

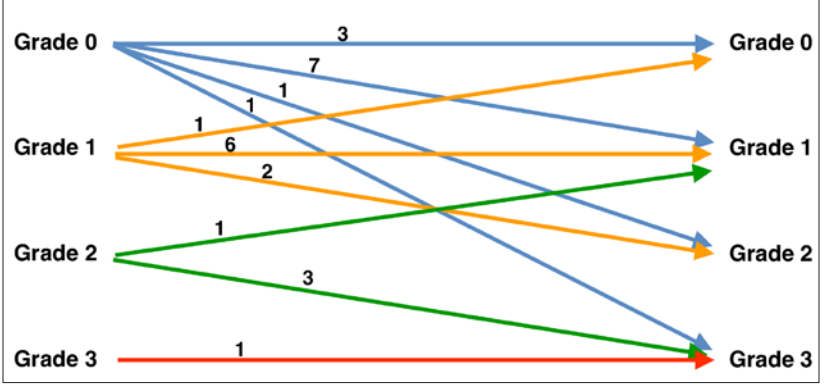
Purpose: Treatment of hip instability in patients with Down syndrome (DS) is difficult and controversial. We investigated the outcomes of the Bernese periacetabular osteotomy (PAO) and factors associated with failure in DS, with a minimum follow-up of four years.

Methods: After IRB approval, 19 DS patients (26 hips) who underwent PAO for hip instability between 1992 and 2011 were evaluated. There were 11 males, eight females, and the average age at the time of surgery was 16.2±4.7 years. Sixteen patients (84%) had pain; five hips were grossly unstable, and one had fixed dislocation. There were five hips with previous arthritis (4 Tönnis grade-II, and one Tönnis-III). Radiographic evaluation included pre- and postoperative lateral (LCEA) and anterior (ACEA) center-edge angle, Tönnis angle (TA), and posterior wall index (PWI). The modified Harris Hip Score (HHS) was used at final follow-up to assess hip pain and function. The failure criterion was the requirement of total hip arthroplasty (THA) or arthrodesis. Average follow-up was 11.6±5.8 years (4.3-24 years).

Results: At the final follow-up, 19 hips (73%) were asymptomatic, and the mean HHS was 85±16.3. There was a significant radiographic improvement, with a mean increase of 34.0±13.1º on LCEA ($p<0.0001$); 37.6±18.7º on ACEA ($p<0.0001$), 0.42±0.35 on PWI ($p<0.0001$), while the TA showed a decrease of 23.0±9.4º ($p<0.0001$). There was no significant arthritis progression ($p=0.132$, Table I). Four patients (six hips) underwent varus shortening derotational femoral osteotomy (VDRO) simultaneously to PAO, and another two patients underwent further VDRO because of postoperative instability. Three hips had required THA (6.7, 13.5, and 15.1 years following PAO). One hip required arthrodesis for a total of four failures (15%), which were associated with preoperative lower LCEA (-22.3±11.7º vs. -0.1±9.0º, $p<0.001$), higher TA (37.3±5.0º vs. 25.1±8.9º, $p=0.048$), higher age at surgery (20.9±7.4 vs. 15.4±3.7 years, $p=0.03$), and previous arthritis ($p=0.006$).

Conclusion: After a mean follow-up of 11.6 years after PAO, 73% of hips were stable and asymptomatic, and the general radiographic aspect showed significantly improvement. Age, severity of dysplasia and arthri-

Table 1. Progression in Tönnis grade of arthritis (number of hips, p=0.132)



tis grade were identified as factors associated with failure.

Significance: In selected Down syndrome patients with hip instability and dysplasia, PAO provides complete redirection of the acetabulum with relative low rate of major complication and preserved function.

Clinical Outcomes of Periacetabular Acetabular Osteotomy Outcomes at Mid-term? A Prospective Multi-center Cohort Study

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LOE–Prognostic–Level III

Purpose: Current literature describing the periacetabular osteotomy (PAO) is limited to single-surgeon, retrospective case series reporting on initial surgeon experiences. Larger, prospective cohort studies are needed to provide improved clinical evidence regarding clinical outcomes, predictors of outcomes and failure rates for contemporary PAO surgery. The purposes of this study is: 1) to report minimum four year patient reported outcomes (pain, hip function, activity, overall health, and quality of life), and 2) report the incidence of early failures and reoperations in patients undergoing contemporary PAO surgery for the treatment of symptomatic acetabular dysplasia.

Methods: A large prospective, multicenter cohort of PAO procedures with comprehensive data collection was established and analyzed at a minimum 4 years. 201 hips were included for analysis. Seventy-eight percent of patients were female and the average age was 25.7 years. Patient reported outcomes, conversion to total hip replacement, reoperations and major complications were documented. Paired t-test was used to assess pre and post PAO clinical outcomes. Variables with $p \leq 0.05$ (95% CI) were considered significant.

Results: At an average of 5.2 years follow-up (range 4.4 to 8.1 years) clinical outcome analysis demonstrated major clinically important improvements in the WOMAC subscores of pain $p<0.001$, function $p<0.001$, stiffness, $p< 0.001$ and total $p<0.001$, in addition to modified Harris Hip, $p<0.001$, UCLA, $p= 0.006$, and SF-12 physical $p= 0.005$. There was no significance in SF12 QOL $p=0.8064$. One hips underwent early conversion to THA, 3 (2%) required reoperation and 7 (4%) had a major complication.

Conclusion: This large, prospective cohort study demonstrates the generalizability and clinical effectiveness of contemporary PAO surgery for the treatment of symptomatic acetabular dysplasia at minimum 4 years follow-up post PAO.

Significance: In well-selected patients treated with sound surgical technique, favorable clinical outcomes are expected and the early failure/reoperation rates are low. Continued expansion and follow-up of PAO cohorts will provide high level clinical evidence to further refine and optimize this powerful hip preservation procedure.

What is the Impact of PAO Surgery on Patient Function and Activity Levels?

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LOE–Therapeutic–Level IV

Purpose: Because of its effectiveness in relieving pain and improving function in the dysplastic hip, the Bernese periacetabular osteotomy (PAO) is becoming a more widely utilized procedure worldwide. These patients are typically younger, highly active, and may desire return to sport activity. However, counseling and managing expectations in these patients is challenging because there is limited information regarding activity level after PAO surgery. The purpose of this study was to analyze physical activity levels after PAO in a large, prospective multicenter cohort.

Methods: Assessment of prospectively collected data from a multicenter study group included 456 hips treated by PAO for hip dysplasia between 2008 and 2010. After exclusions, 359 hips (80 male, 279 female) remained with a mean age of 25.9 years and mean BMI of 25. Patient demographics, radiographic measures, and clinical outcomes were evaluated preoperatively, at 1 year, and at minimum 2 years postoperatively (mean, 44.9 months). Activity level was assessed with the University of California-Los Angeles (UCLA) activity score, and patients were stratified into low activity, moderate activity, and high activity groups based on preoperative function. Descriptive statistics and linear regressions were performed for the primary outcome of change in UCLA score.

Results: Compared to preoperative scores across the complete cohort, postoperative UCLA scores were improved on average 0.6 points at final follow up ($p = 0.001$). When stratified, the low activity and moderate activity groups had significant improvement in UCLA scores ($p < .0001$ and $p=0007$) while the high activity group saw a decrease in UCLA scores ($p<.0001$). mHHS, HOOS Pain, and HOOS Sports and Recreation scores were significantly improved across all activity levels. Univariable linear regression analysis identified prior ipsilateral surgery, arthroscopy at time of PAO, and preoperative ACEA to be predictors of the change in UCLA score ($p < 0.05$). With the multivariable model, the effect of prior ispilateral surgery was maintained ($p = 0.002$).

Table 1: Preoperative UCLA Group Demographics

	UCLA 1-4	UCLA 5-8	UCLA 9-10
n	93	147	119
M	18	26	36
F	75	121	83
Caucasian %	86%	90%	90%
Age (SD), y	26.2 (9.5)	28.8 (8.7)	22.1 (8.0)
BMI	26.1 (5.3)	25.3 (4.7)	23.7 (4.3)
Average preop UCLA score	3.5 (0.7)	6.5 (1.1)	9.7 (0.5)
Average postop UCLA score	6.5 (2.2)	7.1 (2.0)	8.3 (1.8)
Average delta(UCLA)	3	0.6	-1.4
p-value	<0.0001	0.0007	<0.0001

Conclusion: Overall, these data suggest that consistent improvements in activity level and function can be expected following PAO surgery.

Significance: with greater gains experienced by patients with lower preoperative level of activity.

Determining Hinge Abduction in LCPD: Can We Confidently Make the Diagnosis?

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LOE–Diagnostic–Level V

Purpose: The purpose of this study was threefold: (1) test the inter- and intra-observer reliability of the current definition of hinge abduction, (2) provide new criteria to aid in the definition of hinge abduction and re-test the reliability and (3) explore key elements which aid in the diagnosis of hinge abduction.

Methods: Four orthopedic surgeons from different centers with subspecialty pediatric hip interest (7-40 years of experience) independently assessed thirty cases of de-identified radiographs of children with LCPD. Each case included two fluoroscopic images of hip arthrograms (anteroposterior and abduction views), which were randomly ordered by a blinded research assistant for each assessment. The surgeons initially graded the radiographs in a binary fashion (hinge/no–hinge) on two separate occasions separated by a 4-week interval. Following reliability testing and a comprehensive review of the literature on this topic, consensus-building sessions involving all surgeons were conducted to develop an improved definition focusing on key diagnostic features. Surgeons then re-graded a new series of cases following the above protocol. Inter- and intraobserver reliability between first and second and third and fourth readings were assessed using Fleiss' kappa.

Results: Interobserver kappa values for hinge abduction between the first and second surveys were 0.52 (with 0.41-0.60 considered moderate agreement), compared to 0.56 for the third and fourth surveys. First and second reading intraobserver agreement was 0.72 (range 0.59-0.83) compared to 0.85 (range 0.75-1.00) for third and fourth reading. Our consensus sessions identified several key factors in diagnosing hinge abduction including: adequate visualization of the labral contour and ability of the lateral epiphysis to slip below the chondro-labral complex in abduction. Medial dye pooling, often due to asphericity of the femoral head, was not found to be as useful.

Conclusion: Despite a combined experience over 70 years amongst the reviewers, we found only modest agreement in what constitutes hinge abduction, with results slightly more consistent than 50:50 agreement (similar to a coin flip). Consensus discussions did improve our agreement but these modest changes emphasize how difficult it is to develop reliable diagnostic criteria for hinge abduction.

Significance: Accurate, consistent definition of hinge abduction is challenging. Visualization of lateral epiphysis sliding under the chondrolabral complex may be a more reliable diagnostic criterion than presence and size of the medial dye pool. We caution against using hinge abduction as an inclusion criteria or outcome measure for research purposes, as the diagnostic agreement can be inconsistent.

Triple Innominate Osteotomy versus Shelf Acetabuloplasty for Legg-Calvè-Perthes Hips Presented in the Transitional Stage

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LOE–Therapeutic–Level III

Purpose: Some children with severe Legg-Calvè-Perthes disease present late in the transitional stage (late fragmentation to early reossification stage), with an already collapsed and deformed femoral head. Triple innominate osteotomy (TIO) and shelf acetabuloplasty (SA) have been selectively performed as containment surgery for hips with 'reducible subluxation' presented in the transitional stage. The purpose of this study was to assess hip remodeling after TIO in comparison with SA for hips with 'reducible subluxation'.

Methods: Twenty hips treated with TIO and 18 hips treated with SA, which were followed more than 2 years were subjected to the study. Thirteen hips were in Joseph stage IIb and 7 in stage IIIa in TIO group, whereas 11 hips were in stage IIb and 7 in stage IIIa in SA group. The mean age at surgery was 7.8 years (5.1 to 10.8) in TIO group and 8.8 years (7.1 to 10.3) in SA group ($p > 0.05$). The mean duration of follow-up was 5.1 ±1.7 years in TIO group and 9.1 ± 3.0 years in SA group. Various radiological parameters determining remodeling of the acetabulum and femoral head were compared.

Results: One hip was lateral pillar B/C border and 19 C in TIO group, and 1 hip was B, 5 B/C border, and 12 C in SA group ($p=0.046$). Preoperatively, head sphericity index, Sharp angle, Tőnnis angle, center-edge angle, and center-head distance discrepancy (CHDD) were not significantly different between the groups. At the latest follow-up, there were 5 Stulberg class II, 13 class III, and 2 class IV in TIO group, whereas there were 5 class II, 9 class III, and 4 class IV in SA group. Mose sphericity index was 3.5 ± 1.7mm in TIO group but 4.8 ± 1.9mm in SA group ($p=0.033$). Sharp angle and Tőnnis angle were significantly smaller with larger center-edge angle in TIO group. On preoperative arthrogram, epiphyseal extrusion index was more severe in TIO group (0.42 ± 0.05) compared to SA group (0.38 ± 0.05) ($p=0.019$). However, it showed better improvement in TIO group (0.17 ± 0.06) compared to SA group (0.28 ±0.09) ($p < 0.001$). Head sphericity index, sphericity deviation score, extent of head enlargement, articulo-trochanteric distance, alpha angle, and CHDD were not significantly different.

Conclusion: TIO provides better hip remodeling compared to SA for hips presented in the transitional stage.

Significance: This is the first study extensively evaluating the radiological outcomes after TIO versus SA for hips with 'reducible subluxation'.

Can Epiphyseal Unstable SCFE Be Reduced by Closed Reduction with Minimal AVN?

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LOE–Therapeutic–Level III

Purpose: Slipped capital femoral epiphysis (SCFE) evokes pathoanatomical changes to the proximal femur, which can lead to osteoarthritis (OA). As femoroacetabular impingment (FAI) and/or avascular necrosis (AVN) of the capital epiphysis are primary causes of OA, the goal of treatment algorithms is to reduce the residual deformity while also avoiding AVN. Paradoxically, the vascular anatomy of the proximal femur creates a technically challenging scenario in which procedures that address FAI may damage the lateral epiphyseal vessels leading to iatrogenic AVN. In the initial treatment of SCFE AVN most commonly occurs in 'unstable' SCFE most notably when the epiphysis is mobile relative to the metaphysis. In the epiphyseal unstable SCFE treated with closed pinning, it is suggested to limit reduction to either 'incidental' or 'gentle'. However, the objective epiphyseal correction that reduces the risk of OA without causing AVN is unknown. Given that previous studies with long-term follow-up indicate a Southwick slip-angle (SWA) of less than 35 degrees confers low-risk for OA, the purpose of this work is to determine if purposeful reduction of epiphyseal unstable SCFE reaches a goal SWA of < 35 degrees and the associated risk of AVN.

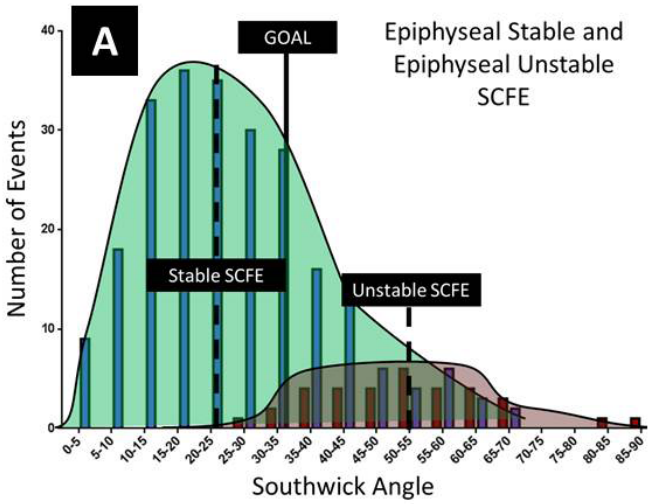
Methods: 277 consecutive cases of slipped capital femoral epiphysis treated closed were identified (1/2007-4/2016). A change in SWA>15 degrees and/or patients with Loder-unstable slips and a reduction noted in the operative report were classified as epiphyseal unstable all other patients were considered stable. Osteonecrosis was determined by postoperative radiographs (Ficat II-IV).

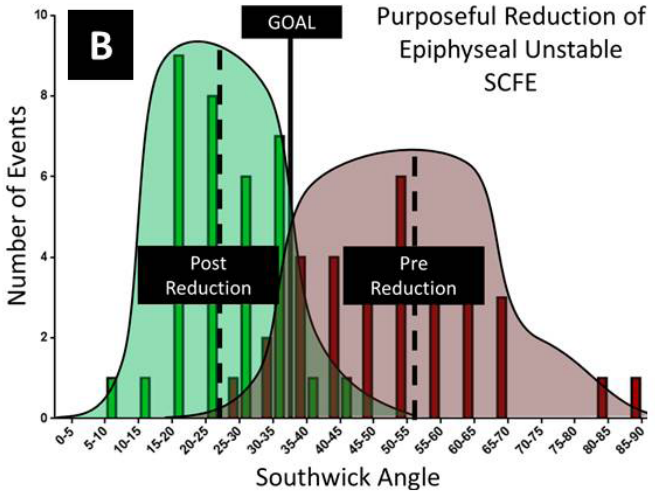
Results: In this cohort (**see table for detailed results**), stable SCFE occurred roughly 10:1 to unstable SCFE (**FIGURE A**). The overall AVN was 1.1% and post-SWA (23.5) was less than the goal of 35. The pre-SWA for unstable SCFEs (**FIGURE B**) (51.0+/-14.8) was significantly greater than the goal SWA of 35 and 34/38 were purposefully reduced below the threshold to (25.3+/-8.2). All 3 cases of AVN occurred in the purposefully reduced epiphyseal unstable SCFEs (7.9%).

Conclusion: The greater majority (>80%) of patients with SCFE have a SWA less than that predictive of impending OA with minimal risk of AVN. Epiphyseal unstable SCFE may be treated with purposeful closed reduction to SWA < 35 degrees safely with a low AVN rate.

Significance: Purposeful closed reduction of epiphyseal unstable SCFE to SWA less than that predictive of impending OA can result in AVN rates less than that reported for open capital realignment and equal to anterior open reduction.

	Total	Unstable	Stable
n	277	38	239
Number of AVN	3 (1.1%)	3 (7.9%)	0
Average Final SWA	23.5 (σ=12.9)	25.3 (σ=8.2)	23.2 (σ=13.5)
Post SW<35 degrees	229 (82.7%)	34 (89.5%)	195 (81.5%)
Average Delta SWA	3.9 (σ=11.0)	25.8 (σ=11.5)	.42 (σ=5.6)
Age (years)	12.1	12.7	12
Follow Up (days)	412	360	418
Weight (kg)	70.4	69.8	70.4





A Nationwide 23-Year Cohort Study of Slipped Capital Femoral Epiphysis in the United Kingdom

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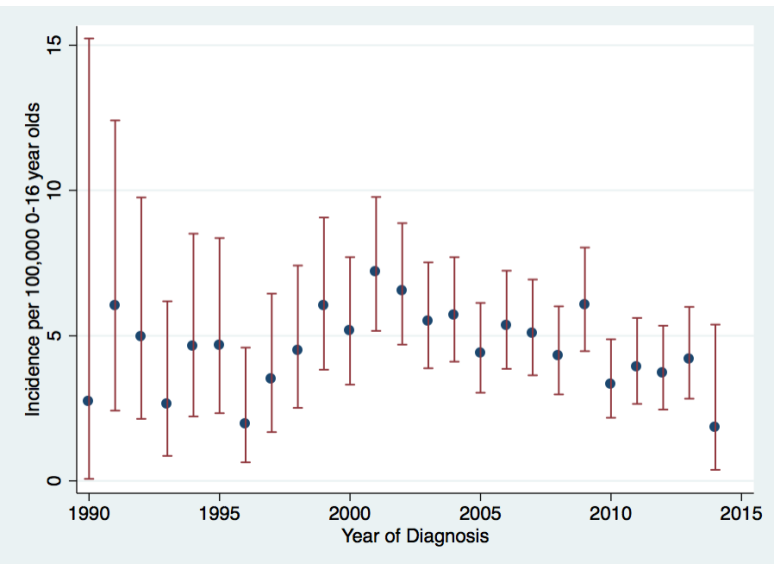
LOE–Prognostic–Level II

Purpose: To describe the epidemiology of Slipped Capital Femoral Epiphysis (SCFE) in the UK, specifically examine associations with childhood obesity and socioeconomic deprivation, and to explore factors associated with diagnostic delays.

Methods: Historic cohort study using linked primary and secondary care data from the Clinical Practice Research Datalink (CPRD) and Hospital Episode Statistics (HES). CPRD is the world's largest database of primary care, and is widely considered as the "gold-standard" dataset in epidemiology owing to the quality of the research data. CPRD includes 650 primary care practices in the UK, equating to 8% of the UK population. It includes the longitudinal medical records of participants from 1990 onwards. Individuals <16 years old with a diagnostic record of SCFE in their electronic medical records were included.

Results: Over the 23-year period from 1990 – 2013, the incidence of SCFE remained constant at 4.8 (95% CI 4.4 to 5.2) cases per 100,000 0-16 year olds. There was a strong association with socioeconomic deprivation. Pre-morbid obesity was also strongly associated with SCFE; mean pre-morbid z-score 1.43 (95%CI 1.20 to 1.68) compared to the UK reference mean. Diagnostic delays were common with most children (75.4%) having multiple primary care contacts with relevant symptomatology, and those that presented with knee pain having significantly longer diagnostic delay (median 161 [IQR 27-278] days) than those with hip pain (20 [5-126]) or gait abnormalities (21 [7-72]).



Conclusion: This is the first population cohort to describe the epidemiology of SCFE. SCFE has a strong association with both area-level socioeconomic deprivation and pre-morbid obesity. The majority of patients with SCFE are initially misdiagnosed and those presenting with knee pain are particularly at risk in the primary care setting.

Significance: In a nationwide cohort, pre-morbid obesity was strongly associated with the development of SCFE. Children presenting primarily with knee pain frequently had marked delays to diagnosis. The national trends in incidence did not concord with the widely held belief that the incidence of SCFE is increasing.

Previous Hip Arthroscopy is Associated with Inferior Early Functional Outcomes after Periacetabular Osteotomy for Acetabular Dysplasia

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LOE–Therapeutic–Level III

Purpose: Many patients with acetabular dysplasia present to tertiary hip centers with history of prior hip surgery, however, the effect of prior hip arthroscopy on functional outcomes after subsequent periacetabular osteotomy (PAO) is unknown.
The purpose of our study is to describe early hip specific functional outcomes in patients treated with PAO after failed previous hip arthroscopy.

Methods: A retrospective cohort study design was utilized. Patients were enrolled from a single center, prospective hip preservation registry. Patients with a minimum of 1 year clinical follow up with preoperative and postoperative outcome scores undergoing PAO were eligible for inclusion (patients, hips) [N=93 patients; mean clinical follow up 24 months [range 11 -58]. The study group consisted of patients undergoing PAO for symptomatic hip dysplasia after prior hip arthroscopy (PREVSCOPE) (22 patients, 25 hips). Patients undergoing PAO without prior hip arthroscopy (PAOALONE) (71 patients, 85 hips) were included as a comparison group. Demographic and radiological variables were recorded. Postoperative functional outcome scores [modified Harris Hip Score (HHS), Hip Outcome Score (HOS), and International Hip Outcome Tool (iHOT-33)] were recorded at 6 months and annually post-operatively.

Results: There were no demographic differences between the two groups at baseline. Preoperative CT scan showed decreased alpha angles in the PREVSCOPE relative to PAOALONE group (median[1st quartile, 3rd quartile] 43°[37,52] versus 55°[47, 63]; p = 0.02). Acetabular version, femoral version, Tonnis grade, preoperative LCEA, and intraoperative procedures performed were not different between the two groups. At 1 year follow up from last hip surgery, mHHS (mean [standard deviation SD]: 73[14] PREVSCOPE versus 86[14] PAOALONE; adjusted difference in means [95% CI]: -13[-20, -7]; p<0.001), HOS ADL (mean [SD]: 84[12] PREVSCOPE versus 93[11] PAOALONE; adjusted difference in means [95% CI]: -9[-15, -2]; p=0.007), HOS Sport (mean [SD]: 62[25] PREVSCOPE versus 85 [18] PAOALONE; adjusted difference in means [95% CI]: -22[-33, -11]; p<0.001), and iHOT (mean [SD]: 62[21] PREVSCOPE versus 79[20] PAOALONE; adjusted difference in means [95% CI]: -16[-27, -5]; p=0.004) were decreased in the PREVSCOPE versus PAOALONE groups. At last follow up, mHHS and HOS Sport were lower in the PREVSCOPE versus PAOALONE group. There was no difference in complication or reoperation rates between the two groups.

Conclusion: Failed previous hip arthroscopy prior to PAO for symptomatic hip dysplasia is associated with inferior hip specific functional outcomes at early follow up despite similar baseline demographic and radiological characteristics.

Significance: Previous hip arthroscopy may slow or reduce recovery in functional outcome scores after PAO.

Outcomes of Hip Arthroscopy in Adolescents: A Comparison of Acute versus Chronic Labral Tears. Two Year Minimum Follow-Up

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LOE–Prognostic–Level II

Purpose: The purpose of this study was to ascertain whether outcomes of hip arthroscopy in patients <18 years old being treated for labral tears differ depending on whether the presentation was acute or chronic. We also present the outcomes of the largest prospectively collected study on hip arthroscopy performed for labral tears in adolescent patients.

Methods: Data were prospectively collected for patients that underwent hip arthroscopy between April 2008 and December 2013. Patients <18 years old, treated for labral tears, and eligible for 2-year follow-up were included in the cohort, with those that had Tonnis >0, revision surgeries, and previous hip conditions excluded. The PROs collected were: modified Harris hip score (mHHS), Non-arthritic hip score (NAHS), Hip Outcome Score-Sport Specific Scale (HOS-SSS) and Visual Analogue Score (VAS). The overall cohort was assessed for outcomes and a comparison was made between patients who presented acutely and those who present in a delayed fashion. Pre-operative and post-operative PROs and ΔPROs between chronic and acute groups were analyzed.

Results: A total of 194 patients met all the inclusion and exclusion criteria, with 157 (80%) having minimum 2-year follow-up. There was significant improvement in all of the PROs for the overall cohort, with an average follow-up of 36.9 months. The only significant differences between the acute and chronic groups found were lower pre-operative PROs and greater change in VAS for the acute group. Overall need for revision surgery was 12%, with a significantly higher rate of revision in the acute group (29%) compared to the chronic group (7.6%).

Conclusion: Hip arthroscopy in adolescent patients being treated for labral tears is safe and effective at 2 year follow-up. While preoperative PRO scores were lower in patients presenting acutely, there were no significant differences in final PRO scores; however, reoperation rate was significantly higher in patients with an acute presentation.

Significance: To our knowledge, this is the largest outcome based study on patients under 18 years of age who have been treated for labral tears with hip arthroscopy. There is increasing evidence that hip arthroscopy has been successfully utilized in managing pediatric and adolescent hip pathology. Our study emphasizes that adolescent patients treated arthroscopically for labral tears can expect significant improvement, whether or not their symptoms are of sudden onset or develop more insidiously.

Congenital Pseudarthrosis of the Clavicle: Outcomes Following Surgical and Nonsurgical Management

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LOE–Therapeutic–Level III

Purpose: Congenital pseudarthrosis of the clavicle (CPC) is a rare entity in which the primary ossification center of the clavicle fails to coalesce, typically resulting in painless swelling in the clavicle region. The purpose of this study was to investigate whether surgical or nonsurgical treatment is superior for this condition.

Methods: A retrospective review of 50 pediatric patients treated for CPC was performed to analyze patient demographics, clinical presentation, radiographs, postoperative course, and surgical outcomes. Patient reported outcome measurements were collected prospectively including the Quick Disabilities of the Arm and Shoulder (QuickDASH) survey and the Patient Reported Outcomes Measurement Information System (PROMIS) upper extremity, pain, and peer relationships domains. These were used to assess overall patient satisfaction, function, and quality of life.

Results: The majority of patients presented with an asymptomatic clavicular bump, however 8 (16%) patients presented with clavicle pain and 2 (4%) patients had limited range of shoulder motion, one of which also had pain. Twenty-four of 50 patients underwent surgical treatment. In the 9 patients who underwent surgery at less than 18 months of age, suture fixation alone was used, whereas the 15 older patients were treated with plate fixation. All surgical patients had resolution of preoperative symptoms including pain and limited range of motion, when present. Four surgical patients had nonunion: three were in the younger cohort treated with suture fixation; the fourth underwent internal fixation with a plate at 9 years old. One patient had postoperative infection which resolved with surgical debridement with implant removal. Twenty-six patients were managed without surgery, seven of which had follow up of at least 6 months. At a mean follow up time of 1.5 years these patients continued to be asymptomatic. A total of 18 patients (11 surgical, 7 non-surgical) responded to the survey. The median overall satisfaction was higher in the operative cohort compared to the nonoperative cohort (operative=10, nonoperative=9, $p<0.05$). Upper extremity function according to the QuickDASH survey was similarly better in the operative cohort (operative=0, nonoperative=4.6, $p<0.05$). The PROMIS domains did not detect a difference between the operative and nonoperative cohorts.

Conclusion: All surgical patients had resolution of preoperative symptoms. Patients who were treated surgically had superior overall satisfaction and upper extremity function compared to the nonoperative cohort.

Significance: This large series of CPC patients improves our understanding of the treatment options and outcomes of both surgical and non-surgical treatment.

Poland Syndrome: Approach to a New Classification. Association with Final Functional Results and Number of Surgeries

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LOE–Prognostic–Level IV

Purpose: The first purpose of this study was to propose a new classification for hand anomalies in patients affected from Poland's syndrome. It aims to be more simple, useful, reproducible and reliable to plan surgical management of hand anomalies.
The second purpose is to find any statistically significant association between this new classification and final functional results (TADA score) and/or number of surgeries.

Methods: Patients affected from Poland syndrome who required some follow up at our Congenital Malformations Unit were reviewed retrospectively.
The period of time was from January 1990 to December 2015. A total of 74 patients were included in the study.
The collected variables were: sex, side, alterations during pregnancy, prenatal diagnosis, type of hand and upper extremity malformation, number and type of surgeries and TADA functional score.
The new proposed classification is based on clinical evaluation of the upper extremity and radiological images. Hands are distributed in six groups:

Type 0 – Isolated pectoralis major aplasia without upper limb affectation.
Type 1 – Hypoplastic hand without syndactyly.
Type 2 – Hypoplastic hand associated to syndactyly and hypoplastic or aplastic middle phalanx.
Type 3 – Syndactyly is complete and affects the thumb associated to an hypoplasia/aplasia of thenar muscles.
Type 4 – Syndactyly is associated to longitudinal deficiency of some digits or metacarpals (partial or complete).
Type 5 – Transversal amputation from metacarpal level to complete aplasia of the hand.

Results: Poland hand types 0, 1 and 2 were the most prevalent ones in our study.
There was not any type 5.
Right side was the most commonly affected, up to 67%.
Thumb affectation (mainly first web narrowing) was present in 27% in our case series. Metacarpal alterations (aplasia or hypoplasia) affected 19% of patients.
There was a statistically significant association between an increasing number of required surgeries and greater types of the proposed classification, so that,

with severity of hand affectation (p<0'001).
Also, statistical analysis put into evidence a greater incidence of worse final functional results in patients affected from greater types of classification (p<0'001).

Conclusion: This is the second largest series of Poland Syndrome ever described and focused, exclusively, in hand management.
This proposed classification provides a simplified form of clinical evaluation, with a logical progressive increase in clinical and functional impairment.

Significance: According to statistical analysis, it offers a clear therapeutic application as it helps to predict the approximate required number of surgeries, as well as final functional results.

Aetiology of Hand Clawing in MPS Children

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LOE–Prognostic–Level IV

Purpose: Mucopolysarcoidosis (MPS) is a group of congenital metabolic conditions resulting in glycosaminoglycans in the soft tissues causing many children develop progressive hand deformities and dysfunction. Much attention is paid to development of carpal tunnel syndrome but we hypothesize that triggering of digits is a major cause of loss of function. The aim of this study was to assessed the incidence and pattern of triggering in this patient group.

Methods: Between 2013 and 2016, 21 MPS patients were referred to the hand clinic and were assessed for causes of upper limb dysfunction. Type of MPS was documented, tourniquet time, associated procedures undertaken and intraoperative findings.

Results: 73 digits in 11 patients had signs of progressive clawing and restricted hand function due to triggering of the long finger flexors and required surgical release. The index, middle and ring fingers were each involved in 28% of cases, the little finger 16% and the thumb 0%.
Whereas previous reports suggest the A1 pulley or flexor retinaculum is the location of triggering, we only found this in 13% of cases, with the vast majority (87%) occurring at the level of the A3 pulley. Restoration of full movement was achieved after surgical release at this level.

Conclusion: Nodules in the long finger flexors at the level of the A3 pulley inhibits both flexion and extension and is a significant cause of loss of hand function in these patients. Despite being the most common site of triggering and being easily amenable to surgery, it has not been previously reported. We recommend routine assessment in these patients and surgical release if hand function is inhibited.

Significance: This study highlights the need to consider the A3 pulley as a cause for triggering in the MPS population.

Lengthening with Monolateral External Fixation versus Intramedullary Nail in Congenital Femoral Deficiency

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LOE–Therapeutic–Level III

Purpose: Limb lengthening is an established treatment for mild/moderate congenital femoral deficiency (CFD) and fibular hemimelia (FH) cases. External, internal, and hybrid fixation have been described for CFD. Our aim was to determine the outcomes and complications of lengthening with monolateral external fixation or magnetically-driven intramedullary nails in patients with CFD.

Methods: Medical records of 62 patients (62 femora) with CFD (some with concurrent FH) were retrospectively reviewed. All underwent femoral lengthening: 32 patients had monolateral external fixation (Group A) and 30 patients had internal lengthening nails (Group B). Mean age for Group A was 9.4±3.8 years and for Group B was 15.4±4.9 years. Mean follow-up was 4.5±2.7 years for Group A and 1.9±0.7 years for Group B.

Results: Mean lengthening achieved was 5.6±1.7 cm for Group A and 4.8±1.4 cm for Group B ($p=0.05$). Mean distraction index was 0.7±0.2 mm/day for Group A and 0.7±0.2 mm/day for Group B ($p=1.00$). Mean consolidation index for Group A was 29.3±12.7 day/cm and 34.8±11.2 day/cm for Group B ($p=0.08$). Mean arc of motion for Group A was 1º±2º to 123º±12º before surgery, -1º±4º to 70º±30º at completion of distraction, and 1º±5º to 81º±30º after consolidation. Mean arc of motion for Group B was 1º±3º to 128º±23º before surgery, 1º±3º to 96º±28º at completion of distraction, and 0º±2º to 122º±23º after consolidation. While preoperative flexion was similar between both groups ($p = 0.35$), Group A had significantly less range of motion at the end of distraction ($p = 0.0007$) and at final follow-up ($p < 0.0001$) than Group B. Obstacle and complication rates were similar for both groups, but Group A had a 63% problem rate while Group B had a 23% problem rate ($p=0.004$).

Conclusion: When compared with limbs treated with monolateral external fixation, limbs treated with the intramedullary lengthening nails had superior final range of motion, lower rate of problems, and similar distraction and healing indices. Internal lengthening nails appear to represent a substantial improvement in treatment.

Significance: The intramedullary lengthening nail system represents a noted improvement in treatment modalities of this complex disorder. One downside is the inability to hinge across the knee to prevent subluxation. Therefore, preoperative knee reconstruction must be performed as needed and postoperative bracing protocols must be followed.

Does the Lateral Malleolus Reconstruction Provide a Stable Ankle Joint in Patients with Fibular Hemimelia?

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LOE–Therapeutic–Level IV

Purpose: One of the most challenging and frequent aspects in the fibular hemimelia (FH) management is to overcome ankle joint instability. Among methods used to restore the function of the ankle joint, early reconstruction with the use of the fibular anlage as the free graft for lateral malleolus restoration has been reported. This study was done to assess whether modified El-Tayeby ankle reconstruction significantly improves the ankle stability in patients with the FH.

Methods: Twelve patients classified as type II Acherman-Kalamchi and type III Paley FH who have undergone the lateral malleolus reconstruction, have been evaluated in terms of ankle stability in weight bearing, clinical position of the foot and radiological position of the ankle joint with the use of LDTA angle. The mean follow-up time in these patients reached 2,5 years. Only patients who were operated over 24 months prior to the final follow-up were included into the study.
The modified El-Tayeby surgical procedure consisted of the postero-lateral release of the ankle joint, achilles and peroneal tendons lengthening, resection of the fibrous part of the anlage and lateral malleolus reconstruction with the use of the released bony-cartilaginous part of the fibular anlage transfixed to the tibia and the talus. Additionally supramalleolar and diaphyseal osteotomies of the tibia were done where needed to address the deformity correction. Six patients underwent lengthening procedure with the ankle transfixation one year post reconstruction.

Results: In all 12 cases stable ankle in neutral position with its lateral ankle support in standing position was achieved and maintained until the last check-up. There were no signs of ankle instability in any of the assessed subjects while standing. The mean LDTA was 86°– in 10 out of 12 the LDTA was considered anatomical. All of the ankle joints remained stable, after the lengthening procedure likewise. Additionally none of the patients presented persistent ailments nor any other complications.

Conclusion: Ankle joint reconstruction with lateral malleolus grafting in complete ab-

sence of the fibula allows achieving clinically and radiologically stable ankle joint before and during lengthening procedures.

Significance: This study supports the idea of adding the procedure of the lateral malleolus restoration to the ankle joint reconstruction to enhance the stability of the ankle joint in patients with fibular deficiency. Achieving and maintaining the proper alignment of the ankle joint in this deformity has tremendous impact on the clinical final outcome of its complex treatment.

Amputation versus Limb Reconstruction for Fibula Hemimelia: A Systemic Review and Meta-Analysis

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LOE–Therapeutic–Level III

Purpose: Fibula hemimelia is the most common congenital deficiency of the long bone that results in a clinical spectrum from complete absence of the limb to a missing toe. Primary treatment options include amputation with prosthetic fitting or limb reconstruction. The aim of our study was to systematically review the literature that compares amputation to limb reconstruction of fibula hemimelia.

Methods: We searched several databases from 1952 to 2016 for any observational or experimental studies that evaluated amputation versus limb reconstruction for fibula hemimelia. We performed a meta-analysis to pool odds ratios (ORs) for a comparison of patient satisfaction and surgical complications between patients undergoing amputation versus limb reconstruction. Descriptive, quantitative, and qualitative data were extracted.

Results: Of the 25 articles identified, 6 studies (retrospective cohort studies) were eligible for the meta-analysis, encompassing a total of 169 fibula hemimelia. The pooled odds ratio (OR = 6.82) for patient satisfaction between amputation and limb reconstruction was in favour of amputation and statistically significant (95% CI: 2.09, 22.20; p = 0.906, I2 = 0%). Furthermore, a significant difference in the rate of surgical complications was detected between the amputation and limb reconstruction groups in favour of limb reconstruction (OR = 21.9, 95% CI: 5.88, 81.56; p < 0.001, I2= 86.1%) despite the significant heterogeneity.

Conclusion: The cumulative evidence at present does indicate a strong association between amputation and better patient satisfaction with less surgical complications for fibula hemimelia.

Significance: Long-term multicenter prospective cohort studies are required to demonstrate the benefits of limb reconstruction in comparison to amputation for fibula hemimelia and answer this question with more certainty and higher level of evidence.

Guided Growth for Genu Valgum in Patients with Skeletal Dysplasias Can Lead to Hip Deterioration

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LOE–Therapeutic–Level IV

Purpose: Guided growth technique is effective and safe method for lower limb axial deformities in children with different pathological conditions including skeletal dysplasias. Specific feature of lower limb deformity in skeletal dysplasia is multilevel involvement. The aim of this study was to assess influence of correction of lower limb axis by guided growth around knee joint on hip anatomy and pathology.

Methods: Retrospective cohort study of 42 patients (77 limbs) with skeletal dysplasias and disostosis treated for valgus knee deformity with guided growth (temporary hemiepyphyseodesis with 8-plates). Standing radiographs of lower limbs and MRI of hip joints were obtained before and after treatment as a part of complex examination.

Results: Central-edge angle improved +8.3±2.7° (p=0.02); extrusion index, neck-shaft angle, acetabular index didn't change significantly. Joint congruency deteriorated in 8 cases (19%). Radiographs demonstrated narrowing of articular space in lateral aspect of the joint (1 or 2 grades according to Yasunaga classification). In 6 of these cases (14%) clinical deterioration was also detected and included hip and groin pain as well as decreased abduction. MRI revealed signs of impingement (high signal intensity within the acetabular labrum, torn labrum, perilabral cyst, cartilage delamination).
Retrospective analysis of radiographs revealed the following preoperative signs which can be assessed as predictive for deterioration: coxa vara with NSA<100° (PV=0.82), articulo-trochanteric distance < 10 mm (PPV=0.91); fair or poor congruency by Yasunaga classification (PV=0.73), type of disorder – rMED (PV=0.82) and COMP-related MED (PV=0.67).

Conclusion: Coxa vara, coxa breva, incongruency of hip joint, diagnosis of recessive and COMP-related multiple epyphyseal dysplasias are predictive factors for hip deterioration after guided growth for genu valgum in patients with skeletal dysplasias.

Significance: Correction of knee deformity in children with skeletal dysplasias should be planned after thorough assessment of hip joint joint to avoid deterioration of the latest. Simultaneous or staged correction of hip deformity is a possible approach in the cases of at-risk.

Congenital Pseudoarthrosis of Tibia (CPT): Comparison of the Effect of Lenghtening Rhythm to the Quality of Callus and Complications

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LOE–Therapeutic–Level III

Purpose: The aim of this study is to evaluate the effect of lenghtening rhythm during distraction osteogenesis to the quality of callus, the long term results and complications.

Methods: In this retrospective cohort study,patients with tibial lenghtening with distraction osteogenesis were calculated to have a median lenghtening speed of 0.61 mm/d and were divided into two groups;patients with a lenghtening speed of 0.678 mm/d (range 0.61-0.77) as being above the median speed as Group 1(14 patients-14 legs);those who had a lenghtening speed of 0.52 mm/d (range 0.32-0.57) with being below the median speed as Group 2(13 patients-13 legs).Group 1 had a mean age of 3.68 at the first operation,a mean follow-up period of 131.14 months and a mean lower extremity limb lenght discrepency (LLD) of 6.18 cm .In Group 2 had a mean age of 3.88 at the first operation,a mean follow-up period of 142.15 months and a mean lower extremity LLD of 5.42 cm.Patients' total amount of lenghtening and amount of residual LLD after lenghtening were compared in addition to the evaluation of the relationship between the lenghtening rthym and callus quality which was assessed according to the Li-classification.Type 1 (fusiform) and type 2 (cylindrical) according to the Li-classification's shape section were considered as callus with good quality.

Results: Group 1 had a mean a lenghtening period-lenght (MLP-L) of 84.64 days-5.74 cm and a mean residual LLD (MRLLD) was 0.43 cm.Group 2 had a MLP-L of 100.92 days-5.13 cm and a MRLLD of 0.29 cm.X-rays taken at the first month of consolidation revealed 4 patients with Type 1(28%) and 3 patents with Type 2(%21) callus in group 1(total rate of callus with good quality(TROCWGQ): %50);9 patients with Type 1(69%) and 2 patents with Type 2(%15) callus in group 2(TROCWGQ: %85)(p=0.003).Callus in group 2 was detected to be morphologically superior to group 1.Total rate of complications was found to be lower in group 2 with a statistical significance.The mean external fixator time-index in group 1 was 215 days-37.5 and 170 days-33.1 in group 2.

Conclusion: The rhythm of lenghtening and its success are still controversial in patients with CPT. Our study showed that patients who underwent distraction osteogenesis below a mean speed of 0.61mm/day had callus with better quality, with lower rates of complications and shorter of external fixator time.

Significance: A median lenghtening rate below 0.61 mm/day was able to yield callus with high quality with successful clinical and radiological results with less complications.

Surgical Treatment of Lower Limbs Deformities in Pseudoachondroplasia: Influence of Post-Operative Residual Knee Joint Obliquity

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LOE–Therapeutic–Level IV

Purpose: Pseudoachondroplasia (PSACH) is a rare osteochondrodysplastic disorder characterized by a short-limb dwarfism. The lower limbs deformity is complexe with a varus or a valgus combined with a distal femoral flessum and a proximal tibial recurvatum. Hyperlaxity is constant and severe, leading to joint instability. The purpose of this study was to evaluate the long term results of surgical correction of lower limbs deformities in PSACH and to specify its indications and terms. The main hypothesis was that surgical correction prevents the knee function degradation. The secondary hypothesis was that post-operative knee joint residual obliquity of the after the first surgery induces the recurrence of the deformity.

Methods: We included 30 patients (59 limbs) in a single-center retrospective study, who had undergone a realignment surgery of the lower limbs between 1975 and 2014 by a single senior surgeon. The mean age at first surgery was 9.2 years old. Varus was more frequent than valgus and most limbs had an obliquity of the joint line. A patellar sub-dislocation was observed in 30% of the patients. Femoral, tibial or combined osteotomies corrected extemporaneously the deformations. They were performed in metaphyseal area, after temporary stabilization of the knee with trans-articular pinning to neutralize hyperlaxity. Transposition of the patellar tendon with release of the lateral retinaculum were performed for 27% of the limbs. Functional, clinical and radiological data were assessed.

Results: Mean follow-up was 16.7 years (up to 42 years). Functional results were satisfying : 100% of the patients reported a benefit (7-point Likert-Scale), the knee function was evaluated at 78,3% (IKDC score). Fourteen limbs (23,8%) had a default of axis after the first surgery (hyper or hypo-correction). The knee joint line was oblique for 64.2% of the limbs after the first surgery. When the joint line was horizontal after the first surgery, the number of limbs with a correct axis was highter than in the opposite case. Furthermore, the number of iterative interventions was lower when the joint line was horizontal. There was no major complication. At last follow-up, 48% of the limbs had no residual angular deformity.

Conclusion: Surgical correction of lower limbs deformities during childhood is efficient and provides good results. The obliquity of the knee joint after surgery increased the risk of recurrence of the deformity.

Significance: Level IV rétrospective study

Best Practices in Peri-Operative Management of Patients with Skeletal Dysplasias

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LOE–Economic and Decision Analyses–Level V

Purpose: Patients with skeletal dysplasia frequently require orthopedic surgery. This patient population has an increased risk for peri-operative complications related to the anatomy of their upper airway, abnormalities of tracheal-bronchial morphology and function; deformity of their chest wall; abnormal mobility of their upper cervical spine; and associated issues with general health and body habitus. Utilizing evidence analysis and expert opinion, this study aims to describe best practices regarding the peri-operative management of patients with skeletal dysplasia.

Methods: A panel of 13 multidisciplinary international experts participated in a Delphi process that included a thorough literature review; a list of 22 possible care recommendations; two rounds of anonymous voting; and a face to face meeting. Those recommendations with more than 80% agreement were considered as consensual.

Results: Consensus was reached to support 19 recommendations for best pre-operative management of patients with skeletal dysplasia. These recommendations include pre-operative pulmonary, polysomnography; cardiac, and neurological evaluations; imaging of the cervical spine; and anesthetic management of patients with a difficult airway for intubation and extubation.

Conclusion: Patients with skeletal dysplasias present unique risks when undergoing general anesthesia. Due to the relative rarity of these conditions, many centers have little or no experience with the pitfalls that may exist when caring for this group. This report intends to outline the best practices in anesthetic care for patients with skeletal dysplasias. In general, a thorough preoperative assessment of cardiac, pulmonary and neurological status is required. Imaging of the spinal column and assessment of airway elements are necessary to avoid catastrophic consequences. Perioperative care should be performed by appropriately experienced personnel who have access to difficult airway equipment.

Significance: Patients with skeletal dysplasia often require orthopedic surgical interventions. The goals of this consensus based best practice guideline are to standardize care, reduce perioperative complications, and improve clinical outcomes for patients with skeletal dysplasia undergoing orthopedic surgery.

Spondylolisthesis is Common, Early and Severe in Loeys-Dietz Syndrome

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LOE–Prognostic–Level IV

Purpose: High Grade spondylolisthesis is uncommon in the general population but may be associated with connective tissue disorders. We studied the prevalence and treatment outcomes of spondylolisthesis and spondylolysis in Loeys-Dietz syndrome (LDS), a connective tissue disorder affecting the musculoskeletal and cardiovascular systems.

Methods: Clinical data and lumbosacral spine imaging of 138 patients with LDS were reviewed. Spondylolisthesis (L4-L5 or L5-S1) and spondylolysis (L4 or L5) were characterized by computed tomography and x-ray correlated to clinical data. Associations were confirmed with use of the Fisher exact test (for genetic mutation) and the Student's t-test (for age at presentation and Meyerding grade). Clinical outcomes were determined through careful medical record analysis.

Results: The prevalence of spondylolisthesis and spondylolysis in patients with LDS were 16.7% and 17.4%, respectively. For patients with spondylolisthesis, mean age at diagnosis of spondylolisthesis was 15.0 years, mean percent slip was 48% and mean slip angle 5.1°. Four patients had L4-5 slip and nineteen had L5-S1 slip. Eleven patients with spondylolisthesis (48%) underwent posterior spinal fusion (PSF), with eight patients 10 years of age or younger at time of surgery. One patient underwent PSF with bone graft fusion alone (no instrumentation) and subsequently developed spondylolisthesis recurrence. The remaining ten patients all underwent PSF with instrumentation and bone graft fusion. Two patients additionally underwent Bohlman interbody fusion. Two patients with instrumentation developed implant failure after the initial surgery (due to rod fracture in one case and pedicle screw migration in the other case). S2 stabilization was required to achieve fusion in these cases. Patients improved significantly by Meyerding grade (3.9 to 1.9) with fusion (p=0.002). No significant associations between LDS type and lumbosacral abnormalities were found.

Age at Diagnosis

Group	No. (%) of occurrences	Mean Age	Std. Dev.
Spondylolisthesis (overall)	23 (16.7)	15	11.8
Spondylolisthesis (non-surgical)	12 (8.7)	21.6	13.0
Spondylolisthesis (surgical)	11 (8.0)	7.3[A]	3.3

Meyerding Classification

Spondylolisthesis Sub-Group	Mean Meyerding Grade	Std. Dev.
Overall	2.5	1.6
Non-Surgical	1.5	1.9
Surgical (pre-operative)	3.9[B]	1.2
Surgical (post-operative)	1.9[C]	1.3

[A] P=0.031 compared to Spondylolisthesis (non-surgical); [B] P=0.0001 compared to Non-Surgical;
[C] P=0.002 compared to Surgical (pre-operative)

Conclusion: High-grade spondylolisthesis, uncommon in the general population, is common in LDS. Many patients with LDS who manifest spondylolysis subsequently develop spondylolisthesis. Those requiring surgery for spondylolisthesis present early in childhood and typically do well with surgery provided instrumentation and bone graft fusion are utilized. Additionally, stabilization of S2 as well as S1 can prevent physeal deformation in this age group.

Significance: Loeys-Dietz syndrome should be considered in patients with high-grade spondylolisthesis. Patients with LDS should be monitored for spondylolisthesis and spondylolysis, starting when they are young.

Outcomes of Orthopedic Surgery in a Cohort of 49 Patients with X-linked Hypophosphatemic Rickets (XLHR)

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LOE–Therapeutic–Level IV

Purpose: XLHR is due to the mutations in the PHEX gene leading to unregulated production of FGF23, hence hypophosphatemia and decreased renal 1,25OH-vitamin D hydroxylation. Amongst other features, XLHR is characterized by leg bowing of variable severity. Phosphate supplements and oral 1,25OH-vitamin D, partially or, in some cases, fully restore the limb straightness. For severe or residual limb deformities, orthopedic surgery may be recommended.
To retrospectively assess the results of surgical limb correction in XLHR children.

Methods: We analysed the relapse incidence and the post-surgical complications in 49 XLHR children (30 females and 19 males) bearing a PHEX mutation (mean age at diagnosis was 5.6 years [± 6.5]) who underwent at least one lower limb surgery.

Results: At first surgery, the mean age was 13.4 years old [± 5.0], 70% of the patients had a genu varum. Except for 3 transient hemi-epiphysiodeses, most surgical corrections were done through osteotomies and bone alignment. 14/49 (29%) of the patients relapsed after the 1st surgery. The age at surgery was inversely correlated with the risk of relapse. The number of additional surgeries significantly decreased with age (2.0 [± 0.9], 1.7 [± 1.0] and 1.2 [± 0.35] in children <11years, between 11 and 15, and >15 years; p<0.001). Above the age of 11 years, patients having a good metabolic control of the rickets (normal alkaline phosphatases) seem to present with a lower incidence of relapse (28% vs 44% in children<11 years).20% of the patients had complications (different from the recurrence of bony deformity) including pseudarthrosis, infection or fractures.

Conclusion: We report here the largest series of surgical procedures in XLHR. Our results confirm that phosphate supplements and vitamin D analogues therapy is the first line of treatment in XLHR to correct the leg bowing. Early surgeries are associated with a high risk of relapse of the limb deformity. Such procedures should be recommended, as a multidisciplinary decision, only in patients with severe distortion leading to mechanical joint and ligaments complications, or for residual deformities once growth plates are fused.

Significance: X-linked hypophosphatemic rickets, osteotomy, PHEX, hemiepiphysiodesis, genu varum, genu valgum

"Next Day" Exam Reduces Radiation Exposure in Cervical Spine Clearance at a Level 1 Pediatric Trauma Center: A Pilot Study

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LOE–Therapeutic–Level IV

Purpose: Cervical spine(C-spine) injuries in pediatric trauma patients present a challenging problem due to their low incidence(1-2%), yet devastating complications. The lack of standardized protocols, unreliable physical examinations, and difficulties in interpreting imaging often lead to further studies such as computed tomography(CT). CT, however, subjects patients to a large amount of radiation exposure and subsequent cancer risk. Our goal is to address these concerns by promoting a C-spine clearance algorithm with the main objective of identifying C-spine injuries while minimizing radiation exposure.

Methods: In October 2012, we revised our original C-spine protocol(2002-2011) in order to improve the process used for C-spine clearance and to guide indications for imaging. This protocol was further revised in 2014 with the specific goal of decreasing unnecessary CT scans through repeat, "next day" physical exams and increasing involvement of the Spine Service to clear C-spines. A retrospective review of the trauma database was performed on patients evaluated for C-spine injury from 2011-2014. Key data points collected along with others included age, arrival date, radiologic studies, discipline that cleared C-collar, missed or delayed injury, time to removal of C-collar, and length of stay. The data was broken down into 3 groups for analysis: patients evaluated under the original protocol, those evaluated under the 2012 protocol, and those evaluated under the 2014 protocol.

Results: A total of 762 patients were included during the study period; 259 were evaluated under the original protocol, 360 under the 2012 protocol, and 143 under the 2014 protocol. The average age of all patients was 8.8 years, with 28% being younger than 5 years**.** During the entire study period, no missed or delayed diagnoses of C-spine injury were identified. CT scan use decreased from 90%(original protocol), to 42%(2012 protocol), to 28.7%(2014 protocol). Additionally, there was an increase in time to C-collar removal at 13-24 hrs from 8%(original protocol) to 22%(2012 protocol) to 19%(2014 protocol). However, this did not increase length of stay, with averages being 2.51 days(original protocol), 2.45 days(2012 protocol), and 2.27 days(2014 protocol).

Conclusion: Repeat, "next day" clinical examinations and increased involvement of the Spine Service decreased radiation exposure without compromising the diagnosis of C-spine injury or increasing length of stay at a Level One Pediatric Trauma Center in this pilot study.

Significance: A pediatric C-spine clearance protocol that emphasizes repeat, "next day" clinical exams and Spine Service involvement may reduce radiation exposure without increasing the missed injury rate or length of stay.

Operative Treatment of Cervical Spine Injuries Sustained During Youth Sports

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LOE–Therapeutic–Level IV

Purpose: To review the injury characteristics, operative treatment, and outcomes in patients who sustained a significant cervical spine injury during youth sports requiring operative intervention.

Methods: A review of patients treated between 2004 and 2012 at a Level 1 trauma center for a cervical spine injury. Patients were included if they were less than age 18 and sustained a cervical spine injury during sporting activities which required operative treatment. Clinical and radiographic data were collected and statistical analysis was performed.

Results: 329 patients were admitted during the study period for a cervical spine injury, 23 of which met the inclusion criteria. The mean age was 14.6 yrs. of age and the sport included: 3 snowboarding, 5 wrestling, 7 gymnastics, 6 football, 1 hockey, and 1 diving. 3 injuries were atlantoaxial and 20 were subaxial of which 9 were fractures and 14 ligamentous injuries. The mechanism was axial loading in 10 patients and hyperflexion in 13 patients. Seven patients (30 %) were noted to have spinal cord injuries (SCI): 1 Frankel A, 2 Frankel B, 3 Frankel C, 1 Frankel D. Two patients had spinal cord contusions on MRI without neurologic deficit. The mechanism was axial loading and location subaxial in all patients with SCI.
All patients underwent fusion and modern cervical instrumentation (6 anterior, 11 posterior, and 6 anterior-posterior). There were no intraoperative complications. No patient had worsening or new post-operative deficit, and 2 patients improved one Frankel grade. Post-operative complications included: 3 patients with prolonged mechanical ventilation requiring tracheostomy, 3 pneumonia, 2 autonomic instability, 1 urinary sepsis. At mean follow-up of 26 months, 22/23 patients had solid arthrodesis.1 patient had a fatigue fracture of anterior plate with no instability on flexion-extension films. At follow-up only one patient had returned to their previous level of sporting activity. Statistical analysis revealed the presence of a complication was most associated with SCI ($p<.05$) and axial loading mechanism was more frequently associated with SCI ($p<.05$).

Conclusion: In our series, cervical injuries requiring an operation were seen in the adolescents due to axial loading and hyperflexion injuries. SCI was frequently present in mechanisms of axial loading (70%). Patients with an SCI were more likely to have a complication during the hospital stay.

Significance: Continued education in youth sports with regard to proper tackling/sliding/falling techniques is needed to potentially avoid catastrophic axial loading injuries to the cervical spine. Modern cervical stabilization techniques may be safely applied to this patient population

Does a Delay in Treatment of Displaced Pediatric Lateral Condyle Fractures Increase the Risk of Complications?

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LOE–Prognostic–Level III

Purpose: To investigate factors associated with specific complications, including early loss in motion and delayed union, and the impact of delayed treatment on displaced lateral condyle fractures.

Methods: A consecutive series of lateral condyle fractures treated at a level one pediatric trauma center between 2008 and 2014 were retrospectively reviewed. Fractures treated surgically with at least 6 weeks of follow-up were included in this study. The maximal radiographic displacement (AP, Lateral, or Oblique view) as well as the time from initial injury to surgical intervention were recorded. Univariate and multivariate statistical analyses were performed comparing the correlation of maximal displacement and timing to surgery with the rate of specific complications of loss in early motion or delayed union. Logistical regression modeling was performed for three groups: those with less than 4mm of displacement, greater than 4mm of displacement, and greater than 8mm of displacement. From this, an odds ratio was calculated.

Results: 408 patients (mean age 4.88 years, 68% males) met the inclusion criteria with an average displacement of 8.24 mm (range 0-41.6 mm) and average time from injury to treatment of 5.2 days (range 0-43). 133 (32.5%) had minimally displaced fractures (<4mm), while 161 (39.4%) had significant displacement (>8mm). Factors associated with the studied complications, compared to those without complications, were older in age (5.95 versus 4.63, $p<0.01$), displayed greater fracture displacement (10.3mm versus 7.8mm, $p<0.01$), and had a greater total time immobilized (38.27 days versus 31.52 days, $p=0.001$). When surgical treatment was greater than one day post-injury, the incidence of these complications was higher in those with <4mm of displacement and >8 mm of displacement (see Table 1). 75 patients had complications; 66 were referred to OT and 9 had nonunion/delayed unions. Patients who had initial displacement >8mm had a 3.3 times higher risk for complication compared to those with <4mm of displacement ($p=0.004$). When surgery was delayed greater than one day, that risk increased to 3.96 times ($p=.001$).

Table 1: The incidence of complications in lateral condyle fractures in three fracture displacement groups treated at 0-1 day and greater than 1 day.

	0-1 day	>1 day
Fracture Displacement	% Complications	% Complications
<4 mm	**5.9%**	**11.2%**
≥4 mm	**23.0%**	**21.5%**
≥8 mm	**21.8%**	**33.3%**

Conclusion: Both, the amount of initial displacement and time to surgical fixation of pediatric lateral condyle fractures, affect the risk of specific complications including early stiffness and delayed union.

Significance: The results suggest that early intervention may be warranted for displaced lateral condyle fractures.

An Increasing Rate of Operative Fixation in Four and Five-Year-Old Children with Femoral Shaft Fractures

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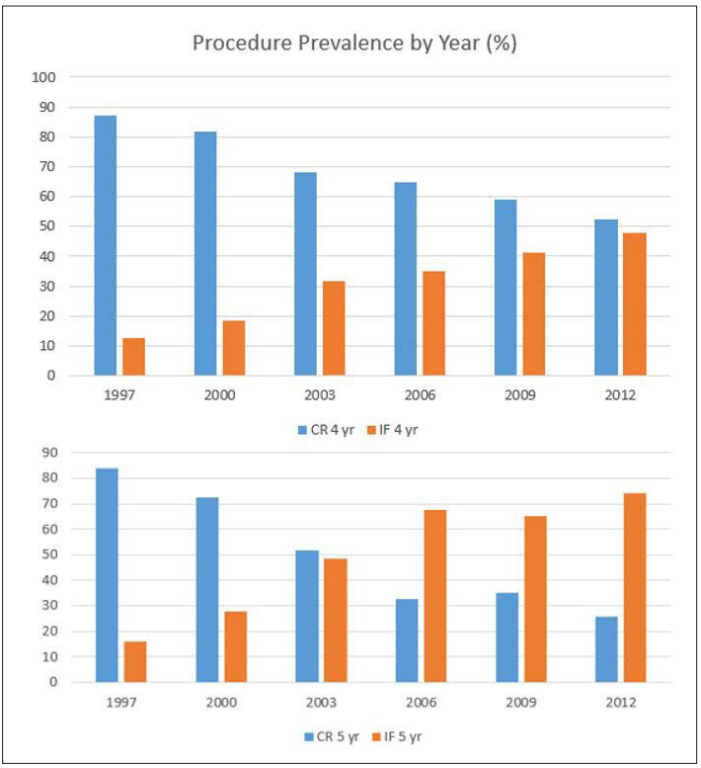
LOE–Prognostic–Level III

Purpose: The treatment of pediatric femoral shaft fractures among 4 and 5 year old children remains controversial and can consist of nonoperative spica casting versus operative internal fixation. The purpose of this study was to identify temporal trends in the management of pediatric femoral shaft fractures in 4 and 5 year old children over a 15 year time period.

Methods: The Kids' Inpatient Database (KID) from 1997 to 2012 was used to extract data on patients aged 4 and 5 with closed femoral shaft fractures. The frequency of nonoperative and operative management were calculated and temporal trends were evaluated. Additionally, we assessed demographic, operative, and hospital characteristics that may be associated with operative versus nonoperative management.

Results: Between 1997 to 2012 operative fixation increased by 13.8% in 4 year old patients and 7.6% in 5 year old patients every three years. The absolute increase in operative fixation was 35% and 58% in 4 and 5 year old patients, respectively over the 15 year period (Figure 1). Patients from lower median household incomes or who had higher loss of function were more likely to undergo operative management. Analysis of demographic variables demonstrated no differences in management based on gender, race, or payment method. Analysis of hospital variables demonstrated no differences in management based on percentage of pediatric discharges (P=0.083), hospital bed size (P=0.249), or hospital ownership (P=0.101). Teaching hospitals were more likely to utilize internal fixation compared to non-teaching hospitals (P=0.034). Geographically, the South and Midwest more frequently utilized internal fixation compared to the West and Northeast (P<0.0001). From a cost perspective, total hospital charge was significantly higher for patients receiving internal



fixation than closed management ($P<0.0001$) at $28,200 and $17,400, respectively.

Conclusion: There is a clear and significant increase in internal fixation for pediatric femoral shaft fractures in 4 and 5 year old children.

Significance: Although there remains no well-defined consensus on how to treat these patients, our study demonstrates that the lower-age limit for operative management of pediatric femoral shaft fractures is decreasing. Further studies with clinical and radiographic outcomes are needed to better identify which patients may benefit from operative management versus closed reduction and casting.

The Effect of Length Stability on the Outcome of Preadolescent Femur Fractures Treated with Flexible Intramedullary Nailing

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LOE–Therapeutic–Level III

Purpose: Since flexible intramedullary nailing (IMN) was first introduced in Europe for the treatment of displaced femoral diaphyseal fractures in school age children, this technique has become the standard of care in Europe and North America. Some authors have reported increased complication rates in older patients, heavier patients, and length unstable fractures. The purpose of this study was to examine the efficacy and complication rates in age and size appropriate patients with either stable or unstable fracture patterns treated with flexible IMN.

Methods: All traumatic pediatric femoral fractures treated with flexible IMN from 1/1/2006 to 12/31/2012 at a tertiary-care institution were identified. Fracture characteristics were based on review of injury films and categorized as either length stable or unstable. Complication rates were defined as patients requiring unplanned surgeries and included nonunion and/or malunion necessitating reoperation, clinically significant LLD requiring surgical intervention, infection, and/or repeat surgery prior to complete fracture healing. Length stability was assessed by measuring the change in femoral shaft length between initial post-operative and healed radiographs. Additionally, we identified a subset of patients with final full-length, standing x-rays and compared leg lengths between stable and unstable populations.

Results: We identified 106 patients with 63 stable and 43 unstable fractures. The mean age of the patients with stable fractures was 8.5 years compared to 7.3 years in patients with unstable fractures. The mean patient weight was 27.5kg in the stable fracture group and 24.6kg in the unstable fracture group. Complications necessitating further surgery were seen in 8 stable fractures (12.7%) including malunion (3), nonunion (1), LLD (2), and early reoperation prior to fracture healing (2). Of the 43 unstable femur fractures, 5 patients (11.6%) experienced complications including refracture (n=1) and early reoperation prior to fracture healing (n=4). There was no difference in complication rates between groups (p>0.1). Elective hardware removal rates were similar between stable (78%) and unstable (65%) groups (p>0.1). There was no difference (p>0.1) in femoral shaft length change with stable (average 0.12mm) and unstable (average 0.18 mm) fractures. Final leg length discrepancies were similar (p>0.1) between stable (7.47mm, n=30) and unstable (5.33mm, n=18) groups.

Conclusion: When patient size and age are controlled, preadolescent children do not experience increased complications after flexible intramedullary nailing of length unstable femur fractures.

Significance: Unstable femur fractures are not at increased risk for more complications, higher implant removal rates, early femoral shortening, or LLD.

Flexible Intramedullary Nailing has Superior Quality and Value to Plate Fixation of Midshaft Femur Fractures in Children 5-11 Years

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LOE–Therapeutic–Level III

Purpose: Current AAOS clinical practice guidelines for pediatric femoral shaft fractures indicate flexible intramedullary nails (FIN) for children 5-11 years old. Growing evidence suggests these fractures may also be treated with open or submuscular plating (SMP). The purpose of this study was to compare operative quality and value metrics between FIN and plating techniques for treatment of midshaft femur fractures in 5-11 year old children. We hypothesized that plating techniques would have a higher EBL, operative time, and fluoroscopy time while having reduced pain compared to FIN technique.

Methods: Following IRB approval, we retrospectively identified all pediatric midshaft femur fractures treated with FIN, SMP, or open plating between 2004 and 2014. Demographic, injury, and surgical data were obtained for analysis. Implant cost (charge to hospital) was obtained from the manufacturer. Complications were defined as: unplanned reoperation, surgical malunion, leg length discrepancy greater than 2 cm, or nonunion. Variables were compared between the three fixation methods using paired t-tests or Fisher's exact test as appropriate.

Results: There were 65 midshaft femur fractures in 63 patients included – 50 in the FIN group and 15 in the plating group. The plating methods were grouped together for analysis as no significant difference was found for any measured variable. There were 21 length unstable fractures with 14 treated by FIN and 7 by plating. There were no statistical differences in Injury Severity Score, length of stay, length unstable fractures, open fractures, fluoroscopy time, pre- to post-operative VAS change, daily opioid consumption, or number of patients requiring opioids at follow up. However, there was a significantly greater operative time (2.5 v. 1.6 hours, $p = 0.007$) and greater EBL (79.0 v. 40.1 mL, $p = 0.05$) for the plating technique compared to FIN. One complication occurred in each group. Implant cost of FIN was $604.52 v. $726.30 for a 14-hole 3.5mm plate and (6) 3.5mm screws.

Conclusion: This study supports the use of FIN or plating for midshaft femur fractures in children 5-11 years old. The use of plates resulted in higher EBL, longer operative time, increased cost, and equivalent pain compared to FIN.

Significance: To our knowledge, this study represents the first direct comparison of FIN and plating specifically for midshaft femur fractures and supports the use of FIN based on the favorable quality metrics, reduced cost of implant, and similar rate of complications.

Early versus Late Treatment of Pediatric Femur Neck Fractures: A Systematic Review and Meta-Analysis

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LOE–Therapeutic–Level III

Purpose: Femur neck fractures in children are rare and represent less than 1% of all pediatric fractures. Osteonecrosis of the femoral head is the most common complication of pediatric femur neck fractures and adversely affects outcome. Time to reduction is one of the most important factors that affect the outcome of these fractures, although there is no consensus on the most predictive factors of osteonecrosis. The aim of this study was to systematically review the literature to determine whether early treatment (<24 hours) of pediatric femur neck fractures is associated with lower rates of osteonecrosis of the femoral head compared to late treatment (>24 hours).

Methods: We searched several databases from 1950 to 2016 for any observational or experimental comparative studies that evaluated early (<24 hours) versus late (>24 hours) management of pediatric femur neck fractures. We performed a meta-analysis to pool odds ratios (ORs) for the comparison of osteonecrosis of the femoral head rates between children undergoing early and late treatment, open and closed reduction, and between displaced and non-displaced pediatric femur neck fractures. Descriptive, quantitative, and qualitative data were extracted.

Results: Of the 127 articles identified, 6 studies (prospective and retrospective comparative studies) were eligible for the meta-analysis, with a total of 231 pediatric femur neck fractures. The pooled odds ratio (OR) for osteonecrosis of the femoral head did not show any statistically significant difference between early (<24 hours) or late (>24 hours) treatment (OR = 1.19; 95% CI: 0.56, 2.51; I^2 = 23.6%), nor between open or closed reduction of pediatric femur neck fractures (OR = 1.62; 95% CI: 0.82, 3.22; I^2 = 19.6%). However, displaced femur neck fractures were 3.8 times more associated with osteonecrosis compared to non-displaced fractures (OR = 3.84; 95% CI: 1.50, 9.87; I^2 = 0.0%).

Conclusion: The cumulative evidence at present does not indicate an association between the time to treatment or the method of reduction of pediatric femur neck fractures and the risk of osteonecrosis of the femoral head. However, there was a significant association between the displacement of the fracture and development of osteonecrosis of the femoral head.

Significance: Children who sustain femur neck fractures should undergo expedient reduction and treatment. Osteonecrosis maybe intrinsic to the fracture type and displacement and not affected by the time to treatment. Multicenter prospective cohort studies are required to answer these questions about the potential long-term complications with more certainty and a higher level of evidence.

Clinical Outcomes of Suture versus Screw Fixation of Tibial Spine Avulsion Fractures

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LOE–Therapeutic–Level III

Purpose: To investigate any post-operative clinical differences in contracture, instability or complications with fixation of isolated tibial spine avulsion fractures using either suture or screw fixation by performing a database review at Boston Children's Hospital.

Methods: Database search was performed from 2000-2014 for type 2 and 3 tibial spine avulsion fractures surgically treated at Boston Children's Hospital which initially produced 162 patients. Study criteria required a minimum 12 month post- operative follow up, being treated only for an isolated tibial spine avulsion fracture, and having only suture or screw fixation. There was a final yield of 76 patients, 40 treated with a screw fixation and 36 treated with suture. Patients were reviewed for post op contracture defined as >5 degrees difference in ROM compared to opposite leg, documented post- operative instability, and post op complications including return to OR for arthrofibrosis, instability, implant complications, ACL tear, and physeal growth arrest.

Results: Contracture was found in 9/36 (25%) in the suture group vs. 12/40 (30%) in the screw group (p=0.68). Instability was found in 2/36 (5%) patients in the suture group vs. 7/40 (18%) in the suture group (p=0.05). Post op complications were found to be 7/36 (20%) in the suture group vs. 15/40 (38%) in the screw group (p=0.04). Post op complications in the suture group included 6 patients who developed significant contractures that required lysis of adhesions, 1 who sustained an ACL tear 10 months after fixation. Post op complications in the screw group included 2 patients who had removal of hardware for mechanical symptoms and pain, one of whom developed ACL incompetence eventually requiring reconstruction. Seven patients had lysis of adhesions with removal of hardware for contracture, 4 other patients had lysis of adhesions for contracture without removal of hardware. One patient underwent lateral hemiepiphysiodesis after occurrence of post op closure of the medial physis.

Conclusion: Suture fixation of tibial spine avulsion fractures resulted in significantly less instability and post-operative complications but yielded similar occurrence of post op contracture.

Significance: This is the largest known study in the current literature comparing clinical outcomes of suture vs. screw fixation of tibial spine avulsion fractures which showed a statistically significant difference in occurrence of post-operative instability and complications in the screw fixation group, but similar occurrence of post op contracture.

Tillaux and Triplane Fractures: K-wires or Just Screw It?

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LOE–Therapeutic–Level III

Purpose: To compare clinical and radiographic outcomes of percutaneous K-wiring and screw fixation for tillaux and triplane fracture.

Methods: A retrospective study was performed on tillaux and triplane fractures presented to our centre from 2003 to 2016. This study compared body weight, surgical time, post-operative casting duration, time to full sports, follow up discharge as well as clinical and radiographic outcomes between different fixation methods. The outcomes were analyzed using the modified Weber protocol.

Results: We identified 49 patients with tillaux (n = 22) or triplane fractures (n = 27). The mean age was 13.4 years old (ranging from 11 to 16). The mean follow up was 7.5 months (ranging from 4 to 24).
18 patients (11 tillaux, 7 triplane) underwent open reduction and percutaneous 2.0mm K-wiring and 31 patients (12 tillaux, 19 triplane) underwent open reduction and cancellous or cortical screw fixation.
The percutaneous wires were all removed in the clinic setting at 1 month post-surgery. Those with screw fixation underwent another surgery at post-operative 7.1±2.7 months for implants removal.
There was no statistically significant difference between the 2 groups with regards to body weight (60.8±12.4kg, 62.9±15.6kg, p=0.850) and time to full sports (4.7±2.2 months, 5.2±3.1months, p=0.527).
However, the skin-to-skin surgical time was significantly shorter (p<0.001) in the percutaneous K-wiring group (41.0±12.8minutes) compared to screw fixation (75.09±32.27minutes). Follow-up time required before discharge was also significantly shorter (p=0.024) with percutaneous K-wiring (5.4±5.3months) compared to screw fixation (8.6±4.3months). Conversely, the casting period post-operatively was longer (p=0.006) with percutaneous K-wiring (7.3±2.3weeks) compared to screw fixation (5.3±2.5weeks).
Clinically, all cases of percutaneous K-wiring showed excellent treatment outcomes. One developed post-operative superficial infection which resolved in 1 week. Cases with screw fixation also showed excellent clinical outcomes. However radiologically, one case developed lateral physeal arrest causing ankle valgus deformity. All patients in both groups had no residual displacement or step with resultant arthritic change on the final follow up.

Conclusion: Tillaux and triplane fractures have equally good outcomes after open reduction with percutaneous K-wiring or internal screw fixation. However, percutaneous K-wiring additionally requires less operation time, a shorter learning curve and shorter follow-up period. It also reduces cost and risk of anesthesia by negating the need for a second surgery for implant removal.

Significance: This study provides evidence that open reduction with percutaneous K-wring is as good as screw fixation in terms of outcomes and has additional advantages of reduced surgical time, shorter follow-up period and reduced overall cost.

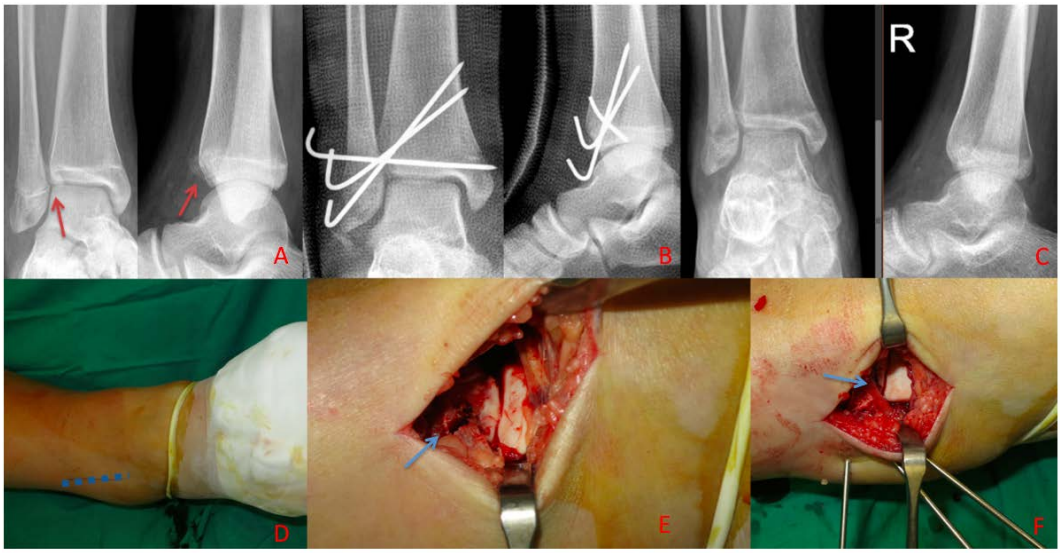

Fig.1 (A) X-ray showing tillaux fracture (red arrow). (B) Post-operative x-ray with percutaneous wire for 1 months and casting for 2 months. (C) Post-operative 6 months x-ray showing good fracture healing with no step off and no signs of arthritic changes. (D) Intraoperative picture showing 3 cm incision with antero-lateral approach. (E) Intraoperative picture showing displaced tillaux fracture. (F) Intraoperative picture showing anatomical reduction with intact joint line achieved (blue arrow) with three 2.0 mm percutaneous wires.

Do All Pediatric Monteggia Fractures with a Complete Ulna Fracture Require Surgical Stabilization?

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LOE–Therapeutic–Level III

Purpose: A recent publication proposed a treatment algorithm for pediatric Monteggia fractures based upon ulnar fracture pattern; surgical stabilization for complete ulna fractures and closed treatment for incomplete fractures. At our institution, all Monteggia fractures are initially managed with a non-operative approach and surgical fixation is reserved for open fractures or fractures that fail to achieve or maintain reduction. The purpose of this study was to evaluate this approach to see if a less aggressive treatment strategy resulted in poor outcomes and excessive complications.

Methods: This retrospective study evaluated all Monteggia fractures presenting to a Level 1 pediatric trauma center (2005-2015). Major complications were defined as those requiring an unplanned second procedure (other than implant removal) or may result in long-term disability (residual radial head subluxation/dislocation). Univariate analysis and subsequent multivariate Classification and Regression Tree (CART) were used to identify variables associated with need for surgical stabilization.

Results: 108 patients were identified, with mean age of 5.8 years (range 1-13) and mean follow-up of 13 weeks. 100 patients were initially treated with closed reduction and casting, while 8 open fractures underwent irrigation / debridement and surgical stabilization. 21 of the 100 (21%) failed cast management and were revised with open reduction internal fixation with a plate or an intra-medullary nail. All were identified and treated within 14 days of injury. 61 fractures were "under-treated" according to the published algorithm and 16 of these (26%) required ultimate surgical stabilization. Univariate analysis found Bado type, complete versus incomplete ulna fracture, level of ulna displacement, and pre-treatment maximum ulna angulation as significant ($p<0.10$), while CART analysis found ulna angulation greater than 35° as the only predictor of surgical stabilization. Overall, good outcomes were achieved with few major complications (n=3; one compartment syndrome, one radial neuropraxia, one ulna re-fracture).

Conclusion: This review of pediatric Monteggia fractures treated with closed reduction and casting found ulna angulation of greater than 35° as the primary variable associated with need for surgical stabilization.

Significance: While treatment algorithms are intended to minimize complications and maximize good outcomes, an unintentional consequence of the recently proposed pediatric Monteggia fracture treatment guideline may be over-treatment of these injuries. In this cohort, the majority of patients were able to avoid the operating room and surgical implants without compromising outcomes. This more conservative approach requires good reduction technique and excellent casting skills. Close monitoring of patients in the first two weeks (during which most reductions were lost) is essential.

Long-term Results after Sustaining a Monteggia Fracture-dislocation During Childhood

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LOE–Therapeutic–Level IV

Purpose: The purpose of this study is to evaluate the long-term clinical and radiological results of pediatric Monteggia fracture-dislocation.

Methods: We reviewed 29 consecutive patients who sustained a Monteggia fracture treated acutely. Demographic data, type of treatment and complications were recorded. Nineteen patients returned for clinical evaluation after an average follow-up of 10.6 ± 6.9 years (median 10), which included a clinical and radiologic assessment of both elbows. Clinical outcomes were described according to the MEPS score, Oxford Elbow Score (OES) and Flynn's criteria. Patients completed the quick-DASH questionnaire to measure disability. Radiographs were assessed for residual or articular incongruity of the proximal forearm, osteoarthritic changes and described using Nakamura's score.

Results: Mean age at the time of fracture was 6.4 ± 2.9 years. The most frequent pattern was an anterior radial head dislocation (50%) and a complete fracture of the ulna (74%). A closed reduction of the fracture-dislocation was performed in 75% of cases. Fixation was used in 28.5% of cases.
No differences were found when comparing patients that could and could not return for the final visit. No patient reported pain. The average score was 5 ± 11.2 for the QuickDASH questionnaire, 4.7 ± 13 for the QuickDASH-sports questionnaire, 98.5 ± 4.9 for the MEPS, and 47 ± 2.6 for the OES. According to Flynn's criteria, results were satisfactory in 89% of cases (60% being excellent). Two patients had a QuickDASH>30 due to persistent RH dislocation secondary to incomplete ulnar reduction and an occasional hand tremor with ulnar neuropathy. Another patient with a MEPS of 80 showed signs of PLRI and ulnar neuropathy with mild cubitus valgus deformity. Four asymptomatic patients had radiological findings of cubitus valgus (2), cubitus varus (1) and avascular necrosis of the RH.
Injured elbows showed decreased pronation when compared to the healthy side (79 ± 16 degrees vs. 86 ± 5 degrees, p=0.014) but no differences were found in flexion-extension, supination, clinical carrying angle, grip strength or discriminatory sensation of the hand and forearm. According to Nakamura, radiological results were good in 87.5%, fair in 8.5%, and poor in 4% of the cases.

Conclusion: Excellent outcomes should be expected when radiocapitellar congruity is achieved. However, some patients may show mild signs of neuropathy and persistent elbow instability but will not seek further treatment.

Significance: This study highlights the importance of continuous follow-up for mild persistent symptoms in this cohort of patients.

Telemedicine: A Novel Approach to the Teatment of Non-displaced Pediatric Elbow Fractures

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LOE–Therapeutic–Level I

Purpose: Telemedicine has been seldom used in the field of pediatric orthopaedics. The purpose of this randomized, controlled study was to assess the use of telemedicine as a tool in the treatment of non-displaced pediatric elbow fractures. We hypothesized that using telemedicine in this setting will result in comparable clinical outcomes and increased patient satisfaction as compared to those obtained in patients treated in a clinical facility.

Methods: We conducted an IRB-approved, single-center, randomized trial, in which 54 consecutive children with type I supracondylar humeral fractures (SCHF) or occult, acute elbow injuries were included. Patients were initially treated with a long-arm, soft fiberglass cast. Then, they were divided in two groups, based on the type of care to be provided during the 4th-week follow-up appointment: Patients in **Group A** (n=27) had their cast removed at our institution, by a member of our staff; patients in **Group B** (n=27) had a telemedicine appointment thru a live, two-way, HIPPA compliant, video-conferencing system (WebEx), and had their casts removed at home by a parent who rolled-back the casting material. Patients in both groups returned to our institution for a final follow-up visit at week 8. We compared the amount of fracture displacement, recovery of ROM, pain, and satisfaction. Additionally, length of the 4th week clinical encounter and the professional fee for that particular visit were compared.

Results: There were 23 boys (43%) and 31 girls (57%), with a mean age of 5 years (2 to 11). No evidence of fracture displacement was seen in either group. At the 8th week follow-up, elbows in **Groups A and B** had minimal changes in carrying angle, as compared to the normal, contralateral elbow (0.4° vs. -0.3°, p=0.1), had similar mean arc of motion (147 vs. 150 degrees; p=0.3), and had achieved an identical relative arc of motion (98%) of that of the normal, contralateral side (p=0.42). For patients in **Groups A and B**, pain scores at the 4th (1.0 vs. 1.6, p=0.03) and 8th week (0.1 vs. 0.0, p=0.2) appointments were low and clinically similar despite statistical significance at 4 weeks. Patient satisfaction at the time of cast removal was of 71% and 100% for patients in **Groups A and B**, respectively (p=0.001). The mean length of the 4th-week clinical encounter was 51 vs. 16 minutes, for patients in **Group A and B**, respectively (p<0.00001). When travel time (from home to our institution) was included, it was 114 vs.16 minutes, respectively (p<0.0001). The mean professional fee for the 4th week clinical encounter was of $231 vs. $185 for patients in Group **A and B**, respectively (p<0.0001).

Conclusion: The use of telemedicine as a tool in the treatment of no-displaced pediatric elbow fractures is appealing. In this particular series, the clinical outcome of those who had a telemedicine appointment, and had their casts removed at home by a parent, was similar to that of patients in whom the cast was removed in our institution. Patients managed thru telemedicine had higher satisfaction rates and spent only

a third of the time for their clinical encounter (or 1/7 if the travel time was included).

Significance: In this particular scenario, telemedicine appears to be a safe, satisfactory, and highly cost-effective tool.

An Anatomic Study on Whether Femoral Anteversion Originates in the Neck versus the Shaft

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LOE–Not Applicable–Level IV

Purpose: Femoral anteversion is generally asymptomatic but can result in lower extremity issues including patellofemoral instability and pain. Surgical correction of anteversion can be performed proximal, mid-shaft or distal. A better understanding of the specific location of the rotational deformity can help guide the optimal location of the osteotomy. To date, studies investigating location of femoral version have been small and limited by imaging techniques. In this study we examine the contribution of the femoral neck and shaft to total femoral version.

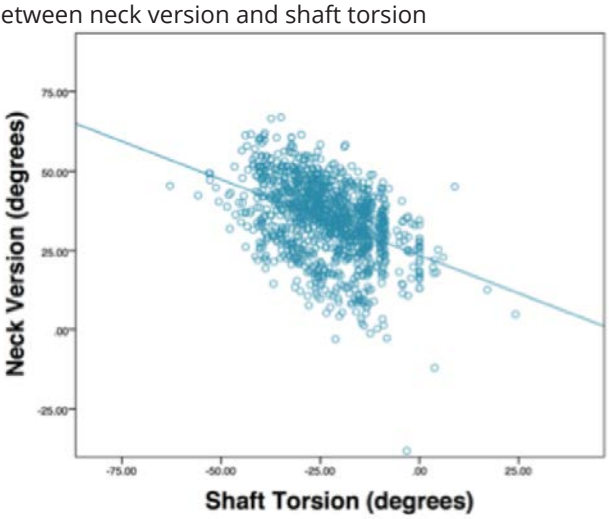
Methods: We studied 590 pairs of well-preserved cadaveric femurs. Total femoral version was defined as the axial plane angle between the femoral neck and posterior femoral condyles. Femoral shaft torsion was defined as the axial plane angle between the lesser trochanter and posterior femoral condyles. Neck version was the mathematical difference between total femoral version and shaft version. Multiple regression analysis was performed to determine the contribution of each segment to total version.

Results: Neck version (standardized beta right femur = 0.564, left femur = 0.634) contributed slightly more than shaft torsion (right femur = 0.473, left femur = 0.470) to overall femoral version, but both were substantial and neither completely predicted overall femoral version (Figure). Age was not found to contribute to femoral version, and sex and race had statistically significant but small contributions.

Conclusion: Our data show that both the femoral neck and femoral shaft substantially contribute to femoral version, and that neither completely predicts total femoral version.

Significance: To our knowledge this is the first study to statistically demonstrate that neither level can be used to predict total femoral version. This suggests that in the average patient there is not a single optimal site for correction or prediction of femoral version from an osteological perspective.

Figure: This scatter plot shows the high amount of variance between neck version and shaft torsion



Distance from Posterior Menisci to the Popliteal Artery in Children: A Cadaver Study

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LOE–Not Applicable–Level IV

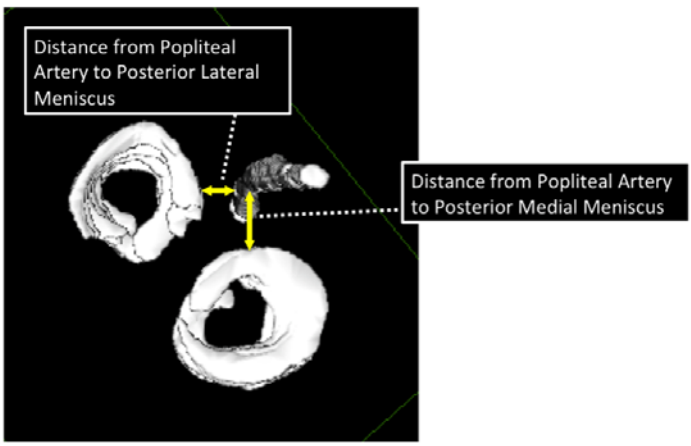
Purpose: There is an increasing incidence of meniscus tears in the skeletally immature, and these patients are more likely to undergo repair due to a better potential for healing, compared with older subjects. Adult studies have examined the anatomy of the menisci and popliteal neuro-vascular structures, however, similar studies have not been performed in pediatric populations. The purpose of this study was to examine the relationship between the popliteal artery and the posterior menisci, and develop recommendations about avoiding neurovascular injury during meniscus repair.

Methods: A series of 19 skeletally immature knee specimens (5 female, 14 male, ages 2-11) underwent dissection followed by CT imaging. Images (0.625 mm slices) were analyzed using OsiriX. Measurements from the posterior aspect of the lateral and medial meniscus to the popliteal artery were performed). A musculoskeletal radiologist and orthopedic sports surgeon confirmed proper identification of all structures and measurements taken.

Results: The distance from the posterolateral meniscus to the popliteal artery was 5.85 mm (range 2.58 to 8.77). The distance from the posteromedial meniscus and the popliteal artery was found to be greater than the posterolateral-popliteal artery relationship (Figure 3). As the specimens went up in age so did the distance between the posterolateral and postero-medial meniscus and the popliteal (Figure 1).

The linear relationship between distance and age is further demonstrated by breaking down the specimens into three age ranges, 2-5, 6-8, and 9-12. The average distances from the posterolateral meniscus to the popliteal artery were 5.22 mm, 6.74 mm, and 8.17 mm, and the average distances from the posteromedial meniscus to the popliteal artery were 12.72 mm, 15.43 mm, and 20.25 mm for each age group respectively (Table 2).

Axial View from Above Meniscus



Conclusion: Meniscus repair is increasingly performed in children. Historically meniscus repair with "inside out" or "outside in" approaches used retractors to protect the

neurovascular bundle. Many surgeons now use all inside repair devices, to minimize the surgical time and the extended incisions required for retractor-based approaches. Most of these devices deliver a fixation device through a sharp needle tip that extends well beyond the limit of the posterior meniscus.

Significance: To reduce the risk of neurovascular injury, surgeons should be aware of these relatively small distances, especially in the case of posterolateral meniscus repair.

3-D Modeling of Lower Extremities with Biplanar Radiographs: Reliability of Measures on Subsequent Examinations

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LOE–Diagnostic–Level III

Purpose: Biplanar radiography with 3-D modeling (EOS) provides a comprehensive assessment of lower limb alignment in an upright weight-bearing position with significantly less radiation than conventional radiography. Adequate visualization of specific bony landmarks in the lower extremity is required to generate 3-D models and can be compromised by standing posture, rotational artifact, and incorrect positioning of the patient. A study was performed to assess the consistency and reliability of two lower extremity 3-D biplanar radiograph models created at least one year apart in a population of children.

Methods: A retrospective cohort study investigating the reliability of subsequent lower extremity 3-D models was performed after local IRB approval (Level III evidence). All patients who had two lower extremity radiographic evaluations with EOS performed at visits a minimum of 1 year apart were included. Digital radiographs, of lower extremities in both frontal and sagittal planes, were acquired simultaneously, using the EOS system. 3-D reconstruction of the images was achieved utilizing the SterEOS software. Pelvic position, femoral and tibial anatomy, and the torsional profile were evaluated and compared using t-tests.

Results: Fifty-three patients with a mean age of 11.7 years (range, 6.1-18.9) met inclusion criteria. The most common diagnosis was cerebral palsy (70%). When comparing 3-D models between visits, minimal differences were noted in proximal femoral anatomy and pelvic alignment (pelvic incidence, sacral slope, sagittal tilt, neck shaft angle). Expected differences in femoral and tibial length corresponded with normal longitudinal growth between visits. Sagittal plane knee position varied widely between examinations. Femoral and/or tibial rotational osteotomies were performed in 37% of extremities between examinations. After femoral derotational osteotomy, a significant difference in femoral anteversion was appreciated when comparing preoperative and postoperative 3-D models. However, this difference was less than the expected difference based on the anatomic correction achieved intraoperatively. No differences were noted in tibial torsion measures after tibial derotational osteotomy.

Conclusion: 3-D modeling based on biplanar radiographs provides consistent and reliable measures of pelvic and hip joint anatomy of the lower extremity. Patient positioning may influence the reproducibility of knee alignment. The torsional profile assessment did not accurately reflect changes obtained by derotational osteotomy.

Significance: Biplanar radiographs with 3-D modeling provide useful assessments of the lower extremity anatomy and alignment. Accurate assessment of transverse plane alignment may require other modalities.

	Visit A (SD)	Visit B (SD)	Visit A vs Visit B p value*
Pelvic Parameters			
Pelvic Incidence (°)	43.3 (10)	46.2 (9.4)	**0.0435**
Sacral Slope (°)	41.7 (9.7)	44.2 (9.7)	**0.0046**
Sagittal Pelvic Tilt (°)	0.8 (13.3)	2.1 (10.3)	0.6083
Lateral Pelvic Tilt (mm)	6.8 (5.4)	9.5 (7.7)	**0.0002**
Pelvis Axial Rotation (°)	-1.1 (4.9)	-1.6 (5.9)	0.6115
Femoral Measurements			
Femoral Head Diameter (mm)	38.6 (4.5)	40.1 (4.2)	**0.0000**
Femoral Offset (mm)	35.3 (6.4)	36.9 (5.6)	**0.0031**
Neck Length (mm)	44.5 (6.1)	46.9 (5.7)	**0.0000**
Neck Shaft Angle (°)	128.4 (8.1)	128.9 (6.1)	0.4895
Lengths			
Femoral (cm)	37 (4.4)	39.1 (3.9)	**0.0000**
Tibial (cm)	32.2 (4.1)	34 (3.7)	**0.0000**
Functional (cm)	69 (8.4)	72.8 (7.8)	**0.0000**
Anatomical (cm)	69.1 (8.4)	73.1 (7.5)	**0.0000**
Knee			
Varus/Valgus (°)	-0.1 (4.4)	-0.6 (3.9)	0.0955
Flexion/Extension (°)	9.6 (15.4)	7.6 (14.4)	0.1441
Femoral Mechanical Angle (°)	90.9 (8.9)	92 (2.7)	0.2400
Tibial Mechanical Angle (°)	89.2 (4.4)	88 (4.9)	**0.0082**
Torsions-(Nonoperative Cohort)			
Femoral (°)	12.4 (15)	19.7 (12.2)	**0.0045**
Tibial (°)	32.3 (6.5)	33.3 (6.1)	0.4292
Torsions-(FRO Cohort)			
Femoral (°)	24.9 (14.6)	11.2 (13.1)	**0.0000**
Torsions-(TRO Cohort)			
Tibial (°)	33.9 (4.5)	32.2 (5.4)	0.1945
**Bold type indicates statistical significance*			

Dynamic Analysis of Surgical Stabilization Options for Pediatric Patellar Instability

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LOE–Not Applicable–Level IV

Purpose: Medial patellofemoral ligament (MPFL) reconstruction and medialization of the tibial tuberosity are the two most common surgical approaches to treat recurrent patellar instability. Options to avoid violating a growth plate in skeletally immature patients include medialization of the lateral patellar tendon and MPFL reconstruction with the femoral attachment moved distal to the growth plate. The current study utilizes dynamic simulation to compare the influence of these surgical approaches on patellar tracking and pressure applied to cartilage.

Methods: Computational models were developed to represent knees of eight patients who participated in an IRB-approved study that characterized patellar tracking based on imaging data. Using a previously validated multibody dynamic simulation approach, knee extension was simulated with the femur fixed. Ligaments and tendons were represented by springs and dampers, and force vectors were applied to represent quadriceps activation. Cartilage contact was governed by simplified Hertzian contact. Patellar tracking was characterized based on coordinate systems embedded in the femur and patella. Patellofemoral contact pressure distributions were determined by balancing forces and moments applied to the patella with reaction forces from the cartilage based on linear elastic theory. The eight models were used to simulate tibial tuberosity medialization (10 mm medialization), anatomical MPFL reconstruction, MPFL reconstruction with the graft shifted 5 mm distally, and medialization of the lateral patellar tendon. Data were compared at individual flexion angles using a Friedman test and post-hoc Student-Newman-Keuls tests with $p < 0.05$ considered significant.

Results: All surgical simulations decreased the lateral shift and tilt of the patella. Patellar lateral shift decreased significantly at all flexion angles, except for the anatomical MPFL reconstruction at 25° of flexion. Patellar lateral shift was significantly larger for anatomical MPFL reconstruction than for tibial tuberosity medialization or lateral patellar tendon medialization from 0° to 45° of flexion. For the two medialization procedures, the lateral patellar shift decreased from 50° to 20° of knee flexion before increasing to full extension. Compared to the pre-operative condition, the medialization procedures also increased the peak contact pressure from 25° to 50°.

Conclusion: Although all surgical simulations reduced lateral maltracking, tibial tuberosity medialization and medialization of the lateral patellar tendon tended to over-constrain the patella and increase maximum cartilage pressure. These procedures may not be appropriate unless the tibial tuberosity is abnormally lateralized.

Significance: This is the first study to use computational simulation to assess multiple surgical treatment options while accounting for the anatomic conditions associated with patellar instability in children.

Trochanteric Entry for Femoral Lengthening Nails in Children: Is It Safe?

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LOE–Therapeutic–Level IV

Purpose: Antegrade intramedullary (IM) nailing for femoral fractures in skeletally immature patients can damage the capital femoral epiphysis blood supply, leading to femoral head avascular necrosis (AVN). Reported AVN rates for trauma nails in children are 2% for piriformis entry and 1.4% for trochanteric entry. These reports do not describe IM lengthening nails. The purpose of this study was to determine whether femoral self-lengthening telescopic nails with a proximal Herzog bend and standard trochanteric entry can be used safely in skeletally immature patients without causing AVN or proximal femoral deformity.

Methods: Medical records were retrospectively reviewed to identify skeletally immature patients who underwent insertion of an IM lengthening nail through the greater trochanter. Inclusion criteria were IM nail insertion occurred between January 2004 and January 2014, at least 1 year of follow-up after insertion, and age younger than 18 years.

Results: Thirty-one femora were lengthened in 28 patients (17 boys, 11 girls). The etiology was congenital femoral deficiency (10), achondroplasia (6), posttraumatic causes (5), hemihypertrophy (3), Ollier disease (2), and miscellaneous (5). Mean age at time of surgery was 12.7 years (range, 7-17.3 years). Mean follow-up after insertion was 3.3 years (range, 1-9 years). Average lengthening amount was 5.4 cm (range, 3-6.7 cm). Nails had diameters of 10.7 mm (24 nails) and 12.5 mm (7 nails). First generation IM lengthening nails were used in 18 femora and second generation in 13 femora. Ten limb segments (7 first generation nails; 3 second generation nails) had 13 complications: delayed union (7), premature consolidation (2), subluxation of knee or hip (2), nonunion (1), and rod failure (1). Ten resolved after operative treatment, 2 resolved after nonoperative treatment, and 1 resolved without intervention. None of the patients developed AVN or proximal femoral deformity.

Conclusion: IM lengthening nails inserted through the greater trochanter may be utilized in skeletally immature patients without increased risk of femoral head AVN or proximal femoral deformity. Larger trials are needed to confirm our hypothesis.

Significance: Provided that strict surgical procedures are followed, insertion of a limb lengthening nail through the greater trochanter can be safe.

Changes of Sagittal Plane Alignment of Proximal Tibia after Limb Lengthening Surgery

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Hae Ryong Song, MD
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LOE–Therapeutic–Level III

Purpose: Lengthening of tibia has been known to be associated with secondary axial deviations in coronal plane. However, there is limited information regarding the change of sagittal plane alignment after excessive lengthening of tibia. We tried to determine whether (1) the radiographic parameters change after limb lengthening and (2) whether there are any differences in sagittal plane alignment between conventional lengthening and lengthening over nail.

Methods: We retrospectively reviewed 43 patients (85 limbs) who underwent tibial lengthening during 2005 to 2015. There were 24 patients in group A, which was treated with conventional Ilizarov technique, and there were 19 patients in group B, which was treated with lengthening over nail. We analyzed basic demographic characteristics, and pre-operative radiographic parameters and compared the result after tibial lengthening. We measured the amount of lengthening and the sagittal proximal posterior tibial angle (PPTA), and compare the pre- and post-operatively on full length roentgenograms. We used student *t*-test and paired *t*-test.

Results: The mean amount of lengthening in group A was 9.31 cm (CI = +- 1.28 cm), with the mean pre op PPTA being 78.2° (CI = +- 1.2°) and mean post op PPTA 71.7° (CI = +- 1.9°). The difference between the mean pre-operative and post-operative PPTA is 6.5° which is highly significant statistically (p = 0.0045). The mean lengthening achieved in group B is 8.75 cm (CI = +- 2.4cm), with the mean pre op PPTA being 76.3° (CI = +- 1.2°) and mean post op PPTA being 73.8° (CI = +- 1.5°). The difference between the mean pre op and post op PPTA is 2.5° which is statistically significant ($p < 0.001$). The mean change of PPTA in group A appears less than that in group B, which is statistically significant (p = 0.003).

Conclusion: Tibial lengthening might result in increasing PPTA after limb lengthening regardless of the procedures. However, LON is preferable over lengthening with ilizarov fixator only, in order to prevent change in PPTA during tibial lengthening.

Significance: In tibial lengthening, treating surgeons should consider the possibility of changes of sagittal plane alignment as well as coronal plane alignment, even though they choose lengthening over nail technique using rigid nail.

Treatment of Slipped Capital Femoral Epiphysis with Disrupted Junction of the Epi- and Metaphysis by the Modified Dunn Procedure

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LOE–Therapeutic–Level IV

Purpose: Surgical treatment of slipped capital femoral epiphyses (SCFE) aims to restore the integrity of the femoral head neck junction in order to prevent loss of function and early osteoarthritis. In case of disrupted junction between epi-and metaphysis with a mobile femoral head the risk for osteonecrosis is reported up to 60% in the literature. We evaluated the results of the modified Dunn procedure for the treatment of slipped capital femoral epiphysis with intraoperative documented disrupted junction between the epi-metaphysis`, so called unstable slips, with regard to clinical outcome and adverse events such as avascular necrosis (AVN).

Methods: We retrospectively reviewed 128 cases with SCFE after treatment for slipped capital femoral epiphysis between 1998-2016. Intraoperatively in 48/128 (37%) hips the junction between epi- and metaphysis was disrupted and the femoral head was mobile on the femoral neck. Average slipping angle was 48°. Clinical and radiological results were analyzed. Mean follow up was 4 years. Preoperative classification regarding stability of the femoral head was compared to the intraoperative findings.

Results: 45/48 (94%) hips had excellent clinical and radiological outcome. At follow up the Harris Hip score and the Merle D Àubigne` score were 99,7 and 17, respectively. Slipping angle improved significantly. AVN occured in three cases (6%). Preoperative clinical estimation of slip stability was not corresponding to the intraoperative findings in the majority of cases.

Conclusion: With surgical hip dislocation and active preservation of the retinacular vessels, a controlled anatomic reposition of the mobile femoral head is possible. Excellent outcome can be found in the 94% of cases with low rates of adverse events compared to the current literature. Only by arthrotomy we are able to safely judge the mechanical stability of the epi-metaphyseal junction of the proximal femur.

Significance: Level 4 retrospective case series

The Early Experience with Open Reduction/Dunn Osteotomy for Unstable SCFE: Predictors of Failure

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LOE–Therapeutic–Level III

Purpose: Unstable slipped capital femoral epiphysis (SCFE) remains a treatment challenge to avoid avascular necrosis (AVN) and femoroacetabular impingement. The optimal treatment should address the deformity, achieve stable fixation of the capital epiphysis, and limit AVN.

Methods: We reviewed our consecutive, prospectively collected series of patients who presented to our institution with an unstable SCFE between2001-2008 and were treated with open reduction and internal fixation via surgical hip dislocation (SHD), also known as a modified Dunn osteotomy.
Analysis was completed to determine incidence of AVN, post procedure complications, need for additional surgery, and identify predictors of AVN.

Results: 24 patients (10F/14M; average age 12.5yrs±1.4 and average BMI 24.6± 4.7kg/m^2) were included: 10 African Americans (42%), 6 Hispanics (25%), and 8 Caucasians (33.3%). The most common mechanism of injury was a fall (n=18; 75%) and most patients were seen within 6 hours from injury (n=11, 45.9%) with 7 (29.2%) > 12 hours. All but one patient presented with pre-existing symptoms between 1 week to 8 months prior to the injury. Seven complained of hip pain, 6 combination hip/thigh and/or knee, 10 of thigh or thigh/knee thigh pain, and 1 lower extremities. OR time was 151.6±34.2 minutes, EBL was 233.8±182.4cc. At the latest follow-up the Southwick angle was 12.6 degrees. Two patients had broken screws after their index procedures and were treated with a revision SHD and reduction fixation of the epiphysis. Four patients (16.6%) developed AVN, 3 (12.5%) requiring surgery with 1 asymptomatic partial head involvement: 1 had THA, 1 required screw removal SHD, 1 required had a hip fusion. The only predictor for AVN was delayed presentation and time to the OR: Patients who presented >12 hours from time of injury had the highest AVN (28.6%) compared to the patients who presented between 6-12 hours (16.7%) and <6hours (9.1%).

Conclusion: Open reduction and internal fixation via surgical hip dislocation for unstable SCFE allows for near anatomic reduction of the epiphysis and a *symptomatic* AVN rate of 12.5% which appears to be related to time to surgery. These data should be utilized to improve the AVN rate since this technique helps avoid the femoral deformity seen for in situ pinning. A randomized control trial comparing this open technique vs in situ pinning is ongoing.

Significance: The open reduction technique for unstable SCFE offers improved deformity correction and avoidance of AVN compared to in situ reports. Opportunities for improvement appear to be related to time to surgery.

Diagnosing Slipped Capital Femoral Epiphysis (SCFE) Amongst Various Medical Specialists

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LOE–Diagnostic–Level I

Purpose: Slipped capital femoral epiphysis (SCFE) is one of the most common hip disorders amongst adolescents with a reported annual incidence of approximately 3-5 per 100,000. Nevertheless, 19.6% to 67.5% of SCFE cases are misdiagnosed by initial examining physicians. This is of concern as a delay in diagnosis of SCFE and increased slip severity lead to poorer long term prognosis, increased risk of hip deformity and osteoarthritis. The purpose of this study was to evaluate how much variability exists amongst pediatricians, radiologists and orthopaedic surgeons to detect SCFE from radiographs.

Methods: 3 pediatric outpatient physicians, 3 pediatric fellowship-trained radiologists and 3 pediatric fellowship-trained orthopaedic surgeons independently completed a web-based survey of 50 AP and frog lateral de-identified radiographs of patients with a diagnosis of SCFE (25), FAI (4), Legg Calve Perthes (11) or no hip pathology (10). Each radiograph showed the ipsilateral side only and age, sex and chief complaint were given. An example of the user interface is shown in Figure 1. Agreement among specialties was assessed using kappa coefficient (Landis and Koch, 1977). Sensitivity, specificity and accuracy in regard to diagnosis of SCFE vs non-SCFE were analyzed.

Results: Interobserver agreement was fair among pediatricians (Kappa-Coefficient 0.33, 95% CI 0.17-0.49), substantial among orthopaedic surgeons (Kappa-Coefficient 0.78, 95% CI 0.62-0.94) and almost perfect among radiologists (Kappa-Coefficient 0.89, 95% CI 0.73-1.00). Sensitivity of SCFE diagnosis, the proportion of SCFE correctly identified, was very high among radiologists and orthopaedic surgeons (range 92-100% for both specialties), but lower for pediatricians (range 56-76%). Specificity, proportion of non-SCFE correctly identified, was high among radiologists (84%) and orthopaedic surgeons (range 72-76%), however variable among physicians

(range 56-80%). Accuracy of SCFE diagnosis was highest in radiologists (88-92%), followed by orthopaedic surgeons (82-88%) and pediatricians (56-78%).

Conclusion: This study demonstrated that interobserver variability, specificity, sensitivity and accuracy for the radiographic diagnosis of SCFE amongst pediatric radiologists and orthopaedic surgeons is higher. Pediatricians demonstrated a decreased sensitivity, specificity and accuracy of SCFE-diagnosis.

Significance: SCFE can be detected on radiographs by physicians of different specialties.

Hip Arthroscopy Successfully Treats Femoroacetabular Impingment in Adolescent Athletes

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LOE–Therapeutic–Level IV

Purpose: There is evidence that femoroacetabular impingement (FAI) is increasingly prevalent among adolescent athletes. Abnormal contact forces across the hip and alterations in bony morphology characteristic of FAI may be especially detrimental in this group, given their young age and active lifestyle. The purpose of this study is to report the findings, outcomes, and return to sport percentage among adolescent athletes with FAI treated with hip arthroscopy.

Methods: A retrospective review of all patients < 18 years who underwent hip arthroscopy for FAI at a single institution was performed. All patients who played a sport and were treated with hip arthroscopy were included. Patients with previous hip surgery and or hip conditions were excluded. Arthroscopic procedures and an assessment of intra-articular findings were recorded. Patient reported outcome (PRO) measures were recorded at 3, 6, 12 months, and 2 years, and included the modified Harris Hip Score (mHHS), the Non-arthritic Hip Score (NAHS), Hip outcome score sport subscale (HOS-SS), visual analogue scale (VAS) for pain, and patient satisfaction. Return to sport percentage and reasons for not returning were also noted.

Results: There were 116 adolescent athletes treated with hip arthroscopy between 2008 and 2014; 93 (80.2%) athletes had 2-year follow-up. Running was the most common sport (25), followed by soccer (13), football and softball (7 each). There were 69 females and 24 males, whose average age was 16.0 years ± 1.2 (range: 13.1 – 18.0). The most common procedures were labral repair (95%), iliopsoas fractional lengthening (75%) and femoroplasty (67%). Capsular repair or plication was performed in most patients (85%). Cartilage damage was more common on the acetabulum than the femur, with Outerbridge grade 2 or higher occurring in 25% and 5% of hips, respectively. Statistically significant improvements were seen in all PROs from pre-op to 2-year follow-up (see Table). The majority returned to their sport at the same or a less competitive level (56%). Among those not returning, most indicated a lifestyle transition, but 15% reported concern of re-injury as a reason for not participating. There were 9 patients (10%) that underwent revision arthroscopy at a mean of 28.7 months post-op.

	Preoperative	3 months	1 year	> 2 years
Patients	93	79	56	93
mHHS	63.3 ± 15.7	89.9 ± 12.1	91.0 ± 11.3	89.3 ± 11.0
NAHS	64.1 ± 18.1	88.2 ± 12.4	90.6 ± 10.4	90.3 ± 10.4
HOS-SSS	41.6 ± 21.0	74.9 ± 25.1	82.7 ± 20.9	83.2 ± 18.3
VAS	5.8 ± 2.4	1.6 ± 1.7	1.3 ± 1.6	1.5 ± 1.8
Satisfaction	--	9.1 ± 1.3	8.9 ± 1.2	8.7 ± 1.4
p-value		p < 0.001	p < 0.001	p < 0.001

Conclusion: FAI exists in adolescent athletes. Hip arthroscopy can be used in this population to address intra-articular pathology with good results at 2 years.

Significance: Hip arthroscopy can be safely and effectively used in adolescent athletes.

Does Concurrent Femoral Head-Neck Osteochondroplasty Improve the Long-term Clinical Results of PAO Surgery for Symptomatic Acetabular Dysplasia?

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LOE–Therapeutic–Level III

Purpose: PAO surgery is an effective treatment for symptomatic acetabular dysplasia yet secondary femoroacetabular impingement (FAI) after PAO surgery is a known cause of failure. We previously reported early follow-up in patients undergoing (PAO) and concurrent femoral head neck osteochondroplasty (OCP) compared to patients undergoing isolated PAO. Our goal was to compare pain, function, activity, quality of life and survivorship for isolated PAO and PAO with concurrent osteochondroplasty.

Methods: Seventy- one of the 88 patients were available for further follow up. Patient reported UCLA, modified Harris Hip Score (mHHS), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) were reviewed.

Results: Thirty-four patients were in PAO/OCP group versus 37 PAO only group. Average follow up of 11 years (range 7 to 15 years). No difference in age, sex, BMI between cohorts. Preoperatively, the UCLA, mHHS, and WOMAC for the PAO/OCP vs. PAO groups were similar (7±3, 64±13, 67±23 vs. 7±3, 65±15, 61±27 respectively). Postoperatively, the UCLA, mHHS, and WOMAC for the PAO/OCP vs. PAO groups showed similar improvements (7±2, 86±16, 89±19 vs. 7±2, 84±21, 82±27 respectively). Both groups showed significant improvement pre to post operatively in mHHS ($P<0.001$). The PAO/OCP group had one subsequent hip arthroscopy and no THA conversions compared to 4 subsequent hip arthroscopies and three THA conversions in the PAO only group. Overall survivorship (with THA or revision PAO as endpoint) was 100% for PAO/OCP compared to 89% for PAO only.

Conclusion: In this long-term follow-up study comparing PAO/OCP and isolated PAO, the majority of patients in both groups have positive outcomes at an average of 11 years postoperatively. Patients that underwent concurrent OCP had fewer subsequent surgeries and no THA conversions at long term follow up.

Significance: This study demonstrates the concurrent procedure to be safe and associated with excellent clinical results.

The Need for Further Corrective Surgery in Developmental Dysplasia of the Hip: Surgical Decision-Making and Practice Variability

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LOE–Prognostic–Level III

Purpose: Many studies on Developmental Dysplasia of the Hip (DDH) use the need for further corrective surgery (FCS) after primary treatment as an outcome representing treatment failure. However, the decision to proceed with, and timing of, FCS can be dependent upon surgeon preference. The purpose of this study was to capture variability in surgical decision-making regarding need for FCS after primary treatment for DDH.

Methods: Twenty cases consisting of patients previously treated for DDH were selected from the records of two pediatric orthopaedic surgeons practicing at different tertiary care hospitals. Demographic information, diagnosis, initial treatment(s) and serial radiographs were compiled and sent to international pediatric orthopaedic surgeons with a practice focus on the hip. For each case, surgeons were asked whether a surgical intervention would be necessary based on radiographs and radiographic measures, and if so, what intervention should be performed. Questions about reason for non-intervention and advanced imaging were also posed. Mean age of patients at time of query was 4.1 years (range 2.0-8.3).

Results: Sixteen surgeons responded to the survey. On the decision for intervention, surgeons were unanimous in favour of intervention on 3/20 cases. Minimal consensus (8 for, 8 against intervention) was seen in 3/20 cases. Average standardized consensus (0 to 1) was 0.52, 95% CI [0.34-0.70]. When respondents felt an intervention was necessary, there was considerable variation in procedure choice. Most frequent procedures of choice were pelvic osteotomy (41%), combined pelvic and femoral osteotomy (24%) and femoral osteotomy alone (11%). Consensus did not correlate with patient age or length of follow-up since index procedure. When "no intervention" was selected, there was considerable variation in reasoning. "Likely to improve on own" was the most frequent reason selected (51%), then "Possible future intervention" (40%) and "Definite future intervention" (8%).

Conclusion: Surgical decision-making for FCS following DDH treatment is widely variable between surgeons. Provided the same series of radiographs and radiographic measures, 16 surgeons unanimously agreed whether or not an intervention was necessary on 15% of cases; and reached majority consensus on only 60% of cases. Further variation was seen in choice of procedure and timing of intervention.

Significance: This international, cross-sectional survey demonstrates the inherent variability in DDH management practice for treating residual dysplasia between pediatric orthopaedic surgeons. This highlights the importance of caution when interpreting studies using FCS as a surrogate outcome measure. Recognition of this variability will aid in the identification of objective outcomes and provide a basis for consensus discussion.

Periosteal Response Following Resection

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Purpose: Increased longitudinal bone growth occurs following periosteal resection. The long accepted mechanism for such growth is that the periosteum serves as a simple mechanical tether restricting growth. Previously we utilized Second Harmonic Generation (SHG) imaging to demonstrate that periosteal fiber alignment adjacent to the physis did not change *immediately* following periosteal resection. In this follow-up study we measured (1) changes in the periosteal fiber alignment over time following periosteal resection using SHG imaging (2) the biologic response of the periosteum to mechanical stimuli and (3) changes in the expression of several growth factors in vivo following the procedure.

Methods: (1) SHG Imaging: twelve seven-week old New Zealand White rabbits were equally divided into non-operative controls and unilateral proximal tibial periosteal resections, sacrificed at 2, 4 and, 8 weeks post-op. Tibiae were carefully removed and the periosteal fibers imaged on the bone using SHG. (2) Three, freshly harvested periosteal samples were used to assess the relative mRNA expression of TGFβ-1, -2, -3, Ihh, PTHrP, Gli, and Patched when periosteal samples were exposed to tensile strain of 1.14%, 2.5%, or 5% in a bioreactor using RT-PCR. (3) An additional nine rabbits underwent periosteal resection and tibiae harvested at 0, 2, and 8-weeks post-resection and immunohistochemistry (IHC) performed.

Results: SHG imaging demonstrated that periosteal fiber alignment adjacent to the proximal physis remained unchanged ($p=0.6$) over time despite changes in growth rates while periosteal fiber alignment in the region adjacent to the resection increased from two to four weeks ($p=0.01$). The periosteal strips were found to significantly ($p<0.05$) up-regulate and down-regulate specific growth factors (TGFβ-1, 2, Ihh, PTHrP) in response to changes in strain. Preliminary blind rank analysis of IHC samples suggest increased expression of PTHrP in the proximal tibial growth plate at eight weeks post resection.

Conclusion: Periosteal fiber alignment adjacent to the growth plate does not change overtime despite changes in physeal growth rates, making it unlikely that these fibers are responsible for mechanically restraining growth. However, as fiber alignment changes in the region of resection and the periosteum in this region is capable of translating mechanical stimuli into biologic responses, it is plausible that the periosteum is regulating growth through secreted growth factors.

Significance: The periosteum may function as sensor for bone growth, biologically regulating the physis in response to stimuli, rather than acting as a simple mechanical restraint.

Using Arm Length to Predict Upper Extremity Peripheral Nerve Position in Pediatric Orthopaedics

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Purpose: Surgical anatomy of peripheral nerves in the upper extremity is well described in adults with frequently cited "safe zones," or reference distances from anatomic landmarks. Most studies investigating peripheral nerve surgical anatomy of the upper extremity use adult cadaveric models, which understandably make similar investigations in children less feasible. Precise quantifiable relationships between neurovascular structures and bony landmarks in the pediatric population remain ambiguous. The goal of this study was to develop a model to reliably predict the location of the radial and axillary nerve in the upper extremity of a pediatric patient.

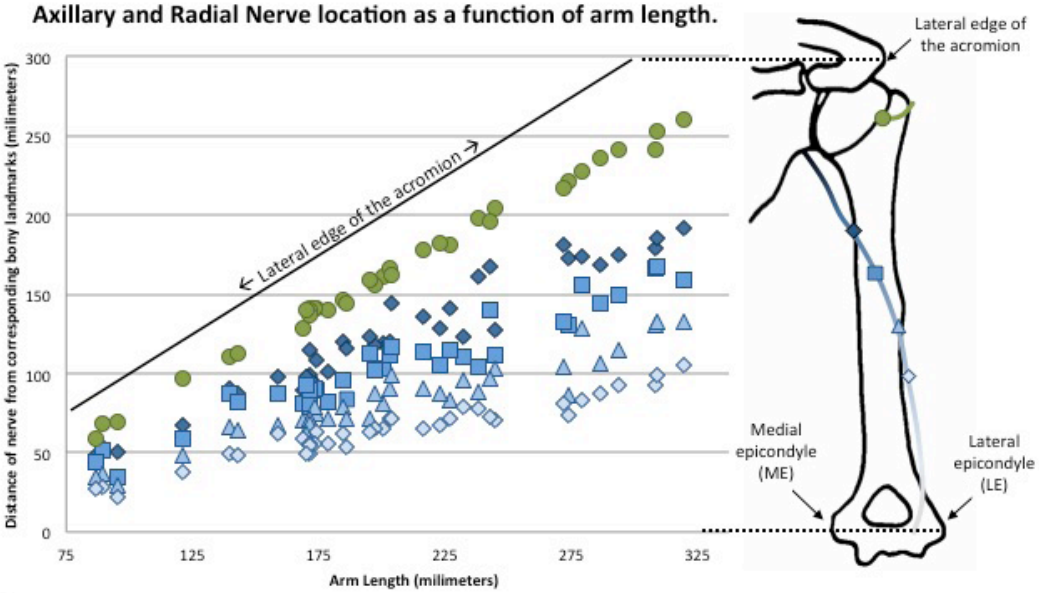
Methods: We conducted a retrospective review of MR studies including the entire humerus of skeletally immature patients from 2001 to the present. Cases with distorted anatomy secondary to an underlying pathologic process and insufficient resolution to identify major peripheral nerves were excluded. Arm length (AL) was measured as the distance from the most lateral aspect of the acromion to the lateral epicondyle. The location of the radial nerve as it crossed the medial cortex of the humerus, the middle of the posterior humerus, the lateral cortex of the humerus, and the point at which it crossed from the posterior to the anterior compartment of the upper arm was identified. The distance between the radial nerve and corresponding distal bony landmarks (medial epicondyle, transepicondylar line, and lateral epicondyle) was recorded and expressed as a percentage of AL. The distance of axillary nerve from the most lateral aspect of the acromion was also measured and expressed as a percentage of AL.

Results: The axillary nerve was predictably identified 19.8% of AL inferior to the lateral edge of the acromion. The radial nerve was predictably found crossing the medial cortex of the posterior humerus 60.1% of AL up from the medial epicondyle, the middle of the posterior humerus 51.2% of AL measured up from the transepicondylar line, the lateral cortex of the posterior humerus approximately 40.6% of AL measured from up from the lateral epicondyle, and the nerve crossed from the posterior to anterior compartment 31.2% of AL up from the lateral epicondyle.

Conclusion: The position of peripheral nerves in the upper extremity can be reliably predicted as a proportion of arm length based on osseous landmarks.

Significance: This is the first study to describe the location of peripheral nerves in the upper extremity as a proportion of arm length for surgical application in the skeletally immature patients.

Axillary and Radial Nerve location as a function of arm length.



Nerve Location and Distance From Landmark	Average % of Arm Length	Standard Deviation	N	Correlation Coefficient	R^2
Lateral acromion to Axillary nerve	19.81	2.82	34	0.9828	0.9659
Radial nerve crossing the medial cortex to ME	60.28	4.67	37	0.9706	0.9421
Radial nerve at the mid-posterior humerus to TE	51.22	4.98	37	0.9624	0.9263
Radial nerve at the lateral cortex to LE	40.75	3.73	37	0.9549	0.9200
Radial nerve crossing between anterior and posterior compartments to the LE	31.75	2.81	37	0.9657	0.9326

An Analysis of Femoral Version in Patients Undergoing Periacetabular Osteotomy

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Purpose: The contribution of transverse plane hip anatomy (femoral version) to the mechanical stability of the hip joint is not well understood and is of increasing interest in the clinical analysis of hip mechanics. The range of femoral version in symptomatic acetabular dysplasia, and the association between femoral version, proximal femoral morphology, and degree of acetabular dysplasia are likely important contributions to hip pathomechanics. However, in patients undergoing periacetabular osteotomy (PAO) for symptomatic acetabular dysplasia, there is a paucity of information regarding these relationships. The purpose of this study was to describe the range of femoral version in patients undergoing PAO, and its effect on clinically measured hip range of motion and preoperative clinical presentation.

Methods: We reviewed 314 patients who underwent PAO for symptomatic acetabular dysplasia between January 2014 and August 2015, and were prospectively enrolled in a longitudinal clinical study. Preoperatively, all patients completed questionnaires about their symptomatology and had pelvic radiographs and CT scans. Using the CT scan, femoral version and alpha-angle of the upper femur were measured. On AP pelvis and false profile radiographs,Tonnis angle, lateral center edge angle, cross-over sign, and posterior wall sign were assessed. Preoperative clinical outcome scores included modified Harris Hip Score, HOOS, UCLA, and WOMAC. Correlation of femoral version, ROM, LCEA, ACEA, Tönnis angle, and α-angle was analyzed with a Spearman's Rank-Order Correlation ($P < 0.05$ considered significant). A Bonferroni correction was used to adjust the P-Value for family-wise comparisons.

Results: Based on the 314 patients in our cohort, the mean femoral version was 19.7 degrees ± 11.2 (range -20° to 50°). Femoral version correlated strongly with clinically measure hip range of motion, but did not correlate with either radiographic severity of acetabular dysplasia or preoperative symptomatology.

Conclusion: Despite concerns that transverse plane femoral anatomy influences stability of the hip joint, we did not find an association between measured femoral version and either the severity of acetabular dysplasia or the degree of presenting symptoms.

Significance: This study suggests that acetabular characteristics are primarily responsible for clinical presentation of acetabular dysplasia and that independent treatment of femoral version in the absence of clinically significant gait disturbance may not be necessary.

Correlation of Functional and Radiological Results with Three-Dimensional Gait Analysis in Patients with Unilateral Slipped Capital Femoral Epiphysis

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Purpose: Slipped capital femoral epiphysis (SCFE) is known to produce characteristic deformities in proximal femur, which affect hip motion and may cause gait disturbance. The aim of this study was to evaluate correlation between kinematic-kinetic changes related to postoperative residual deformity after in situ pinning of SCFE and clinical and also radiographic results.

Methods: Three-dimensional gait analysis of SCFE patients who were treated with in situ pinning were evaluated. To measure patient's quality of life and physical function, Harris hip score and Pediatric Outcomes Data Collection Instruments (PODCI) scores were used. Preoperative and sixth months postoperative Southwick angles (SA) in the anterior–posterior (AP) and lateral views and Articulo-Trochanteric Distance (ATD) were measured. A control group consisted of age-matched healthy people with no history of any medical problems that resulted in problems during gait.

Results: Thirty-one patients with mean age of 16 years were included. The average age of patients at surgery was 12.9 years and mean follow-up time was 3.3 years. The mean preoperative Southwick angles of the patients in AP view was 19.68 and lateral view was 32.78. Postoperative measurements of the SA in AP and lateral views were 14.48 and 23.38 respectively. The Southwick angles in postoperative AP view showed significant correlation with the mean knee flexion, thorax tilt and gait velocity ($p < 0.05$).

There was a significant correlation between the SA in postoperative lateral view and minimum knee flexion during swing ($p < 0.05$) and gait velocity ($p < 0.01$). There was a significant correlation between ATD with maximum internal rotation of hip, maximum knee abduction angle and knee abduction ($p < 0.05$). The Harris hip scores correlated significantly with maximum ankle dorsiflexion and foot progression angle (FPA) ($p < 0.05$). The Adolescent Global Functions Scales significantly correlated with pelvic tilt, the FPA, mean spine tilt and minimum spine tilt (towards to standing limb side, maximum spine tilt (towards swinging limb). The Adolescent Happiness Scales correlated with mean pelvis internal rotation and FPA ($p < 0.01$). The Adolescent Pain and Comfort Scales correlated with FPA ($p < 0.05$). The Adolescent Sports and Physical Function Scales correlated with the pelvic tilt, FPA and spine tilt. The Adolescent Transfer and Basic Mobility Scale significantly correlated with pelvic tilt, spine tilt and FPA ($p < 0.05$).

Conclusion: There were significant correlations between both functional and radiological results with the gait analysis data of patients with unilateral SCFE.

Significance: Three-dimensional gait analysis can be used as an evaluation tool for functional and radiographic outcomes of patients with SCFE.

Incidence of Acetabular Dysplasia in Breech Infants following Initially Normal Ultrasound: The Effect of Variable Diagnostic Criteria

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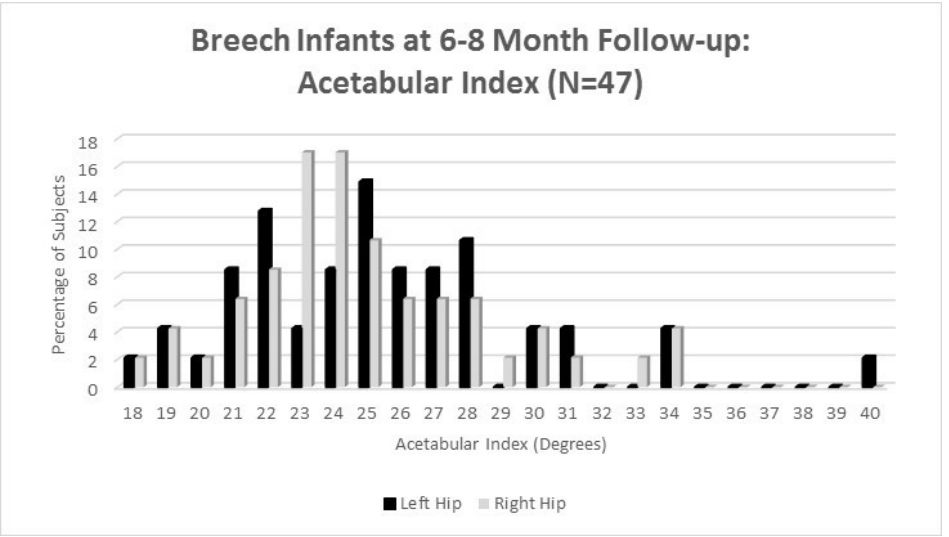
Purpose: Breech presentation is an important risk factor for developmental dysplasia of the hip (DDH). The purpose of this study was to determine the prevalence of acetabular dysplasia at 6 months of age in patients with breech presentation and previously normal hip ultrasounds, reporting primary radiographic measurements to allow for comparison with other patient cohorts.

Methods: A retrospective analysis of breech infants with initially normal clinical examinations and hip ultrasounds was performed to determine the rate of subsequent acetabular dysplasia and the distribution of acetabular index (AI) at approximately 6 months of age. Exclusion criteria included presence of an underlying diagnosis, prior treatment with Pavlik harness, or absence of relevant imaging data. AI was measured bilaterally on anteroposterior (AP) pelvic radiographs and reported using descriptive statistics.

Results: Forty-seven breech infants (38 female, 9 male) were eligible for analysis. All infants demonstrated normal ultrasound findings at a mean age of 6.9 ± 1.7 weeks and returned for follow-up at a mean age of 6.4 ± 0.5 months. On follow-up AP pelvic radiographs, mean right hip AI was 25.0° (SD ± 3.6°, Range = 18°-34°) and mean left hip AI was 25.5° (SD ± 4.9°, Range = 18°-40°). (Figure 1) If one uses a single standard deviation above the population mean (AI ≥28°) as criteria for diagnosing acetabular dysplasia, 16/47 patients in this cohort (34.0%) would be dysplastic. Alternatively, if two standard deviations above the population mean (AI ≥30°) are used to diagnose dysplasia (the most commonly used single threshold), only 5/47 patients (10.6%) would meet diagnostic criteria. However, strict adherence to Tönnis' previously established normative AI values stratified by gender and laterality results in only 3/47 patients (6.4%) qualifying as dysplastic.



Conclusion: The significant proportion of breech infants who, despite normal initial ultrasound findings, were diagnosed with dysplasia at approximately 6 months of age supports continued observation of breech-born patients beyond six weeks of age. However, reliance on different threshold values for diagnosing acetabular dysplasia can lead to wide discrepancies in reported prevalence rates.

Significance: Acetabular dysplasia is an important concern for breech infants even after normal initial US, but the prevalence can vary from 6-34% within the same cohort simply due to variable diagnostic criteria. For future studies, we encourage the reporting of primary AI values and distribution to facilitate direct comparison and meta-analysis of study data.

Disappearance of Soft Tissue Interpositions after Gradual Reduction using Overhead Traction in Late-Presenting DDH: A Prospective Comparative Study on Serial MRIs Between Pre-Walking and Walking Children

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Purpose: In late-presenting DDH, intra-articular soft tissue interpositions may prevent concentric reduction of the femoral head into the acetabulum. The purpose of this study is to assess changes in soft tissue interpositions after overhead traction (OHT) using serial MRIs and to compare them between pre-walking and walking children.

Methods: This is a prospective study of 60 children aged 6-31 months with DDH conservatively treated with OHT, our previously described method (JPO 2013), between 2007 and 2015. All hips were successfully reduced. One week after reduction, the hips were immobilized with cast for 1 month followed by hip flexion-abduction brace for 3-5 months. MRI was routinely performed at 1 and 6 weeks after reduction. The 3rd MRI was done only when concentric reduction was not achieved at the 2nd examination. The distance between the femoral head and acetabulum (DFHA), the thickness of the ligamentum teres (TLT), and morphological abnormalities (hypertrophy/inversion) of superior, anterior, and posterior labrums were measured using the T2-weighted coronal and axial images. Comparisons were made between pre-walking and walking children.

Results: Fourteen children who underwent MRI only once for various reasons were excluded. The remaining 32 pre-walking (34 hips) and 14 walking (14 hips) children were analyzed, and the mean ages at reduction were 9 (range, 7-13) and 22 (range, 13-33) months, respectively. Serial MRIs demonstrated that the intra-articular interpositions tended to disappear with time in all cases. On the 1st and 2nd MRIs, there were significant differences between the pre-walking and walking groups in the DFHA ($p=0.0003$ and $p<0.0001$) and the TLT ($p=0.0193$ and $p=0.0008$) (Table 1). The abnormal labrums which were frequently observed on the 1st MRI in both groups, decreased in pre-walking children but sustained in walking children on the 2nd MRI (superior, $p=0.0043$; anterior, $p=0.0001$; posterior, $p=0.0130$) (Table 1). Seven pre-walking (22%) and 10 walking (71%) children underwent the 3rd MRI at 4-8 and 4-10 months after reduction, respectively. Although there was still a significant difference between the groups in the DFHA ($p=0.0274$), the TLT and the abnormal labrums decreased even in the walking children (Table 1).

Conclusion: In both pre-walking and walking children with DDH, intra-articular soft tissue interpositions of the hips gradually decreased during immobilization following OHT. The interpositions of pre-walking children normalized more rapidly than those of walking children.

Significance: This study suggests that most children aged <3 years with DDH do not need surgical treatment of intra-articular interpositions which are usually observed soon after reduction.

Table 1. Comparison of MRI measures between pre-walking and walking children in DDH treated with overhead traction.

Variable		MRI	Pre-walking children (n = 34)	Walking children (n = 14)	p value
Distance between the femoral head and acetabulum		1st	3.9 ± 1.0 mm	6.1 ± 2.1 mm	0.0003†
		2nd	2.1 ± 0.8 mm	4.4 ± 1.7 mm	<0.0001†
		3rd*	2.3 ± 0.4 mm	2.8 ± 0.5 mm	0.0274†
Thickness of the ligamentum teres		1st	3.3 ± 1.0 mm	4.1 ± 0.7 mm	0.0193†
		2nd	2.4 ± 0.7 mm	3.2 ± 0.6 mm	0.0008†
		3rd*	2.1 ± 0.5 mm	2.6 ± 0.7 mm	0.1271
Rate of abnormal labrums	Superior labrum	1st	100%	100%	1.0000
		2nd	59%	100%	0.0043†
		3rd*	0%	40%	0.0557
	Anterior labrum	1st	100%	100%	1.0000
		2nd	24%	86%	0.0001†
		3rd*	0%	10%	0.3885
	Posterior labrum	1st	79%	93%	0.2559
		2nd	21%	57%	0.0130†
		3rd*	29%	10%	0.3229

*The 3rd MRI data were available for 7 pre-walking and 10 walking children.
†Statistically significant ($p < 0.05$).

Intraoperative Arthrogram Predicts Residual Dysplasia after Successful Closed Reduction of DDH

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Purpose: To analyze the occurrence of residual dysplasia after successful closed reduction of developmental dysplaisa of the hip(DDH), and to find out the correlation of arthrogram guided closed reduction quality with residual dysplasia with a new intraoperative radiographic criteria.

Methods: A consecutive series of patients with DDH treated at our institution by arthrogram-guided closed reduction during 2006 March to 2013 June were reviewed retrospectively. A total of 126 patients with 139 hips were included in this study. There were 23 males and 103 females involving 88 left hips and 51 right hips. The average age at closed reduction was 14 months (range, 7-19 months), and the average follow-up was 36 months (range, 24-100 months). Femoral head coverage(FHC) and arthrography type (A/B/C) on best reduced arthrographic image, acetabulum index and Wiberg Center-Edge(CE) angle on anterio-posterior(AP) pelvis radiograph at latest follow-up were measured. Residual hip dysplasia was determined according to Harcke acetabular dysplasia radiographic standard. Patients were divided into non-late acetabular dysplasia(non-LACD) group and late acetabular dysplasia(LACD) group according to final results, and age at reduction, gender, and side were compared between two groups. The correlation between FHC and arthrography type with residual hip dysplasia were analyzed. Multiple Logistic regression analysis was used to analyze gender, AI at CR, arthrography type and FHC with late acetabular dysplasia. ROC curve analysis was used to determine the cutoff value of FHC.

Results: Forty-five hips were determined as residual hip dysplasia among 139 hips, and the occurrence rate of residual hip dysplasia was 32.4%. 11(7.9%) hips occurred AVN, of which 9(81%) hips showed acetabular dysplasia. There was no significant difference among age at reduction, gender and side between two groups. There was significant difference with FHC(51.2±15.3% and 28.5±15.9% respectively, t=4.718, P=0.000) between two groups. And the percentages of LACD in the arthrography type C group was significantly higher than type A and B groups ($\chi 2$=17.170, p=0.017). However, the FHC value was the only prognostic factor for late acetabular dysplasia according to multiple logistic regression analysis. There was a clear cutoff value of FHC (30%) under which 81.8% hips were determined as late acetabular dysplasia according to ROC curve analysis.

Conclusion: Intraoperative arthrogram femoral head coverage(FHC) is an alternative predictor for residual hip dysplasia in DDH closed reduction, and FHC ≤30% can be considered as unacceptable reduction criteria.

Significance: Intraoperative arthrogram femoral head coverage(FHC) can be used to determin the reduction acceptable or not.

The Boston Periacetabular Triple Osteotomy for the Treatment of Hip Instability in Down Syndrome - Preliminary Results

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Purpose: To investigate the outcomes of a modified anteverting periacetabular Triple osteotomy in skeletal immature Down syndrome patients with hip instability.

Methods: After IRB approval, 20 Down syndrome patients (11 females, nine males) with hip instability who underwent a modified anteverting Triple osteotomy (29 hips) were evaluated. The average age at the time of surgery was 7.4±2.2 years, and follow-up was 3.4±2.4y (1.0-8.9y). There were 22 dislocatable/reducible hips (Bennet-II), six dislocatable hips with incongruent reduction (Bennet-III), and one fixed dislocation (Bennet-IV). Four patients (five hips) had previous varus derotational femoral osteotomy (VDRO) that failed to stabilize the hip. Radiographic evaluation included pre- and postoperative lateral (LCEA) and anterior (ACEA) center-edge angle, and acetabular inclination angle (AI). At the final follow-up, a modified Harris Hip Score (HHS) was used to assess hip pain and function. Failure was defined as persistent postoperative instability.

Results: At the final follow-up, 25 hips (86%) were stable, and the mean HHS was 84.6±18.3. There was a significant radiographic improvement, with a mean increase of 17.9±12.9º on LCEA ($p<0.0001$); 8.7±12.4º on ACEA ($p=0.03$), while the AI angle showed a decrease of 13.7±9.6º ($p<0.0001$). Three patients underwent VDRO simultaneously to Triple. There were 22 (76%) hips with no complication or complications that did not require change in postoperative course; six (21%) minor complications requiring ambulatory treatment and one major complication (3%). There were four failures (14%), one in a GMFCS-4 household patient, and three hips in two patients that are currently being treated with a brace. The most common complications were a stress reaction on the inferior ischiopubic ramus (9/29 hips-31%) that healed without an intervention and asymptomatic non-union of the ischial or pubic portion of the osteotomy (6 hips-21%). Two cases presented a premature closure of the triradiate cartilage without further residual dysplasia. There was one self-limited avascular necrosis of the femoral head.

Conclusion: Our modified anteverting Triple osteotomy provided global deformity correction and hip stability in 86% of the unstable Down hips after a mean follow-up of 3.4 years. However, we noticed that one third of the patients develop a stress reaction at the ischiopubic synchondrosis.

Significance: Hip instability in Down syndrome presents a complex surgical challenge. A complete redirection anteverting osteotomy of the acetabulum with adequate correction of acetabular retroversion allows for correction of the instability in the majority (86%) of the patients with a low rate of major complications.

Long Term Outcome Following Multilevel Surgery in Cerebral Palsy

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Purpose: Multilevel surgery (MLS) is an established modality in the management of progressive musculoskeletal deformities that occur in Cerebral Palsy (CP). This study evaluates the long term outcome of a consecutive, single centre cohort.

Methods: Formal authorisation to conduct this investigation was obtained from the National Health Service, Health Research Authority via a local Research and Ethics Committee.
A long term retrospective study was performed on all patients with diplegic CP who had undergone MLS more than ten years previously.
Gait analysis was performed using the Edinburgh Visual Gait Score (EVGS) and Functional Walking Score (FWS) six months preoperatively, three years postoperatively and at most recent review. The Short Form-36 (SF-36), Western Ontario and McMasters University Osteoarthritis Index (WOMAC) Functional Scale questionnaire and a verbal qualitative interview were used to evaluate outcome.

Results: Complete assessment was performed in 27 of 39 patients who met the inclusion criteria. Four patients were uncontactable, six patients refused to participate and two patients had incomplete data.
The mean follow-up was 17.7 years (range 10.7-23.8 years) and mean age at final review was 31 years (range 24-41) The mean FWS at the most recent review was 6.9 (range 2-9) with a mean increase of 1.0 compared with preoperative gait analysis.
There was a mean improvement in the EVGS of 18.4 (range -44-4) compared to the preoperative assessment, but a mean deterioration of 2.9 points, compared to the initial postoperative analysis.
The mean Physical Health and Mental Health Scores for the SF-36 were 39.5 (range 17-61) and 53.0 (range 23-69) respectively. The mean WOMAC Functional Score was 54.2 (range 26.5-75) and 96% of patients self-reported that they would recommend the procedure to other patients in the same situation.

Conclusion: MLS aims to improve function, by correcting the musculoskeletal deformities associated with CP. This study has shown that although there is a deterioration in initial outcome, there is long term improvement in FWS and EVGS, with associated improvement in function, independence and patient satisfaction.

Significance: There is a paucity of information on the long term outcome of MLS in patients with diplegic cerebral palsy. This study demonstrates long term benefits that continue into adulthood and will inform discussions with patients and families considering this treatment option.

The Outcome of In-Situ Fixation of Unstable Slipped Capital Femoral Epiphysis: Is the Rate of Avascular Necrosis (AVN) as High as Previously Reported?

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Purpose: There is limited information regarding the outcome of unstable Slipped Capital Femoral Epiphysis (U-SCFE). Available series are small, with rates of AVN as high as 50%. We report the outcome of a relatively large group of U-SCFE's that were treated with in-situ fixation.

Methods: We performed an IRB-approved, retrospective analysis of patients with SCFE's that were treated with in-situ fixation at our institution between 2005 and 2016. Pre- and post-operative clinical and radiographic information was collected. The complication rate, presence of impingement, and final hip ROM were recorded. The outcome of U-SCFE's was compared to that of stable ones (S-SCFE). The influence of multiple clinical and radiographic factors on the outcome was analyzed.

Results: During the study period, a total of 184 SCFEs were treated in 154 patients. There were 100 males and 54 females, with mean age of 12 years, mean weight of 72 kg, and mean follow-up of 108 weeks (24 to 354). The SCFE was classified as stable in 166 cases (S-SCFE - 90.2%), and unstable in 18 cases (U-SCFE - 9.8%). Mean length of symptoms prior to admission was 13 weeks. Mean Southwick angle at presentation was 33° (0° to 79°). All surgeries were performed in a flat-top table, without mechanical traction. A single screw was used to fix all S-SCFEs, while a combination of 1 (66.7%) or 2 (33.3%) screws was used to fix U-SCFE's. For U-SCFEs, the joint was decompressed by either needle aspiration or small capsular incision. Mean length of surgery was 57 minutes. **Table 1** demonstrates differences between U-SCFEs and S-SCFEs. In short, patients with U-SCFE's were more commonly male, lighter, had shorter duration of antecedent pain, more severe deformity, and required longer surgeries. The final ROM of the affected hip was comparable in both groups. A total of 11 complications (6%) were seen, including AVN (2.1%) and the need for subsequent surgery (3.9%). The rate of AVN in U-SCFEs and S-SCFEs was 11.1% and 1.2%, respectively (p=0.04). The rate of impingement in U-SCFEs and S-SCFEs was 44.4% and 27.6%, respectively (p=0.1).

Table 1.

	Stable n=166	Unstable n=18	p
Gender (M/F)	105/61	13/5	0.3
Age at presentation (years)	11.9	11.6	0.7
Weight at presentation (Kg)	72.7	65.7	**0.05**
Length of symptoms prior to surgery (weeks)	14.4	7.0	0.06
Southwick angle at time of presentation (degrees)	31.7	44.4	0.004
Length of surgery (min)	55.4	74.3	<0.0004

Conclusion: U-SCFEs are challenging. Patients with U-SCFEs tend to be lighter, have a more severe pre-operative deformity and present a greater operative challenge as

suggested by longer operative times. The greater preoperative deformity seen in U-SCFEs correlated with a higher rate of radiographic impingement during follow up.

Significance: While the results of this study suggest that the risk of AVN is significantly higher in U-SCFEs, it does appear that the rate is much lower than previously reported in smaller series of U-SCFE's.

The Management of Paediatric Open Tibial Fractures – Nine Years' Experience of 61 Cases at a Paediatric Specialist Centre: A Retrospective Case-Series

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Purpose: Open tibial fractures are complex and difficult to treat, with current evidence pre-dating the introduction of national standards in 2009. We investigate the management of skeletally immature open tibia fractures at a paediatric trauma centre, encompassing a multi-disciplinary combined orthopaedic and plastic surgery pathway.

Methods: A retrospective review was performed over nine years. Sixty-one children were treated with a mean age of nine years and median follow-up of ten months. Patients received intravenous antibiotics, early debridement and combined multidisciplinary treatment of skeletal and soft tissue injuries in line with BOA standards.

Results: There were 37 diaphyseal fractures and 24 distal tibial fractures. Of the distal fractures, eight involved the physis. Motor vehicle collisions accounted for two thirds of the injuries and 38 patients arrived out of normal working hours. The fracture stabilisation methods comprised: casting in 9 cases (15%); elastic nailing in 19 (31%); Kirschner wiring in 14 (23%); IM nailing in 1 (2%); ORIF in 3 (5%); and external fixation in 15 (25%). Wound management comprised: primary wound closure in 24 cases (39%), delayed primary closure in 11 (18%), SSG in 8 (13%), local flap with SSG in 17 (28%) and a free flap in one case. Seventy percent of cases were Gustilo grade 3.
We observed four superficial (6.6%) and three deep (4.9%) infections. Two deep infections occurred following open reduction and plate fixation and the third after Kirschner wire stabilisation of a distal injury. No patients who underwent primary wound closure developed infection. No patients failed to unite, although nine patients did require revision of mono-lateral to circular frame for delayed union (2/9) or unsatisfactory limb alignment or length (7/9).
Median time to union was 14 days longer in diaphyseal compared to distal fractures (76 vs. 91 days, p=0.016). We found adolescent children had a longer time to union compared to patients under 12 years old (114 vs. 80 days, p=0.045). Gustilo grade 3B injuries required twice the hospital stay compared to less severe injuries.

Conclusion: Paediatric patients have favourable healing potential with better outcomes than adults. We discourage the use of internal plate devices but advocate aggressive debridement in theatre with early definitive combined orthopaedic and plastic surgery skeletal stabilisation and synchronous soft tissue cover.

Significance: A large sample, multi-surgeon study where treatment regime of urgent antibiotic administration and multi-disciplinary early debridement had a low deep infection rate of 4.9%.

Health-related Quality of Life after Midshaft Fractures of the Clavicle in Children and Adolescents

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Purpose: Midshaft clavicle fractures are among the most common fractures in children and adults. There is a considerably debate regarding the preferred treatment strategy. While this used to be a classic domain for conservative treatment, there is a notable trend in the literature towards operative treatment, both in adults in children, especially in displaced fractures. In pediatric traumatology, there is only a limited number of trials that include a clinical long-term follow up which include a larger number of patients.
The aim of this study was to examine the health-related quality of life after pediatric and adolescent midshaft clavicula fractures in a large pediatric trauma center.

Methods: We identified a total of 785 patients treated conservatively or operatively for a fracture of the clavicle in our institution between 01.01.2004 and 31.06.2015. Exclusion criteria were age greater than 16 years, inability to fill in the questionnaire because of language deficiencies, neurologic or metabolic disorders or birth trauma. Of these, 682 had a midshaft clavicle fracture, as defined by the middle 1/3 of the clavicle. All patients were sent a questionnaire that included the Quick-DASH (Disabilities of the Arm, Shoulder, Hand) and the Peds-QL (Pediatrics Quality of Life).

Results: Currently, we were able to follow-up on 183 boys and 148 girls, resulting in a follow-up rate of 48.5%. The average age of the study participants was 6.78 (range 0.46 to 18.86)years. Of these, 324 were treated conservatively and 7 were treated operatively (ESIN (n= 4), plate (n=1), Ex Fix(n=2)).
At a mean follow-up of 6.1 years (range 0.99 to 12.33 years) the mean Quick Dash was 2.99 (SD 6.08) and the mean PedsQL Score was 96.74 (SD 8.23). In addition, 91% of participants reported good to excellent satisfaction with the cosmetically appearance. Data collection is continuing and data from a more complete follow-up will be presented.

Conclusion: In our preliminary analyses of 331 children and adolescents with a midshaft fracture of the clavicle, there were good to excellent result in the majority of our patients who were treated conservatively. While these preliminary results might be biased due to a non-complete follow-up, there was not statistically significant effect of age at accident, gender or initial dislocation. Therefore, conservative treatment appears to result in high health-related quality of life in this patient group.

Significance: Our data do not justify the current trend towards operative treatment for midshaft fractures of the clavicle in children and adolescents.

Growth of the Spine in Early Onset Idiopathic Scoliosis

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Purpose: The pattern and velocity of spine growth in early onset scoliosis has not been known. A retrospective study had been designed to measure the velocity of the spine from the infantile to later juvenile period in patients with infantile idiopathic scoliosis (IIS). The purpose of the study was to identify the growth pattern and velocity of the spine in early onset idiopathic scoliosis.

Methods: A consecutive series of IIS patients who had Mehta casting beginning <3 years of age and had radiographs measuring <10 degrees at a follow up of mean 6.3 years (5-7.4 years) from a single institution were studied. The PA full-length spine radiographs of each patient were used for measurement. The thoracic length, lumbar length, and each vertebral body height were measured. The parameters were categorized in three time periods: 0-3, 4-5, and 6-8 years old. Comparisons were made between the three periods to determine the growth spurt of the spine.

Results: There were 14 patients at an average age of 23.3 months at first casting, treated with an average of 4.8 casts over a 10.2 months period. The age of the final follow-up was average of 7.8 years old (6.5-9.2 years old). The growth rate of the thoracic and lumbar spine was greater in the 0-3 years (1.32 cm/year and 1.14 cm/year) compared to the 4-5 years (thoracic 0.81 cm/year and lumbar 0.59 cm/year) ($p<0.05$) and 6-8 years (thoracic 0.70 cm/year and lumbar 0.54 cm/year). The mean growth rates in the upper thoracic and lumbar vertebral height in the 0-3 years were greater than the ones in the 6-8 years ($p<0.05$), with no significant difference between 4-5 years and 6-8 years. The growth rate of the lumbar vertebral height was greater than the middle thoracic which was greater than the upper thoracic during the 0-3 years of age ($p<0.0001$) (Table).

Table: Velocity of the Vertebral Body Height (mm / year) in IIS

	0-3 years	4-5 years	6-8 years	All 3* P-Value
Upper thoracic Vertebra (T1, 2, 3, 4)	0.6 ± 0.4	0.7 ± 1.0	0.2 ± 0.5	0.03
Middle Thoracic Vertebra (T5, 6, 7, 8, 9)	0.9 ± 0.3	0.8 ± 0.5	0.4 ± 0.7	0.08
Lower Thoracic Vertebra (T10, 11, 12)	1.1 ± 0.3	0.9 ± 0.9	0.6 ± 0.9	0.26
Lumbar Vertebra (L1, 2, 3, 4, 5)	1.3 ± 0.5	1.0 ± 1.0	0.6 ± 0.7	0.004
All 4* P-Value	<0.0001	0.52	0.28	

* A Friedman's test was used for all time points and locations, followed by Wilcoxon's Signed test for two time points. Due to multiple comparisons, we may want to adjust for multiple comparisons and manually conduct a Bonferroni correction (alpha = 0.05# of comparisons).

Conclusion: The initial growth spurt of the spine in IIS is in the first three years of life and is greatest in the lumbar spine.

Significance: Initiating casting prior to 3 years of age will provide the greatest opportunity for success since rapid growth occurs in this time period.

Peri-operative Outcomes in Obese versus Non-obese Children Following Posterior Spinal Deformity Surgery: An ACS-NSQIP Analysis

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Purpose: Posterior spinal fusion for the treatment of scoliosis is one of the most common spinal procedures in the pediatric population. However, the role obesity may play on outcomes following this extensive surgery is poorly understood. The purpose of this study was to evaluate the effects of obesity on short term peri-operative outcomes in posterior spinal deformity surgery.

Methods: The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database for children was queried to identify pediatric patients who underwent posterior spinal deformity correction surgery. Children were categorized as obese if their BMI exceeded 95th percentile for their age group in months or if their BMI exceeded 30 kg/m2. They were then compared in regards to demographics, pre-operative comorbidities, intra-operative, and post-operative outcomes. Statistical analysis was performed utilizing independent t-tests for continuous variables and chi-square analysis for categorical data. An alpha level of <0.05 denoted statistical significance.

Results: A total of 4410 patients met the inclusion criteria for the study. Of these, 3768 patients were non-obese while 642 patients met the criteria for pediatric obesity. Preoperatively, obese patients were more likely to be males (35.5% vs. 29.3%, $p<0.05$), younger (13.1 ± 2.8 vs. 13.7 ± 2.9, $p<0.05$), and diabetic (0.9% vs. 0.3%, $p<0.05$). Obese patients also demonstrated a lower incidence of cerebral palsy (5.0% vs. 12.1%, $p<0.05$) and nutritional support (3.6% vs. 10.5%, $p<0.05$). Intra-operative findings demonstrated longer total operative time (314.5 ± 118.9 vs. 293.6 ± 116.6 mins, $p<0.05$) and time under anesthesia (423.4 ± 133.6 vs. 401.0 ± 132.2 mins, $p<0.05$) in the obese cohort. Post-operatively, obese patients demonstrated a higher incidence of superficial surgical site infection (SSI) (2.2% vs. 0.8%, $p<0.05$), deep SSI (2.3% vs. 0.9%, $p<0.05$), and pulmonary embolism (0.2% vs. 0.0%, $p<0.05$). No other differences were observed in demographics, medical conditions, or post-operative complications.

Conclusion: Obesity significantly increases the risk for early complications in pediatric patients undergoing spinal deformity surgery. Obese patients are at increased risk for longer operative time, anesthesia exposure, postoperative infection, and pulmonary embolism.

Significance: These potential complications contribute significantly to morbidity and may even be life threatening. As such, spine surgeons should be cognizant of these potential adverse outcomes and should consider the benefits of prophylactic protocols. In addition, prospective standardized studies should be conducted to elucidate the risk obesity may play in the development of adverse outcomes following spinal deformity surgery in the pediatric population.

Table 1: Demographic and Preoperative Risk Factors for Obese Patients Undergoing Posterior Spinal Deformity Surgery			
	Obese	**Non-Obese**	**p-value**
Count	642	3768	
Age (years)	13.1 ± 2.8	13.7 ± 2.9	**<0.05**
Gender			
Male	35.5%	29.3%	**<0.05**
Female	64.5%	70.7%	
Ethnicity			
White	67.9%	67.2%	
AA or Black	13.9%	15.2%	
Hispanic	8.7%	5.8%	0.70
Asian	1.7%	2.4%	
Other/Not Reported	7.8%	9.4%	
Diabetes	0.9%	0.3%	**<0.05**
Asthma	9.7%	9.4%	0.82
Cystic Fibrosis	0.0%	0.0%	-
Bronchopulmonary Dysplasia/Chronic Lung disease	3.4%	4.4%	0.26
Structural pulmonary/airway abnormality	6.9%	5.8%	0.30
Esophageal/gastric/intestinal disease	9.3%	11.7%	**0.09**
Biliary/liver/pancreatic disease	0.5%	0.3%	0.47
Cardiac risk factors			
Minor	3.9%	5.5%	0.14
Major	2.2%	2.9%	
Severe	0.3%	0.7%	
Acute Renal Failure	0.0%	0.0%	-
Cerebral Palsy	5.0%	12.1%	**<0.05**
Neuromuscular Disorder	21.8%	24.4%	0.16
Immune Disease/Immunosuppressant Use	0.3%	0.5%	0.47
Bone Marrow Transplant	0.0%	0.2%	0.22
Solid Organ Transplant	0.3%	0.1%	0.29
Nutritional support	3.6%	10.5%	**<0.05**
Bleeding Disorders	0.6%	0.9%	0.48
Hematologic Disorder	1.9%	1.6%	0.68
Chemotherapy for malignancy within 30 days	0.2%	0.1%	0.88
Radiotherapy for malignancy in last 90 days	0.0%	0.0%	-
Prior Operation within 30 days	1.9%	1.1%	**0.09**

Anterior Spinal Growth Tethering Leads to Asymmetric Growth of the Apical Vertebra

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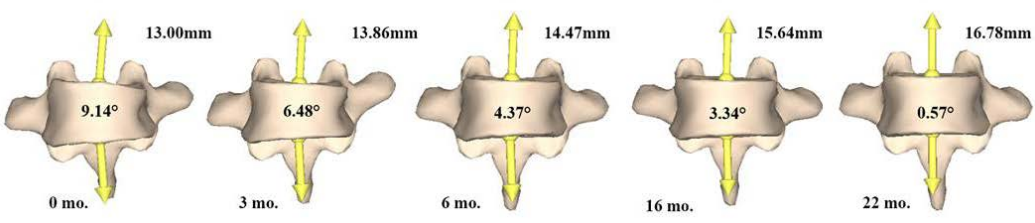
Purpose: Anterior spinal growth tethering (ASGT) is a relatively new non-fusion method of spinal growth modulation that aims to create asymmetric growth of vertebrae resulting in progressive scoliosis correction during the adolescent growth spurt. The purpose of this study was to evaluate if ASGT results in asymmetrical apical vertebral body growth and leads to scoliosis correction.

Methods: A retrospective review of patients treated with ASGT between 2011 and 2014 was conducted. Patients with ≥17 months of follow-up and simultaneous bi-planar x-rays were required for inclusion. Patients were excluded if there was evidence of tether breakage prior to 18 months of follow-up. 3D reconstructions based on the bi-planar images were subsequently reconstructed (SterEOS software) and various dimensions/angles of each apical vertebra were serially quantified via custom Matlab (Mathworks, Natick, MA, USA) software. The rate of change over time in each variable of interest (Cobb angle, apical vertebra body convex and concave side heights, apical vertebra body anterior and posterior heights, apical vertebra coronal plane wedging angle, apical vertebra sagittal plane wedging angle) was calculated for the individual patients and compared between groups utilizing nonparametric statistics: patients with scoliosis correction/improved Cobb angle and those with no correction/continued curve progression.

Results: Of 13 subjects included, 9 had progressive improvement in their scoliosis and 4 did not improve or worsened. The average age at tether placement was 11.8±1.8 years with a mean pre-operative scoliosis Cobb angle of 51°±11° (35°-69°). All patients were Risser 0. Follow-up ranged from 17-36 months with 4 to 7 post-operative visits. Following tether placement the FE Cobb angle was reduced to 34°± 8°. Over time, the correction group demonstrated significantly less apical vertebral wedging in the coronal plane, (ave rate of change -0.11°/mo) compared to the no correction group (0.04°/mo, p=0.02). The correction group also showed increased vertebral height over time on the concave side of the curve (0.11mm/mo), as compared to the no correction group (0.01mm/mo, p=0.005). Figure 1 is a case example of how the apical vertebral wedging decreased and vertebral height on the concave side increased over 22 months.

Figure 1: Apical vertebral wedging and concave vertebral height changing over 22 months follow-up.



Conclusion: ASGT in immature patients with thoracic scoliosis has the potential to asymmetrically modulate the growth of the apical vertebra. Greater concave sided growth was associated with greater degrees of overall Cobb angle correction.

Significance: This study offers convincing 3D radiological evidence that ASGT works to modulate vertebral growth as the mechanism of progressive scoliosis correction.

Construct Levels to Anchored Levels Ratio and Rod Diameter are Associated with Implant-Related Complications in Traditional Growing Rods

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Purpose: Implant-related complications (IRC) are among the most common adverse events in traditional growing rod (TGR) surgery for early-onset scoliosis. The current study hypothesized that anchor type and anchor configuration are associated with IRC.

Methods: A multicenter EOS database was queried. Patients with: 1) age ≤10 years at surgery; 2) spine-based dual TGR; 3) minimum 2-year follow up; and 4) available imaging were included. Cephalad and caudal foundations were grouped based on number of instrumented levels and anchor type. All radiographs were reviewed and IRC was defined as rod fracture, anchor pull out, prominence, and loosening. Based on statistical findings, a "Construct Levels to Anchored Levels" (CL/AL) ratio was calculated, which is the number of levels spanned by instrumentation divided by the number of levels with bone-anchor fixation. Receiver operating characteristic curve was used to define CL/AL threshold.

Results: 274 patients divided to complicated (n=140) and non-complicated (n=134) groups. Mean follow up was 6.3 years (2.1-18.0 years). No significant differences in age, gender, BMI, ambulatory status, etiology, primary curve size, T1-S1 height, coronal and sagittal balance, and rod material were observed between two groups. Comparative analysis showed that connector type, presence and location of crosslinks, number of levels instrumented, number and type of anchors, presence of pelvic fixation, and mirroring of cephalad and caudal foundations were not different (Table 1). However, maximum kyphosis and rod diameter were significantly different. CL/AL ratio threshold was 3.5. Multivariate analysis of kyphosis, rod diameter and CL/AL ratio showed a significant association with IRC ($p<0.05$).

Conclusion: While patient characteristics like kyphosis have been proven to be associated with instrumentation failure, it is a combination of characteristics that include rod diameter and CL/AL ratio that showed significant correlation with IRC. It is recommended to validate the proposed CL/AL ratio in future studies.

Significance: In addition to patient characteristics

Table 1.

Pre-operative Demographics and Radiographic Parameters				
	Complicated	**Non-Complicated**		**P value**
N	140	134		
Age	6.5	6.9		0.186
BMI	16.7	17.4		0.325
Primary Curve (°)	76.9	73.1		0.109
Coronal Balance (mm)	30.1	25		0.598
Sagittal Balance (mm)	22	20.3		0.941
T1-S1 height (mm)	261.5	266		0.393
Maximum Kyphosis (°)	55.2	46.1		0.014*
Comparisons After Controlling for Maximum Kyphosis				
Max Kyphosis	**Odds Ratio** 1.1	**Lower** 0.97	**Upper** 1.24	**P value** 0.123
CL/AL ratio				
<3.5	1			
3.5≤	3.43	1.89	6.24	< 0.001*
Rod Diameter				
<4mm	5.52	1.66	18.37	0.019*
4-5mm	3.65	1.29	10.31	0.005*
5 mm < (reference group)	1			0.015*

* Statistical significance was set at $p<0.05$

consideration of length of construct to number of anchored levels ratio and rod diameter should be a part of preoperative planning to minimize implant-related complications.

Correcting for Patient Rotation with Respect to the X-ray Scanner Improves the Prediction of the 3D Sagittal Spinal Measurements from Radiographs

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Purpose: To estimate the 3D thoracic kyphosis from 2D radiographical measurements in the frontal and sagittal view.

Methods: 46 right thoracic AIS patients received biplanar radiographs. Using a dedicated software, 3D reconstructions of the spine were generated to provide 3D measurements of T1-T12, T1-T4 and T4-T12 kyphosis, L1-S1 lordosis, and pelvic rotation. Using the same radiographs, 2D T1-T12, T1-T4, T4-T12 kyphosis and L1-S1 lordosis, thoracic and lumbar Cobb angles, and the frontal Cobb deformity between T1-T4, T4-T12 were manually measured. Pelvic axial rotation was measured using the frontal and sagittal distances between the two femoral heads on the X-ray images (Fig.1). In addition, 2 factors determining the direction of rotation of the lumbar and pelvis (+1 clockwise, 0 counter clockwise) were considered. A multiple linear regression model was used to predict 3D kyphosis/lordosis from 2D kyphosis/lordosis, 2D frontal curve measurements of the thoracic and lumbar, 2D femoral head rotation, and the two directional factors.

Results: 2D and 3D pelvic rotation were significantly correlated ($r = 0.84$, $p<0.05$). 3D T1-T12 kyphosis was predicted from 2D T1-T12 kyphosis, 2D pelvic rotation, 2D thoracic Cobb, and the direction of pelvic rotation ($R^2 = 0.80$, $p<0.05$). The 3D L1-S1 lordosis was significantly predicted by the 2D L1-S1 lordosis, 2D pelvic rotation, and the direction of lumbar rotation ($R^2 = 0.60$, $p<0.05$). The mean absolute error between the predicted T1-T12 kyphosis and 3D kyphosis was 4.1° and between predicted lordosis and 3D lordosis was 6.7°. The prediction of the segmental sagittal measurements (T1-T4 and T4-T12 kyphosis) was only predicted by 2D T1-T4 ($R^2= 0.34$, $p<0.05$) and 2D T4-T12 ($R^2=0.66$ $p<0.05$) kyphosis; the corresponding segmental measurements of the frontal thoracic (T1-T4 and T4-T12 Cobb) and pelvic rotation did not appear significant $p>0.05$.

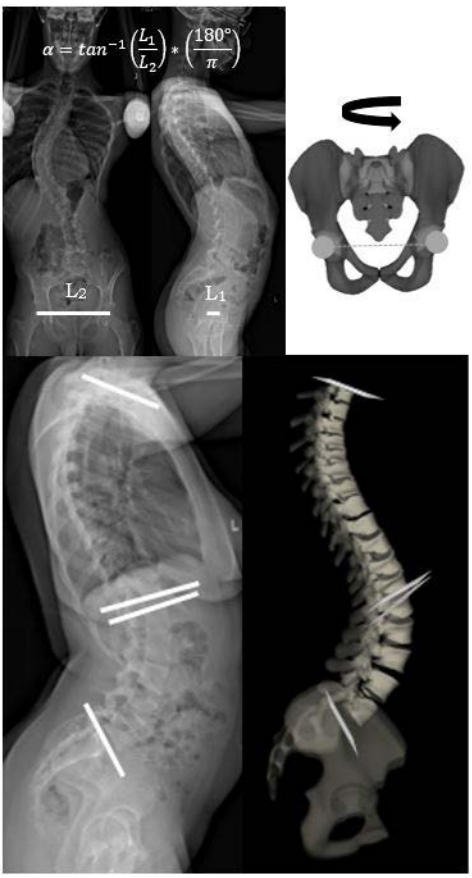

Figure 1- demonstration of 2D versus 3D A) pelvic rotation and B) sagittal spinal measurements

Conclusion: Considering the pelvic rotation correction can significantly impact the prediction of the 3D kyphosis and lordosis measurements from the 2D radiographic measurements. The T1-T4 and T4-T12 kyphosis do link to the overall rotation of the scoliotic curve, thus could not be predicted by the frontal plane spinal deformity and pelvic rotation.

Significance: While discrepancies in patient positioning are unavoidable, the presented method permits to correct for patient's rotation with respect to the scanner and use the 2D radiographical measurements to achieve a better estimate of true 3D sagittal plane measurements.

Expect Minimal Further Correction and Higher Risk of Complications in Revisions from Traditional Growth Rods to Magnetically Controlled Growing Rods

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Purpose: Magnetically controlled growing rods (MCGR) first appeared in the U.S in 2014. While MCGR may minimize surgeries needed for lengthenings compared to traditional growth-friendly instrumentation for early onset scoliosis (EOS) patients, research studies are still lacking. In this study, the spinal deformity correction and complications between new MCGR implants and conversions from other growth-friendly instrumentation were compared. We hypothesize greater curve correction in new MCGR implants compared to conversions, while complications will be higher in conversions.

Methods: In this retrospective cohort study, MCGR patients were queried from a multi-center EOS registry between 2014-2016. Major Cobb and kyphosis angles at immediate and 1-year post-operative visits, and 1-year complications were compared between new implants and conversions.

Results: In total, 49 patients (mean age 7.8y; 28 female/21 male) were identified. The scoliosis etiology included congenital (7), idiopathic (18), neuromuscular (15), and syndromic (9). There were 31 patients with new MCGR insertion and 18 converted to MCGR at a mean of 3.5 years after original implantation. The average lengthenings per year were 3.6 (new implants) and 3.8 (conversions). For new implants, the mean Cobb/kyphosis angles changed from 71.4°/56.7° preoperatively to 40.9°/43.2° immediately after surgery, and 45.4°/46° at 1-year evaluation. The change for the conversions was 63.1°/52.5° to 61.3°/57.4°, and finally 56.1°/58.5°. There were significant decreases in both Cobb and kyphosis angles for the new implants immediately after surgery ($p<0.05$), but not for the conversions. There were 16/49 (33%) unique patients with complications and 24 incidences. Complications occurred for 26% and 44% of the new implants and conversions respectively and the difference trended towards significance ($p=0.18$). While there was a clinically significant difference in complications between the groups, there was no difference in severity per the Smith Classification.

Conclusion: New MCGR implants had significant Cobb and kyphosis angles correction while conversions did not, due to their previous implants' correction. The higher complication risk for the conversions is likely influenced by prior spine surgeries. Despite this, the conversion goals were achieved by minimizing the need for repeat lengthening surgeries and by maintaining curve correction.

Significance: MCGR has significant benefit in treating EOS patients by obviating the need for repeat surgical lengthening procedures. This study demonstrates that MCGR is successful in achieving spinal deformity correction in newly implanted patients, while also maintaining prior correction in converted patients. The higher risk of complications in conversions was expected due to prior surgical history, but still reduces converted patients' future exposure to surgical lengthenings.

Incidence of Preoperative Intra-spinal and Extra-Spinal MRI Abnormalities in Adolescent Idiopathic Scoliosis

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Purpose: Indications for the routine use of preoperative magnetic resonance imaging (MRI) in patients with adolescent idiopathic scoliosis (AIS) remain controversial. Previous studies have reported an incidence of intra-spinal MRI abnormalities between 2.8% and 28%, however none of these studies comment on the incidence of extra-spinal abnormalities. A large prospective study concluded that patients with clinical and radiographic diagnosis of AIS should not have preoperative MRI. The purpose of this study was to determine the incidence of intra-spinal and extra-spinal MRI abnormalities in patients with a clinical and radiographic diagnosis of AIS, and to determine if any of these findings required surgical management prior to spinal deformity surgery.

Methods: We retrospectively reviewed the medical records of a consecutive series of patients with AIS managed with surgery from 1996 – 2015. All patients were evaluated by a single surgeon and all underwent a routine neural axis MRI prior to surgery. MRI reports were reviewed for all patients, and intra-spinal and extra-spinal abnormalities were recorded. Abnormalities were classified into the following groups: Chiari malformation, syringomyelia, intra-spinal mass, other CNS abnormality, extra-spinal abnormality, spondylolysis/spondylolisthesis, and degenerative changes. Descriptive statistics were used to describe the incidence and types of abnormalities.

Results: Medical records and MRI reports were available for a consecutive series of 261 patients with AIS. MRI abnormalities were noted in 121 patients (46%). After excluding patients with degenerative changes, MRI abnormalities were noted in 69 patients (26%). The incidence of Chiari malformation was 1.5% and syringomyelia was 5.4%. Extra-spinal abnormalities were noted in 10% of patients, and these findings ranged from benign cysts to malignant soft tissue tumor. Most notably, a massive syrinx associated with Chiari type 1 malformation was discovered in a completely asymptomatic patient with normal preoperative evaluation and reflexes. This finding resulted in neurosurgical decompression prior to spinal deformity surgery. Similarly, a Wilm's tumor was discovered in another patient that was treated with surgical resection prior to spinal deformity surgery. Preoperative MRI findings altered surgical management in 0.7% of patients with AIS.

Conclusion: Significant intra-spinal and extra-spinal MRI abnormalities were noted in patients with AIS. Routine preoperative MRI prior to spinal deformity surgery may be indicated, and it may provide additional health benefits and possibly cost savings.

Significance: Preoperative MRI may reveal significant intra-spinal and extra-spinal abnormalities requiring surgical management prior to spinal deformity surgery.

Clinical Outcomes of Pre-Operative Halo Gravity Traction versus Intra-operative Halo Femoral Traction in the Management of Severe Scoliosis in Cerebral Palsy

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Purpose: Pre-operative halo gravity traction (HGT) has been utilized in the operative management of severe curves in neuromuscular scoliosis (NMS). Recently, intra-operative halo-femoral traction (IHFT) has become more widely used, but there is a paucity of data comparing these two techniques in the cerebral palsy (CP) patient population. Thus, the purpose of this study was to assess clinical outcomes of HGT versus IHFT in the management of NMS in patients with CP.

Methods: Retrospectively, patients were included with a diagnosis of NMS secondary to CP who underwent posterior spinal fusion. The HGT cohort included patients with pre-operative HGT and IHFT, where the IHFT cohort received no pre-operative intervention. Pre-treatment and follow-up data points were collected, which included curve type, curve magnitude, presence of hyperkyphosis (>60°), pelvic obliquity (degrees from horizontal), duration of hospitalization (LOS, days) and associated post-operative complications. Statistical significance was defined as $p \leq 0.05$.

Results: 12 patients (75% male) were treated with HGT and 21 (57% male) were treated with IHFT. See Figure 1 for demographic and initial spinal curve characteristics of the cohorts. Maximal coronal curve correction was 63° (±31.0°) and 65° (± 18.4°) for the HGT and IHFT groups respectively (p=0.19). Lumbar curve correction was 43° (±25.9°) for HGT and 62° (± 22.9°) for IHFT (p=0.05). Change in pelvic obliquity was 10° (± 9.6°) in HGT and 19° (± 9.6°) in the IHFT cohort (p=0.03). LOS averaged 36 (± 9 days) in the HGT compared to 16 (± 12 days) in IHFT (p<0.01). 5 patients in the HGT cohort had hyperkyphosis, with average correction of 11° (±6.4°) compared to nine patients in the IHFT with an average of 26° (±20°) of correction (p=0.07). There was one complication (wound infection) in the HGT cohort (8%) and four complications (femur fracture, wound infection, hardware removal, revision PSF) in the IHFT (19%) (p=0.88) cohort.

Conclusion: The HGT and IHFT cohorts had similar pre-operative demographics and curve severity, with the exception of increased weight placed in the IHFT cohort. Post-operatively, there was no difference in maximal coronal or sagittal curve correction in the cohorts. However, there was statistical improvement in lumbar curve correction, pelvic obliquity and decreased LOS in the IHFT group.

Significance: Consideration should be given to the use of IHFT for the management of severe curves in patients with NMS secondary to CP, since IHFT achieves improved lumbar curve and pelvic obliquity correction without the incremental increase in hospital stay associated with HGT.

Figure 1: Demographics and Initial Spinal Curve Characteristics

	Pre-Operative Halo Gravity Traction		Intra-Operative Halo Femoral Traction		
	Average	**STD**	**Average**	**STD**	**p value**
Age at Halo (years)	14.1	2.4	15.8	2.5	0.70
GMFCS Level V (%)	73%	-	86%	-	0.92
Weight at Halo Application (kg)	54.9	12.0	39.2	9.7	0.78
Weight of Maximal Traction (lbs)	37.8	8.4	46.4	-	0.02
% of Body Weight in Traction	46.6%	7.9%	55%	15%	0.04
Duration of Pre-operative HGT (days)	22.4	6.7	-		
Type of Curve					
C shaped (%)	64%	-	39%	-	0.80
S shaped (%)	36%	-	61%	-	0.80
Pre-Halo Thoracic Curve (degrees)	54.0	34.2	46.6	22.2	0.51
Pre-Halo Lumbar Curve (degrees)	65.7	38.2	85.0	26.0	0.14
Pre-Halo Maximal Curve (degrees)	87.8	26.9	90.3	16.0	0.77
Sagittal Profile Kyphosis (degrees)	51.8	22.3	52.2	32.4	0.96
Number of Fusion Levels	15.8	3.6	16.8	0.9	0.37
Follow-up Duration (months)	13	11	18	18.4	0.30

3D Acetabular Changes following Ischemic Osteonecrosis of the Femoral Head in a Porcine Model

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Purpose: While the pathogenesis of femoral head deformity following ischemic osteonecrosis has been studied extensively, accompanying morphological changes to the acetabulum have not been investigated in a systematic fashion. The purpose of this study was to determine if acetabular changes accompany femoral head deformity in a well-established piglet model of Perthes disease and to define associated acetabular changes using advanced 3D CT imaging and modeling.

Methods: 24 male pigs (aged 5-9 weeks) had ischemic osteonecrosis of the right femoral head induced by suture ligation around the femoral neck and transection of the ligamentum teres. The pigs were sacrificed at 8 weeks postoperative when a moderate to severe femoral head deformity is expected in this model. The deformity was quantified using epiphyseal quotient, a ratio of maximal femoral head height to its diameter on AP radiograph. 3-D CT reconstructions of each pelvis were obtained using MIMICS software. Custom MATLAB software was then used to radially section the acetabulum into 8 regions to measure acetabular coverage angles (**Fig. 1**). Paired t-test was used to compare the left, non-operated to the right, operated side. Significance was set at $p<0.05$.

Results: Femoral epiphyseal quotient for the non-operated side averaged 0.50±0.02 while the operated side averaged 0.34±0.08, indicating a moderate to severe femoral head deformity. 3-D CT assessment of acetabular morphology showed a significant decrease in the acetabular anteversion and tilt of the affected side compared to the normal side (33±6° vs. 38±5° and 34±4° vs. 38±3°, $p < 0.001$). There was also a decrease in the overall average acetabular coverage angle in the affected side in all 8 regions measured. The inferior-posterior, posterior, superior-posterior, and superior quadrants were significantly lower in the affected side compared to the non-operated side ($p<0.05$).

Conclusion: Development of femoral head deformity following ischemic osteonecrosis produced a significant decrease in the acetabular anteversion and coverage angle, similar to the findings noted in patients with Perthes disease.

Significance: This is the first study to investigate the 3-D morphological changes to the acetabulum in a well-established piglet model of Perthes disease. Development of femoral head deformity produced acetabular changes described in patients with Perthes disease. The model may serve as a valuable tool to determine the relationship between femoral head deformity and acetabular changes seen in Perthes disease.

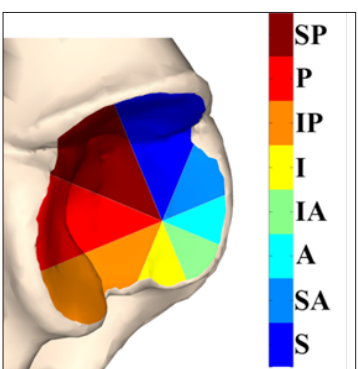

Figure 1: The 8 regions of the acetabulum radially sectioned for acetabular coverage angle analysis.

Percutaneous Metaphyseal Juxta-physeal Perforations: A New Potential Approach to Limb Lengthening

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Purpose: Bone lengthening has developed considerably during the last decades and is mainly based on the callotasis principles. Many complications of lengthening procedures are reported in the literature, the number of which increases with the number of required lengthening sessions to achieve limb equalization. We postulated that percutaneous juxta-physeal perforations could improve bone growth while decreasing the risks related to lengthening procedures and this study was undertaken to test this hypothesis.

Methods: This is an IRB approved experimental study on 10 New Zealand white rabbits aged between 8 and 9 weeks who underwent percutaneous image guided juxta-physeal perforations at the right proximal tibia, whereas the left tibia served as control. Radiological controls were performed monthly to measure the longitudinal growth and any angular deviation of the operated and non-operated tibias. A paired 2-tailed t-test was used at the end of the experiments to compare the differences in growth between the right side (operated) and the left side (control). After completion of the study, the rabbits were sacrified and a histopathological study was undertaken.

Results: The operated tibia became longer than the non-operated one by 3.06 mm±2.09 at week 4; 4,13mm±1.8 at week 8; and 4,66mm±1.88 at week 16. There has been also an increasing valgus of the operated tibia of +0.38° at week 4; +3.8° at week 8, and +4.7° at week 16. The left (control) tibia showed initially a varus deviation followed by a trend to approach its starting angle over time.

Conclusion: Percutaneous metaphyseal perforations have shown to produce limb lengthening and angular deviation in New Zealand rabbits, probably through an increase in physeal activity induced by hyper-vascularization. They may be used in children as an adjunct or in alternation with serial lengthening in severe limb length inequality, thereby reducing lengthening complications.

Significance: This study opens prospects for other experimental research assessing non-invasive techniques to improve bone growth in other diseases such as acetabular dysplasia, and may serve as a model for future studies concerning similar topics.

Restoring the Damage Growth Plate Using a Drug- and Cell-Loaded PGLA Scaffold in a Rabbit Model

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Purpose: Premature closure of the growth plate can occur in children following fractures or infection, resulting in leg length discrepancy or angular deformity. We sought to evaluate novel regenerative techniques including drug-loaded, porous PGLA scaffolds and cell-based therapies to restore the damaged growth plate using an immature rabbit model. We hypothesized that scaffolds loaded with stem cells and GSK-126 would result in improved anatomic alignment after physeal bar resection compared to controls.

Methods: Twenty- five Immature New Zealand rabbits underwent ablation of the medial proximal tibial physeal bar (IACUC #, A25515). Three weeks after surgery, physeal bar resection was carried out from all rabbits and scaffolds were implanted as an interposition graft–. There were four treatment groups: blank, GSK-126-loaded, cell-loaded, and GSK-126-cells-load scaffolds. GSK-126, a potent epigenetic regulator, eluted from the scaffolds in a sustained manner over 21 days. Rabbit bone marrow stem cells (BMSCs) were loaded onto the scaffolds and grown for 48 hours (Fig. 1). MicroCT, MRI, radiographs and histology were performed to assess angular deformity and anatomy at 3 weeks after physeal bar resection.

Results: Significantly larger angular deformities were observed in the surgical groups compared to the control limb, with mean femorotibial angle of 25 vs. 3 degrees ($p<0.001$) and metaphyseal-diaphyseal angle of 69 vs. 90 degrees ($p<0.001$). There was no significant difference in anatomic axis or metaphyseal-diaphyseal angle in the blank scaffold group ($p=0.36, 0.63$) compared to the treatment groups (Figure 2). Physeal bar and scaffold were visible on MRI (Figure 3), and microCT showed disruption of the physis.

Conclusion: We attempted regeneration of the physis in a rabbit model, which effectively created a physeal bar. Interestingly, there was no detected difference in restoration of physeal growth using either blank, drug-loaded, or cell-loaded scaffolds. MRI and CT were effective means of measuring the extent of the physeal bar in addition to standard histology.

Significance: Further work is needed to optimize drug and cell delivery to the damaged physis in order to facilitate regeneration and restoration of physeal growth.

Figure 1. The BMSCs seeded scaffold under the fluorescence microscope. Green color indicates living cells growing on scaffold.

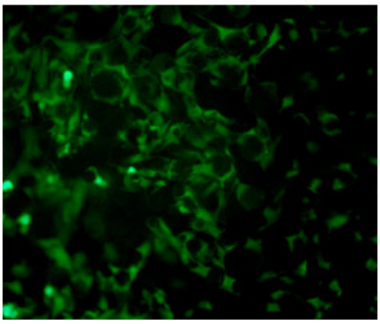


Figure 2: Tibiofemoral Anatomic Axis for Physeal Bar Resection vs. Controls

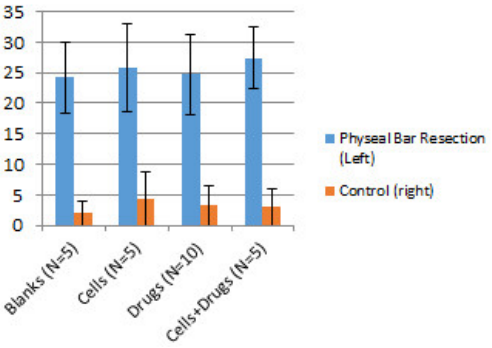
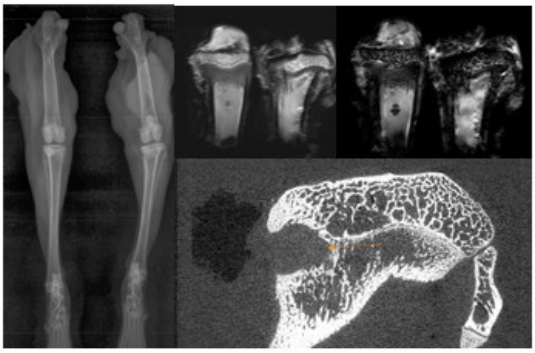


Figure 3. Left affected leg was treated with physeal bar resection and subsequently reconstructed with drug- and cell-loaded scaffolds.



Three Dimensional Analysis of Bone Morphology Following Periosteal Transection

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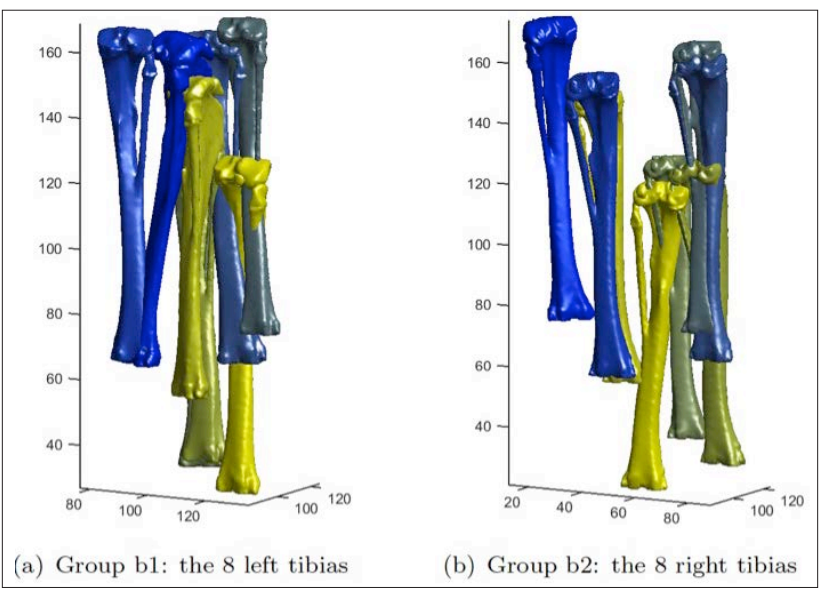
Purpose: Accelerated longitudinal growth following periosteal procedures has been previously demonstrated. Circumferential periosteal transection resulted in increased bone length. To date, the effect of such procedure on the three-dimensional shape of the bone is unknown. In this study we use comparative intuitive geometric measures and statistical shape analysis to compare the overall three-dimensional shapes of the bones following periosteal transection.

Methods: Eight, 7-9 week old New Zealand White rabbits underwent unilateral circumferential periosteal transection of the tibia at the level just distal to the MCL insertion on one limb, while a sham procedure was performed on the other. The animals were recovered and CT scans of the tibia were then performed immediately post-operatively eight weeks later. The CT images were then utilized to create three-dimensional models (Figure below) that were then subjected to comparative intuitive geometric measures and statistical shape analysis.

Results: No significant differences in shape were found between control and operative tibiae at time zero (immediately following transection). At eight weeks postoperatively, significant differences were found in tibial length (1.5+/-1.1% increase, $p=0.002$) and circumference (7+/-2.7% increase, $p<0.001$). In addition the experimental limbs were found to have significantly more proximal bend ($p<0.001$) than the sham limbs.

Conclusion: Cutting the longitudinal periosteal fibers resulted in longer and larger bones, thus it appears that the periosteum plays a role in regulating bone length and bone width (diameter).



(a) Group b1: the 8 left tibias (b) Group b2: the 8 right tibias

Significance: As the mechanical strength of long bones is dependent on geometry, the increased diameter of the bones following periosteal transection may have therapeutic implications outside of those of treating limb length discrepancies and angular deformities.

Characterising Variability of Gait in Ambulant Children under Five

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Purpose: It is normal practice during gait analysis to compare an individual patient's data to a "normal", age-matched reference set of data. Currently, clinical gait analysis is not usually carried out in those under five years of age because toddler data is characteristically "noisy", and it is unknown whether there is such a thing as "normal" toddler gait. Therefore the aim of this project was to characterise the variability in gait parameters of children under five, and to determine if, and at what stage, a "normal" reference data set can be defined in this population.

Methods: Data from 44 young children (9 and 59 months), 78 older children (6-16 years), and 44 adults (22 male, 22 female) were collected via the full-body conventional gait model (PlugInGait), using 12-16 Vicon cameras (100Hz) during level walking at self-selected pace. Temporal spatial parameters (STPs), foot clearance, and motion of the head and centre of mass (COM) were calculated. Inter-subject variation was calculated by determining the absolute deviation of the median trial for each subject from the group mean, and comparing across age groups. In addition, different age brackets from the younger children group were compared to older children and adults, to determine at what age the inter-subject variation stabilised. Finally, each gait parameter was plotted against age to determine the trend with increasing age.

Results: Inter-subject variation was found to be significantly greater in young children, compared to both older children and adults, in all gait parameters assessed. The age at which inter-subject variation approximates that of older children appears to be around 24 months. This is particularly evident when STPs are normalised to leg length.

Conclusion: Traditionally, clinical gait analysis has not been performed on children under five years of age, partly based on the assumption that it is difficult to establish a "normal" dataset for comparison in young children. The results of this study suggest that this may be possible from as young as two years of age. STPs, as well global measures of COM and head motion appear to stabilise by this age. This is consistent with previous research suggesting early, rapid developing in walking ability[1]. It remains to be seen whether joint angles (kinematics) and kinetic measures follow a similar pattern.

Significance: Gait maturation is at reasonable level at the age of two years with consistent patterns allowing the development of normative data for comparison.

Effects of Hypothyroidism on Articular Cartilage in Miniature Swine

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Purpose: Thyroid hormone, implicated in the growth and development of articular cartilage, has unknown effects on this tissue in a disease state, such as hypothyroidism. Previous work established a defined hypothyroid condition in immature miniature swine, and this investigation compared articular cartilage structure from proximal femurs in these animals to normal control swine.

Methods: Two 11-week-old male Sinclair miniature swine were made hypothyroid by administration of 6-propyl-2-thiouracil (PTU) in their drinking water; two animals without PTU served as controls. Proximal femurs from 25-week-old animals were studied by histology, immunohistochemistry (IHC) and histomorphometry. Histology (Safranin-O red staining) was used to identify proteoglycans in tissue sections, IHC assessed types II and X collagen, and histomorphometry measured articular cartilage mean tissue height and cell density. Nested mixed effects ANOVA examined histomorphometric data statistically with $p \leq 0.05$ considered significant.

Results: Compared to controls, hypothyroid articular cartilage had distinctly different proteoglycan and type II collagen staining patterns and intensities. Type X collagen was absent in hypothyroid and control articular cartilage but present in control physeal cartilage. Hypothyroid articular cartilage compared to controls demonstrated a statistically significant increase in mean tissue height (2337.0 ± 132.8 μm vs 1076.1 ± 132.7 μm, $p = 0.021$) and decrease in mean cell density (27.6 ± 1.0 cells/cm^2 vs 31.0 ± 1.0 cells/cm^2, $p = 0.016$).

Conclusion: Hypothyroidism in immature miniature swine resulted in proteoglycan and type II collagen staining differences in articular cartilage compared to counterpart control specimens. Hypothyroidism also yielded statistically significant histomorphometric changes in articular cartilage structure compared to controls. Despite small (n = 2) sampling in this study, statistical considerations suggest analyses of additional numbers of animals would reproduce similar statistically significant differences in articular cartilage mean tissue height and mean cell density. Thus the histomorphometric changes are important and compelling. Histomorphometric results and altered proteoglycan and type II collagen staining in hypothyroid compared to control specimens all indicate delayed progression of development of articular cartilage in hypothyroid animals. These data support the concept that thyroid hormone is fundamental to articular cartilage growth and development. Understanding thyroid hormone role more completely in this animal model of hypothyroidism may provide greater insight into development and diseases of human articular cartilage.

Significance: Hypothyroidism in immature miniature swine caused critical articular cartilage structural changes and these differences may provide insight into human articular cartilage development and diseases.

Prediction of Fractures in Pathological Bones using Finite Element Analysis Method

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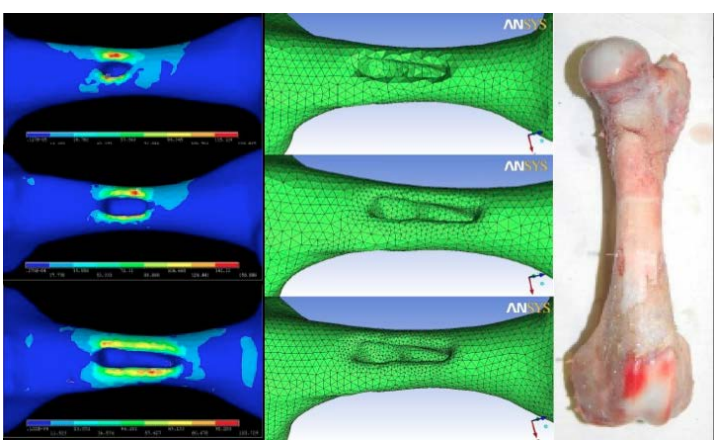
Purpose: Currently, clinical guidelines and radiographic measurements are used as methods for predicting pathological fractures of bones. However, these criteria may be insufficient to achieve adequate prediction.
The method of finite element analysis (FE), uses information obtained through CT scans of a bone specimen generating a computational model of its structure including its mechanical properties, which allows to assesse resistance and strength of bone tissue at moment of failure.
We aimed to determine the predictive capacity for fractures of computer finite element models constructed from CT scans in porcine bones with structural cortical alterations simulating metastasic bone disease.

Methods: 18 fresh frozen porcine femurs distributed in 3 groups were used. Rectangular lytic efects of three different sizes were simulated by perforating the cortex at the diaphysis, with the size established as percentages of diaphyseal diameter.

After creating the defects, a CT scan was performed to generate the computational model and later each of the specimens was subjected to a mechanical test in bending flexion measuring the force required to cause failure. This was then compared to the computer model.

Results: The force required for failure (fracture) of the specimens was inversely proportional to the size of the defect. In computational models the same behavior was observed. A direct correlation with R^2 of 0.98 between the forces in actual tests versus computational models was observed.

Conclusion: In the model of porcine femur with diaphyseal defects computational modeling of cortical bone defect through finite element analysis is able to predict with high accuracy the force required for its fracture against bending and compression forces. This study opens new lines of research in the area of assessing bone fracture risk with metastatic bone lesion.



Significance: CT scan based finite element analysis may provide a useful tool for identification of probable pathological fractures requiring prophylactic stabilization.

Clinical Feasibility of Meclozine for Improvement of Short Stature in Achondroplasia

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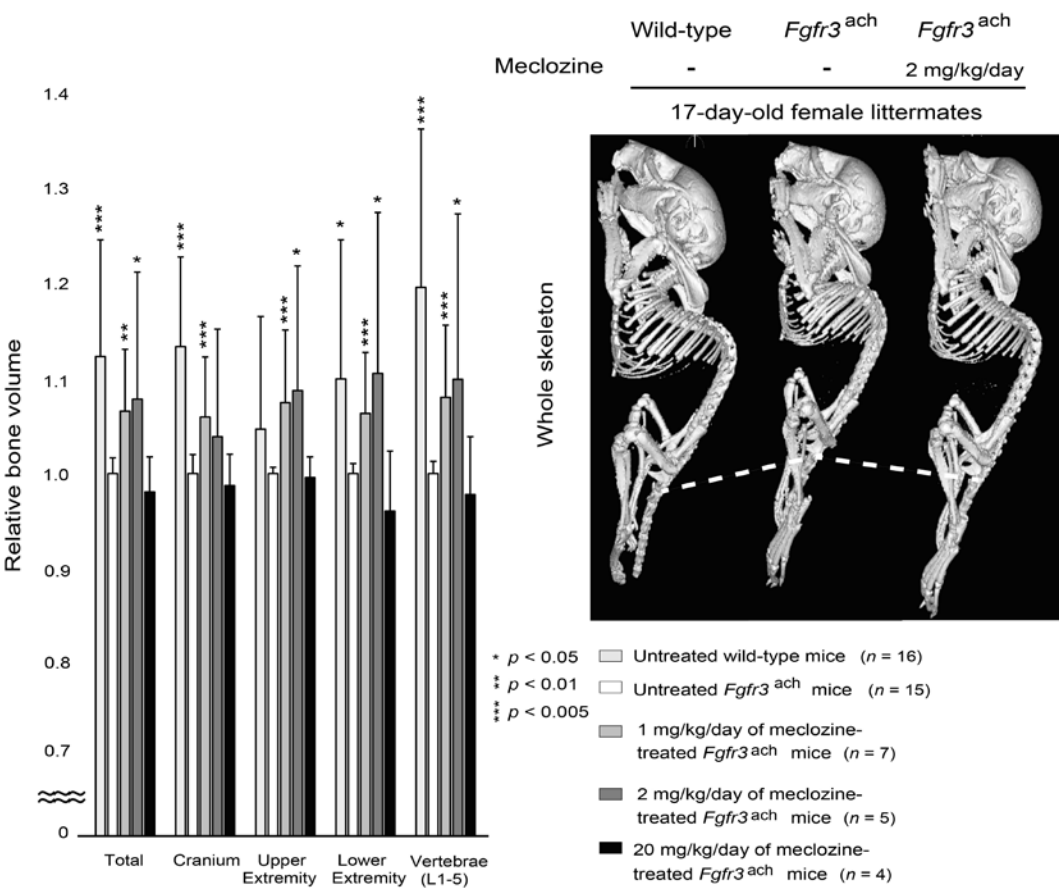
Purpose: Achondroplasia (ACH) is one of the most common skeletal dysplasias characterized with disproportionate short stature. ACH is caused by gain-of-function mutations in the fibroblast growth factor receptor 3 (*FGFR3*) gene. By comprehensive screening of FDA-approved drugs, we identified that meclozine, an over-the-counter drug for motion sickness, promoted longitudinal bone growth in transgenic ACH mice by inhibiting FGFR3 signaling. In the present study, we investigated the optimal dose of meclozine for the treatment of short stature in ACH for further clinical feasibilities.

Methods: We orally administered 1, 2, or 20 mg/kg/day of meclozine twice a day to *Fgfr3*^{ach} mice of postnatal day 7 for 10 days. Body length was measured during the course of treatment and normalized to that from sex-matched littermates of untreated *Fgfr3*^{ach} mice. At the end of the treatment, the mice were subjected to micro-computed tomography (micro-CT) scans for calculating the each bone length and bone volume. Plasma concentration of meclozine was serially measured by collecting blood samples from 8-week-old mice treated with a single oral dose of 2, 6, or 20 mg/kg of meclozine for pharmacokinetics. Simulated plasma concentrations repeated oral administration of meclozine for 7 days were calculated by using the data of pharmacokinetics after single dose.

Results: The 1 or 2 mg/kg/day of meclozine significantly increased the body length of *Fgfr3*^{ach} mice. Micro-CT examinations demonstrated that bone volumes of *Fgfr3*^{ach} mice including total, cranium, upper extremity, lower extremity, and vertebtae were significantly increased by 1 or 2 mg/kg/day of meclozine treatment compared to that of untreated *Fgfr3*^{ach} mice. Individual bone lengths including the humerus, radius, ulna, femur, tibia, and vertebrae of *Fgfr3*^{ach} mice treated with 1 or 2 mg/kg/day of meclozine were longer than those of untreated *Fgfr3*^{ach} mice. The treatment of 20 mg/kg/day of meclozine, however, showed no positive effects on longitudinal bone growth. Pharmacokinetics of 2 mg/kg of meclozine administered to mice was similar to that of 25 mg meclozine tablet used for motion sickness in human. Simulated curve indicated that there was no accumulation after repeated dose of 2 mg/kg/day of meclozine while 20mg/kg/day of meclozine showed accumulation property.

Conclusion: The 1 or 2 mg/kg/day of meclozine promoted longitudinal bone growth in ACH without accumulation after repeated dose. These results indicated clinical feasibilities of meclozine for improvement of short stature in ACH.

Significance: This study demonstrates that the dose of meclozine for anti-motion sickness has a potent effect on longitudinal bone growth in achondroplasia.


Wild-type
Fgfr3 ach
Fgfr3 ach
Meclozine
-
-
2 mg/kg/day
17-day-old female littermates
Whole skeleton
Relative bone volume
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0
Total
Cranium
Upper Extremity
Lower Extremity
Vertebrae (L1-5)
* p < 0.05
** p < 0.01
*** p < 0.005
Untreated wild-type mice (n = 16)
Untreated Fgfr3 ach mice (n = 15)
1 mg/kg/day of meclozine-treated Fgfr3 ach mice (n = 7)
2 mg/kg/day of meclozine-treated Fgfr3 ach mice (n = 5)
20 mg/kg/day of meclozine-treated Fgfr3 ach mice (n = 4)

The British Orthopaedic Surgery Surveillance Study: A Nationwide Approach to Develop Evidence Based Care

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University of Liverpool, Liverpool, United Kingdom

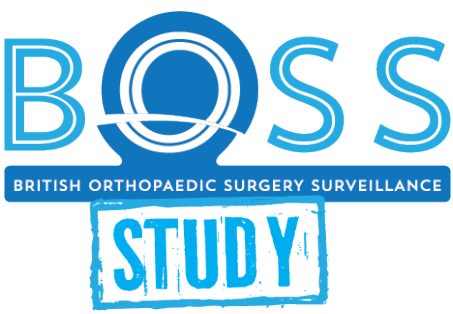
Purpose: To describe the creation of the British Orthopaedic Surgery Surveillance (BOSS) Study. The BOSS Study is a nationwide UK surveillance system in children's orthopaedic surgery, which is intended to generate comprehensive national cohorts in rare orthopaedic disease.

Methods: Comprehensive anonymised cohort studies have been adopted within the UK NHS to investigate rare diseases within paediatric medicine and obstetrics. These surveillance systems offer the opportunity to investigate rare diseases on a nationwide scale, with the ability to provide high-quality epidemiological data and feasibility data to contribute toward the development of randomised clinical trials. We adapted the methods of other UK surveillance systems, and applied these to orthopaedic surgery. Cases are identified by a nationwide network of surgeons who complete data collection via RedCap. Cases are cross-referenced against national hospital-billing records, and independent reports by orthopaedic trainees (residents) to ensure that the record is complete. Cases are followed-up for a defined period from diagnosis. Case identification is finite, and the diseases changed at fixed periods (18 months) in order to maintain interest amongst collaborative members.

Results: In the first few months the BOSS Study has identified over 220 new cases of SCFE and Perthes' disease across the UK. BOSS is open at 143 (of a possible 144) UK Hospitals that treat SCFE or Perthes' Disease. Over 300 consultant orthopaedic surgeons are contributing to the data collection, and over 150 orthopaedic trainees (The BOSS Collaborative). Routine billing data is provided by NHS England, NHS Scotland and NHS Wales. Data collection includes the details of the management of the case, and the acquisition of routine radiographs. All surgeons are encouraged to confirm case ascertainment each month (even if zero); 85% of surgeons engaged with this last month which helps ensure the completeness of reporting.

Conclusion: The BOSS Study is a versatile mechanism by which to readily collect nationwide surveillance cohorts, and is transferable to other healthcare settings. The BOSS Study may significantly improve the understanding of rare paediatric orthopaedic diseases, either by providing feasibility data to contribute to the development of RCTs, or as stand-alone comprehensive cohorts.

Significance: Nationwide surveillance systems provide a powerful means by which to investigate rare diseases. Whilst registries may seem appealing, finite comprehensive cohorts may provide a better opportunity to investigate such diseases by overcoming many of the hurdles of a registry.



An Evaluation of the Effects of Elevated Body Mass Index on Skeletal Age

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Moreno Valley, California, United States

Purpose: The prevalence of overweight children has risen since the 1980's, resulting in worldwide healthcare challenges. There is a paucity of literature describing the effects of an elevated body mass index (BMI) on skeletal age. Many treatment decisions in Children's Orthopaedics are based on age.
The purpose of our study was to determine if a discrepancy between chronological age (CA) and skeletal age (SA) exists when comparing overweight to non-overweight children. We hypothesized that overweight children would have an advanced SA.

Methods: A retrospective review of patients treated recently at our facility between the ages of 8-17 was performed. Children were enrolled and stratified based on age, sex, race, and BMI percentile.
Eligible children had an adequate hand radiograph and a correlating BMI. Those with inadequate radiographs, hand deformities that prevented accurate aging and/or any developmental pathology or treatment that affected skeletal development were excluded.
Groups were composed of 6 males and 6 females per age group 8-17 years. Half were overweight or obese (BMI percentile >/=85th percentile).
2-blinded physicians, a fellowship trained pediatric orthopaedic surgeon and a pediatric radiologist independently evaluated the radiographs and recorded the SA using the Greulich and Pyle Atlas. Inter-rater reliability was assessed. Subjects with poor correlation were excluded. Groups underwent statistical analysis (repeated measures ANOVA) to evaluate for any discrepancy between CA and SA, comparing the overweight and non-overweight cohorts.

Results: 120 patients were enrolled with an Intraclass Correlation Coefficient(ICC) of 0.904. Subjects where SA varied by greater than one year were excluded from the analysis(N=24), raising the ICC to 0.95. The average SA for the remaining subjects(N=96) was used in the analysis. The difference between CA and SA in the elevated versus non-elevated BMI cohort was significantly different($p<0.001$). Overweight children were found to have an advanced SA($p<0.001$) while no significant difference was seen between CA and SA for the non-overweight cohort($p=0.72$).

Conclusion: There is a significantly greater discrepancy (average 13 months) between CA and SA in overweight children when compared to non-overweight children of the same age and sex (no discrepancy).

Significance: The importance of addressing the challenges surrounding increasing childhood and adolescent obesity rates around the world has been well documented. This includes the need to increase research in this area, and address knowledge gaps in the management of these children. Our conclusions are highly translational. Based on our cohort, overweight children must be approached with the expectation of significantly earlier skeletal maturity when providing orthopaedic care.

Patients with Down Syndrome Have Acetabular Retroversion with Global Deficiency, While High Femoral Anteversion and Low Femoral Head Coverage Are Further Associated with Instability

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Purpose: The etiology of hip instability in Down syndrome is not well understood. We investigated the morphology of the acetabulum and femur using Computed Tomography (CT) in unstable and stable hips of patients with Down syndrome, and compared them with matched controls.

Methods: Following IRB approval, 42 patients with Down syndrome with pelvic CT scan for evaluation of hip anatomy were compared to 42 subjects without Down syndrome or history of hip disease who underwent CT for suspected appendicitis. Subjects between cohorts were matched by age and sex. The average±SD age was 11.3±5.3 years, with 23 males and 19 females in both groups. The lateral center-edge angle (LCEA), acetabular inclination angle (AI), coronal acetabular-depth-ratio (ADR), acetabular version (AV), and both anterior and posterior acetabular sector angles (AASA, PASA) were compared. The neck-shaft-angle (NSA) and femoral version (FV) were additionally measured in Down syndrome patients. Hips in patients with Down syndrome were subdivided into stable (n=21) and unstable (n=63) groups for further comparison.

Results: Patients with Down syndrome had a lower mean LCEA (10.8±12.6° vs. 25.6±4.6°; p<0.0001), higher AI (17.4±10.3° vs. 10.9 ±4.8°; p<0.0001), lower ADR (231.9±56.2 vs. 306.8±31.0; p<0.0001), more retroverted acetabulum (7.8°±5.1° vs. 14.0°±4.5°; p<0.0001), lower AASA (55.0±9.9° vs. 59.7±7.8°; p=0.005), and PASA (67.1±10.4° vs. 85.2±6.8°; p<0.0001) compared to controls. Within the Down syndrome cohort, unstable hips showed significantly reduced LCEA and ADR, while the AI and FV were significantly increased when compared to stable hips. No difference was found in the AV or the NSA; however unstable hips had significant worse femoral head coverage by the acetabulum as assessed by lower AASA and PASA.

	Down Syndrome	Control	p value		Down syndrome Stable Hip (n=21)		p value	p value
	n=84 hips	n=84 hips	Down vs Control		Down Syndrome Unstable Hip (n=63)		Stable vs unstable	vs control
Neck shaft angle (degrees)	133.6 ± 6.6	Not available	Not available		Stable	133.2 ± 6.4	0.81	
					Unstable	133.7 ± 6.7		
Femoral version (degrees)	30.4 ± 14.3	Not available	Not available		Stable	23.6 ± 10.6	0.002	
					Unstable	32.7 ± 14.6		
Lateral center edge angle (degrees)	10.8 ± 12.6	25.6 ± 4.6	<0.0001		Stable	24.9 ± 8.4	<0.0001	0.97
					Unstable	5.9 ± 9.9		<0.0001
Acetabular index (degrees)	17.4 ± 10.3	10.9 ± 4.8	<0.0001		Stable	7.4 ± 4.6	<0.0001	0.02
					Unstable	20.8 ± 9.5		<0.0001
Acetabular version 10 mm from the roof (degrees)	-7.2 ± 8.6	6.4 ± 5.6	<0.0001		Stable	-7.9 ± 8.7	0.47	<0.0001
					Unstable	-7.0 ± 8.7		<0.0001
Acetabular version center of the femoral head (degrees)	7.8 ± 5.1	14.0 ± 4.5	<0.0001		Stable	7.6 ± 3.8	0.93	<0.0001
					Unstable	7.8 ± 5.5		<0.0001
Anterior Acetabular Sector angle (degrees)	55.0 ± 9.9	59.7 ± 7.8	0.005		Stable	64.5 ± 8.0	<0.0001	0.13
					Unstable	51.9 ± 8.4		<0.0001
Posterior acetabular Sector angle (degrees)	67.1 ± 10.4	85.2 ± 6.8	<0.0001		Stable	78.1 ± 7.0	<0.0001	<0.0001
					Unstable	63.4 ± 8.6		<0.0001
Coronal acetabular Depth ratio	231.9 ± 56.2	306.8 ± 31.0	<0.0001		Stable	288.7 ± 46.7	<0.0001	0.06
					Unstable	212.3 ± 45.0		<0.0001

Conclusion: Patients with Down syndrome have more retroverted and shallow acetabulum with reduced coverage of the femoral head anteriorly, superiorly, and posteriorly (i.e. globally). Furthermore, instability in Downs hips appears to be associated with reduced acetabular coverage of the femoral head globally and increased femoral anteversion, but not with differences in acetabular retroversion or neck-shaft angle.

Significance: This study supports a spectrum of abnormal acetabular and femoral morphology associated with hip instability in patients with Down syndrome. Surgical treatment of hip instability in Down syndrome should consider correction of acetabular retroversion and global insufficiency (more severe posteriorly), as well as excessive femoral anteversion.

Fracture Patterns Differ Between Osteogenesis Imperfecta and Routine Pediatric Fractures

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The Johns Hopkins Hospital, Baltimore, Maryland, United States

Purpose: Physicians are sometimes called upon to estimate the likelihood that an individual fracture may be due to Osteogenesis Imperfecta (OI). Additionally, parents often question whether their child's fracture may represent abnormal bone quality. We sought differences between OI and routine pediatric fractures for diagnostic purposes.

Methods: A retrospective review of patients with OI and without OI presenting between January 1, 2005 and December 31, 2015 at a single institution was performed. Fractures occurring between 0 and 21 years that did not result from motor vehicle accidents and non-accidental trauma were included. Fractures in the non-OI group presumed to be pathologic were excluded. Data collected were age at fracture, gender, fracture pattern, fracture location, and OI type. Chi-squared and Fisher's exact tests were used for analysis, with $p<0.05$ considered statistically significant. Recursive partitioning was used to develop a fracture pattern classification tree.

Results: The non-OI and OI group consisted of 199 patients with 272 fractures and 58 patients with 247 fractures, respectively. The mean age at fracture was slightly higher in the non-OI group (non-OI: 8.2 years, OI: 6.9 years; $p=0.001$). OI types included type 1 (31.6%), type 3 (50.2%), type 4 (5.7%), type 5 (0.8%), and unreported (11.7%). OI patients had more oblique ($p=0.011$), femur ($p<0.001$), tibia ($p=0.027$), fibula ($p=0.029$), simultaneous tibia-fibula ($p=0.011$), and other diaphysis fractures ($p<0.001$). Transverse ($p=0.011$), buckle ($p<0.001$), humerus ($p<0.001$), supracondylar humerus (SCH) ($p<0.001$), radius ($p<0.001$), ulna ($p<0.001$), both bone forearm (BB forearm) ($p<0.001$), and physeal ($p<0.001$) fractures were more common in the non-OI group. Of note, SCH (n=3, 1.2%), physeal (n=3, 1.2%), buckle (n=6, 2.9%), and BB forearm fractures (n=8, 3.2%) were rarely observed in the OI group. These findings were consistent in a subgroup analysis of type I OI, except transverse fractures lost significance and foot fractures were noted to be more common. Among the different fracture types analyzed, the combination of diaphyseal, femoral, radial, and ulnar fractures most accurately predicted OI and non-OI patients in this study (Figure 1).

Conclusion: OI patients appear to have more frequent diaphyseal, femoral, non-radial, and non-ulnar fractures. Physeal, SCH, buckle, and BB forearm fractures should lessen the index of suspicion for OI in patients presenting with equivocal clinical signs or repeated fractures.

Significance: In conjunction with clinical history and physical signs, radiographic fracture pattern provides a useful adjunct to better estimate pretest probability of OI.

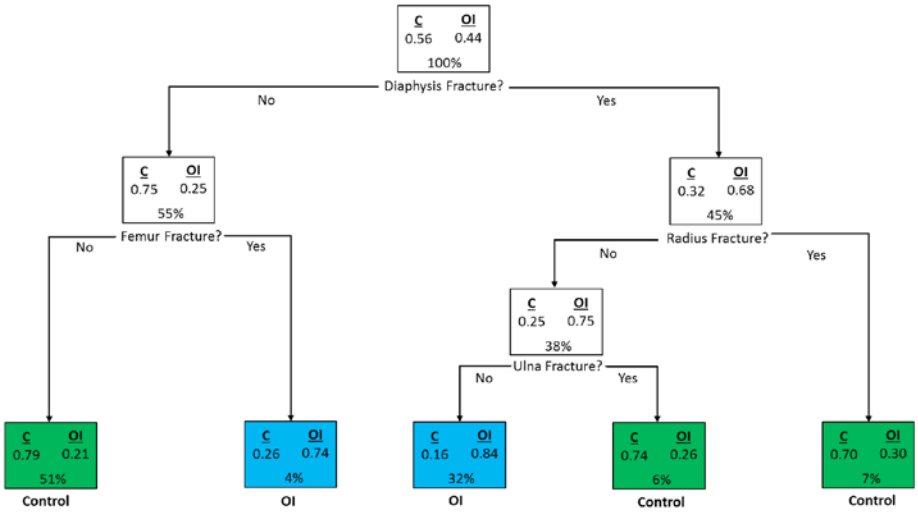

Figure 1. Osteogenesis Imperfecta classification decision tree based on review of 247 OI and 272 non-OI (control) fractures from 2005 to 2015. Blue cells are classified as OI and green cells as control. The two numbers at the top of each cell represent the proportion of patients in the control (left) and OI (right) groups, respectively. The number at the bottom of the cell represents the percentage of total patients in each grouping.

Abbreviations: Osteogenesis Imperfecta - OI

Complex Treatment of Pseudoartrhosis of the Tibia with the Periosteal Grafting and Intramedullary Fixation

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Dega Hospital, Poznan, Poland

Purpose: In the last few years, to improve the outcomes of congenital pseudarthrosis of the tibia (CPT) treatment, new procedures were added to the standard protocol: periosteal grafting, bone morphogenic protein (BMP) and bisphosphonate administration. In this study we analyzed the results of CPT treatment with periosteal graft combined with intramedullary (IM) nailing with or without Ilizarov frame.

Methods: Retrospective study of medical records and the radiographs of 10 patients with CPT treated with the complex procedure containing: resection of the hamartomatous periosteum, splitting of proximal tibial end or pseudarthrosis site resection, IM fixation, periosteal and cancellous bone grafting from the iliac bone was made. Mean age at the surgery was 5.4 years. Nine patients had NF-1 and one patient - idiopathic CPT. LLD ranged 0 - 10 cm (average 3.7). The anteroposterior preoperative scan of all patients were studied for assessments of ankle joint mortise, where proximal migration of the fibula was evaluated according to Malrotha scale for fibular shortening. The patients were classified according to El-Rosasy-Paley as type I in 5 cases, and type II in 5 cases. All the cases were classified as type IIC according to Crowford classification. The average follow-up after the above-mentioned operation was 7.9 years (range 5-9.9).

Results: Primary pseudarthrosis union of the tibia was achieved in 9 patients, at a mean time of four and the half months (range 4-6 months). Failure to obtain bone union after 13 months in the youngest patient needed reoperation with the same technique which achieved solid union. Only in one case out of ten the refracture of the tibia occurred, which was successfully managed by the repetition of the primary surgery.

Conclusion: Primary union of CPT in most of the cases can be obtained and maintained with limited pseudarthrosis resection, periosteal and cancellous bone grafting and intramedullary rod fixation.

Significance: The presented here method significantly increases the chance of achieving and maintaining the bone union in cases of congenital pseudoarthrosis of the tibia which is essential for good functional outcome. Application of this method of surgical treatment has become an important tool in the treatment of one of the most challenging orthopedic conditions, which CPT presents to be.

High Prevalence of Tethered Cord and Neuraxis Abnormalities in Costello Syndrome

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Purpose: Costello syndrome (CS) is a rare RAS/MAPK pathway disorder (rasopathy) related to Neurofibromatosis and Noonan syndrome. Patients with CS have an increased prevalence of Chiari I malformation. They also have extensive musculoskeletal manifestations. The aim of this study was to assess the prevalence of other neuraxis anomalies in CS patients.

Methods: This was a retrospective cross sectional review of clinical and imaging data from an IRB approved study of 48 patients with CS due to an *HRAS* mutation. 73 brain MRIs (41 patients) and 36 spine MRI's (29 patients) were reviewed by a pediatric neuroradiologist, a pediatric orthopedist and a geneticist with special interest in CS. The prevalence of spinal cord anomalies, including tethered cord, fatty filum, syrinx, etc were analyzed. Tethered cord was defined as the conus lying below L3. We also studied the prevalence of transitional vertebrae.

Results: Tethered cord was seen in 14/29 spine MRI's reviewed, which is much higher than in the normal population. 8/14 of these patients underwent surgery for release of tethered cord with improvement in symptoms. 3 patients needed repeat releases. We found additional anomalies as listed in Table 1. 5/29 spine MRI's revealed the presence of 6 lumbar vertebrae. There was no apparent genotype/phenotype correlation with the respective different *HRAS* mutations.

Neuraxis abormality	Number of patients
Chiari | malformation	12 (29.25%)
Tethered cord	14 (48.3%)
Syringomyelia	5 (17.24%)
Transitional vertebrae (6 lumbar)	5 (17.24%)

Conclusion: CS patients have multisystem anomalies with major neuromuscular manifestations. The prevalence of tethered cord in this population is very high compared to the normal population. Because many of these patients have 6 lumbar vertebrae, it is important to count vertebral levels from the top down to accurately localize the tip of the conus and make the correct diagnosis of a tethered cord. One patient in this study was retrospectively diagnosed with a tethered cord and underwent surgery with significant improvement in symptoms.

Significance: The high prevalence of tethered cord in the CS population suggests the need for full spine MR imaging. All spine MRI's need to have at least a scout with the entire spine to enable appropriate numbering from the cervical spine down. Appropriate clinic-radiologic correlation of musculoskeletal and neuraxis abnormalities may aid in appropriate treatment selection in these patients.

Hip Surgery in Aitken A & B PFFD

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Purpose: To evaluate results of hip reconstruction surgery in Aitken Type A & B Proximal Femoral Focal Deficiency (PFFD) with respect of proximal femoral defect ossification (union), biomechanical aligement, number of operations/reoperations as well as functional outcomes and pain, To arrive at optimal treatment protocol for this condition.

Methods: All patients seen at one institution with diagnosis of PFFD were reviewed. All patients with Aitken A & B (type I) who underwent hip reconstruction surgery were included in the surgery. Their demographic, imaging and clinical data were reviewed. Patients were evaluated with respect of stated goals of treatment. That is proximal femoral ossification, normalization of hip biomechanical alignment and functional improvement. Re-operations and underlying reasons were reviewed and tabulated to arrived at optimal treatment protocol.

Results: Out of 31 patients diagnosed with PFFD, 12 fulfilled the criteria of Aikten A & B PFFD who underwent surgical hip reconstruction. Seven patients were followed to skeletal maturity and in five remaining patients the average follow-up was 3.5yrs (1-7yrs). The number of hip operations ranged from 1-4 per patient. The longer the follow-up and younger the age of the first hip operation the greater need for re-operation. All patients eventually achieved stated goals of union, normalization of hip biomechanics and improvement in gait/prosthetic perameters. Hip surgery also offers additional benefits for patients with rotationplasty for rotational and length fine tuning of the rotationplasty.

Conclusion: Our data support a conclusion that surgical normalization of Aitken A & B PFFD hips can be a successful undertaking. However, multiple re-operations are usually required to achieve this goal. Both a delay in proximal femoral ossification and recurrent varus deformity are the main causes of re-operations. Inherently assymitrical growth of the proximal femur in these children would be the main culprit. Fine balance between prevention of worsening hip dysplasia, potential for hip remodeling and the need for multiple re-operations in the young children makes us conclude that optimal age for the initial hip reconstruction is in the 4-5yrs of age. It should consist of valgus realignment of at least 130deg neck shaft angle. Additional operation however would appear to be inevitable to maintain the goals to skeletal maturity.

Significance: Our result on this rarely reported condition offer a guideline for treatment of these challenging patients. Satisfactory results can be expect in the majority of these patients.

Hospital Outcomes in Pediatric Patients with Prader-Willi Syndrome (PWS) Undergoing Orthopedic Surgery

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Purpose: Prader-Willi Syndrome (PWS) is a rare disorder that results from an abnormality of chromosome 15. The hallmark symptoms of PWS include obesity, hyperphagia, hypotonia, cognitive delay, and hypogonadism. Musculoskeletal involvement is not uncommon and includes scoliosis, lower limb deformities, hip dysplasia, and osteoporosis. While the prevalence of these pathologies have been determined to some degree, large studies evaluating hospital outcomes in PWS patients undergoing orthopedic surgery are limited.

Methods: An analysis of the National Inpatient sample from 2001 to 2012 was performed. An estimated 3684 patients with PWS were identified. All patients with PWS undergoing orthopedic surgery were subsequently identified using ICD-9 coding. General patient characteristics, relative percentages of orthopedic procedures performed in this population, and post-operative measures including complications and lengths of stay were determined.

Results: 334 (9%) of PWS patients underwent orthopedic surgery (mean age 10.33 sd 4.5). 71% of patients were Caucasian, 15% Hispanic, 9% African-American. 51% of the patients were male, 49% female. Most common concomitant comorbidities included chronic pulmonary disease (14.3%), hypertension (5.8%), hypothyroidism (4.7%), and diabetes (4.3%). The most common identifiable orthopedic procedures performed were spinal fusion (165/334, 49%) followed by lower extremity procedures including fracture fixation and osteotomies (50/334, 15%). Complication rates were highest in patients undergoing spinal fusion (59/165, 36%; $p < 0.001$), followed by those undergoing lower extremity procedures (5/50, 10%; $p < 0.01$). Most common post-operative complications in all orthopedic surgeries were directly related to the surgery itself (24.3%; including device related complications), post-operative anemia (8.2%), pneumonia (2.7%), and urinary tract infections (0.5%). Mean length of stay was doubled (6.7 days) for patients undergoing spinal fusion compared to those undergoing other orthopedic procedures (3.2).

Conclusion: The most common inpatient orthopedic procedure in pediatric patients with Prader-Willi Syndrome is spinal fusion. Chronic pulmonary disease is the most common concomitant comorbidity in patients with PWS. Complication rates are highest in PWS patients undergoing spinal fusion and are directly related to the surgery itself. A multi-disciplinary approach to peri-operative management is recommended.

Significance: Physicians should be aware that chronic pulmonary disease is the most common comorbitiy in patients with PWS. The highest complication rate in PWS patients undergoing orthopedic surgery is with spinal fusion surgery. Orthopedic surgeons should consider a multi-disciplinary approach to peri-operative management of these patients.

Dual Interlocking Telescopic Rod for Tibial Stabilization in Osteogenesis Imperfecta Patients

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Purpose: We devised and used interlocking telescopic rod for stabilization of the long bones in osteogenesis imperfecta (OI) patients, of which the sleeve was anchored by T-piece but the obturator by interelocking pin at the distal epiphysis, in order to avoid damage to the distal joint. Here, we introduce a modification for the tibia, dual interlocking telescopic rod (D-ITR), of which both sleeve and obturator were anchored by interlocking pin, and analyze outcome of D-ITR comparing to that of single interlocking telescopic rod (S-ITR).

Methods: Twenty-eight tibiae of 18 patients with osteogenesis imperfecta treated with D-ITR and followed more than two years were included in this study. 5 tibiae were Sillence type I, 11 type III, 9 type IV, and 3 type V. The mean age at the time of the surgery was 8.0 years (3.1 to 14.1). The mean duration of follow-up was 4.4 years (2.0 to 8.6). We have applied adjunctive unicortical locking plate fixation in 4 tibiae at the time of the index operation. Outcomes of D-ITR were compared to those of 31 tibiae (19 patients) treated with S-ITR, of which demographic data were not significantly different from those of D-ITR.

Results: We successfully anchored the sleeves and obturators at the epiphyses with interlocking pins in 26 tibiae (93%) and failed in 2 tibiae (7%), which were excluded in additional analyses. The mean elongated length of rod over the follow-up period was 43.1mm (6.6 to 92.7). The median elongation and median surgery-free survival times were 5.6 years [95% confidence interval (CI), 3.8-7.5] and 4.7 years (95% CI, 4.3-5.0). The mean survival time of rod was 6.7 years (95% CI, 5.6-7.9). These parameters as well as the frequency of proximal migration of the obturator and backing-out of the interlocking pin were not significantly different from those of S-ITR. Proximal migration of the sleeve requiring additional surgery took place in 8 cases with S-ITR, while none with D-ITR (p=0.006). Distal migration of the sleeve, which necessitated making cortical window or osteotomy to remove the sleeve, took place in 3 cases with S-ITR, while none with D-ITR. Six D-ITR were removed during revision surgery without any difficulty or complications.

Conclusion: D-ITR provides effective stabilization of the tibia in OI patients. Proximal interlocking is technically more demanding, but provides better anchor and allows easier removal.

Significance: We introduce a better stabilizing tool for the tibia of OI patients.

Is There Any Correlation Between Sagittal Spinopelvic Parameters and Hip Joint Contracture after Femoral Lengthening in Achondroplasia / Hypochondroplasia?

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Purpose: Femoral lengthening may be indicated in patients with achondroplasia in order to improve their quality of life. However, excessive femoral lengthening is associated with decreased range of motion of the adjacent joints, decreased new bone formation, delayed weight bearing, and fractures of the regenerate bones. Among them, hip joint contracture is the most serious complication and may be treated with consequent surgical management. Spinal hyperlordosis and abnormality of spinopelvic parameters have been frequently found in the patients with achondroplasia/hypochondroplsia. We attempted to determine whether (1) sagittal spinopelvic parameters; (2) factors related with surgery; and (3) patients demographic characteristics are associated with hip joint contracture after femoral lengthening in patients with achondroplasia/hypochondroplasia.

Methods: We retrospective reviewed the records of 30 patients (60 limbs) who underwent femoral lengthening at our institute between 2004 and 2015. Patients were categorized into following 2 groups according to occurrence of hip joint contracture; group A (Hip joint contracture), group B (No contracture). Pre-operative demographic data and spinopelvic radiographic parameters were analyzed. We evaluated sagittal spinopelvic radiologic parameters using sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), S1 overhang (OH), thoracic kyphosis (TK), thoraco-lumbar kyphosis (TLK), lumbar lordosis 1 (LL1, L1-S1), lumbar lordosis 2 (LL2, T12-S1), and sagittal balance (SB). Other factors related with surgery such as lengthening percentage (%), amount of lengthening (mm) were also evaluated. Multivariate logistic regression and student t-test were used for statistical analysis.

Results: The number of patients with hip joint contracture (Group A) was 19 (63%). The number of patients with no contracture (Group B) was 11 (37%). There was no difference in their demographic characteristics between the groups in the age of operation, gender ratio, and diagnosis. The factors related with the surgery showed differences between the groups in amount of lengthening (group A: 101mm, group B: 78mm, p=0.01) and lengthening percentage (group A: 43%, group B: 29%, p=0.02). The univariated analysis of all the variables showed that amount of lengthening, lengthening percentage, and preoperative TK had p values of <0.15. The only variable that remained significant after multivariate analysis was diagnosis and preoperative TK (p=0.02).

Conclusion: The hip joint contracture after femoral lengthening seems to be related with large amount of lengthening in the patients with achondroplaisa / hypochondroplasia. There was strong association between the hip joint contracture and the preoperative decreased thoracic kyphosis after femoral lengthening.

Significance: Treating surgeons should evaluate the pre-operative spino-pelvic balance before extensive femoral lengthening procedure.

Orthopaedic Management of Leg Length Discrepancy in Proteus Syndrome: A Case Series

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Purpose: Proteus syndrome (PS) is a rare mosaic disorder comprising asymmetric bony and soft tissue overgrowth leading to significant morbidity. Placement of guided growth hardware with subsequent epiphyseal arrest improves leg length and angular deformities in pediatric patients without PS. However, patients with PS are known to be at high risk for developing perioperative complications. The purpose of this study was to review the surgical approach and present outcomes, complications, and recommendations in eight patients with PS and leg length discrepancy (LLD).

Methods: We conducted a retrospective chart review of eight patients with PS whose primary reason for surgery was LLD. Patients were eligible if they met clinical diagnostic criteria for PS and if the NIH team performed at least one of their surgical interventions between 2005 and 2015. Surgical techniques included guided growth, with tension band plates, applied one or more times, and epiphyseal arrest, supplemented with PS specific monitoring including, rapid mobilization, DVT prophylaxis, and sequential compression devices.

Results: Eight patients, followed for an average of 4.6 years (range 1.0-7.1 years) after the index procedure, were included in this analysis. Average age at first LLD surgery was 9.4 years (range 6.1-13.6 years); the average LLD was 3.4 cm (range 0.4-7.0 cm) at presentation, and 5.0 cm (range 1.8-10.0 cm) at the time of the first LLD surgery. Participants underwent 23 total surgeries (range 1-5 per patient) and seven patients have completed surgical intervention. For six patients, the average LLD correction at last follow-up was 3.2 cm (range 0.8-6.6 cm). We encountered three orthopedic complications: one patient developed a fracture of the fibula and ankle varus following development of a distal lateral tibia exostosis, and two patients developed mild knee valgus, which responded to standard guided growth techniques. There were no medical/perioperative complications.

Conclusion: This case series suggests that guided growth and epiphyseal arrest in children with PS can reduce leg length discrepancy with few orthopaedic or medical/perioperative complications.

Significance: Because of its extreme rarity, randomized surgical trials cannot be performed for patients with PS. However, this relatively large case series provides insights and recommendations on the application of guided growth and epiphyseal arrest techniques, combined with with PS specific monitoring, to reduce leg length length discrepancy in children with PS, despite the high risk of orthopaedic and medical/perioperative complications in these patients.

Fassier-Duval Rods are Associated with Superior Probability of Survival Compared to Static Implants in a Cohort of Children with Osteogenesis Imperfecta Deformities

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Purpose: Survival of Fussier-Duval telescoping rods (FDRs) as compared to static implants in surgically naïve limbs of children affected by osteogenesis imperfecta (OI) is not well characterized. The purpose of this study was to compare risk of lower extremity implant failure in FDR versus static implants.

Methods: Data were retrospectively collected from OI patients who underwent surgical treatment of a fracture or boney deformity using either the FDRs or static implants (Rush rods, flexible nails, or Steinmann pins) between 1995 and 2015. The timing of implant failure among FDRs versus static implants was the primary outcome variable of interest. Comparisons were limited to limbs with no prior history of implants and secondary revision failures were not considered in this study. The null hypothesis of no difference in risk of implant failure between the FDRs and static implant groups was tested using a Cox-proportional hazards regression analysis. The model was adjusted for correlation due to the inclusion of multiple limbs per patient and the potential confounding effect of age at treatment, previous history of surgery in an unrelated limb, and gender.

Results: The FDR group included implants in the femur (n=8, 8/20) and tibia (n=12, 12/20). The static implant group included implants in the femur (n=17, 17/25), tibia (n=7, 7/25), and fibula (n=1, 1/25). After adjusting for surgical history, age at surgery, and gender, the hazard or risk of implant failure in the static implant group was 5.7 [95% CI: 1.1 to 29.1, p = 0.0379] times the risk of implant failure in the FDR group. Gender was also significantly related to implant failure. The risk of implant failure among females was 2.7 [95% CI: 1.3 to 5.6, p = 0.0060] times the risk of implant failure among males. Two-year implant survival was 90% [95% CI: 66 – 97%] in the FDR group compared to 46% [95% CI: 26-64%] in the static implant group.

Conclusion: Among surgically naïve limbs, FDRs were associated with significantly improved probability of survival compared to static implants. The current study was limited to index implant only. Difficulty exchanging rods and managing failures must also be taken into consideration when determining optimal treatment for patients affected by OI.

Significance: Interpretation of studies relate to OI fixation is challenging due to inclusion of multiple limbs per patient, index failures with revision failures, and pooling of weight bearing limbs with non-weight bearing limbs. This work accurately delineates the advantages of FDRs following primary implantation.

Congenital Absence of the Fibula: Excellent Results following Amputation with Severe Limb Deformity

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Purpose: Fibula hemimelia is the commonest long bone congenital deficiency. Complete absence of the fibula often presents with significant leg length discrepancy and severe foot deformity. Parental counselling over treatment strategies is paramount in obtaining the optimum functional outcome for the child. Options include amputation, limb reconstruction and accommodative extension prosthesis. Amputation offers a single surgical event with minimal complication risk. The aim was to compare the results of an amputation protocol with those treated with extension prostheses.

Methods: 32 patients with complete fibula absence were identified. 9 patients (5M: 4F), mean age 22yrs at presentation, had utilized an extension prosthesis as primary treatment. 23 patients (16M: 7F), mean age 10m at presentation, underwent 24 amputations during childhood: no initial correction of the tibial kyphus was undertaken in 21/23 patients. Mobility was assessed using the SIGAM and K scores, quality of life using a PedsQL inventory questionnaire and pain by a verbal severity score.

Results: Patients in the extension group had a median follow-up of 5.5 years compared to 3.3 years in the amputation group.
19 Syme and one Boyd amputation in 19 patients were performed early (mean age 15 months (7-36m)). 3 Syme and one trans-tibial amputation in 4 patients took place in older children (mean age 6.6 years (4-13y)).
Two patients in the extension group underwent surgery: one correction of tibial deformity and one ankle fusion. In the amputation group 1/21 patients required subsequent correction of a significant tibial kyphus. One amputation patient required secondary resection of a calcaneal remnant and one had conversion of the Boyd to Syme amputation. All surgical procedures facilitated prosthetic fitting.
2 stumps had wound infections that resolved with antibiotics and 2 had recurrent folliculitis.
There were significantly higher K scores (mean 4 vs 2) and lower pain scores in the amputation group allowing high impact activity compared to community ambulation in the extension prosthesis group. The SIGAM and PedsQL scores were all better in the amputation group, but not significantly. There was no significant difference in the scores between early and late amputation.

Conclusion: Childhood amputation for severe limb length inequality and foot deformity in congenital fibula absence offers excellent functional outcome with prosthetic support. The tibial kyphus does not need routine correction and can aid prosthetic suspension. Accommodative extension prostheses offer reasonable long term function but outcome scores are lower.

Significance: This study provides outcome data to inform parents considering the difficult option of amputation surgery.

Bladder Exstrophy - Parents and Patient Satisfaction and the Role of Pelvic Osteotomy

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Purpose: Bladder exstrophy is a rare congenital disorder challenging both urologic and orthopedic surgeons. The role of a pelvic osteotomy (PO) with wide pubic symphysis diastasi in order to re-adapt the defect has been discussed lately. This study aims to investigate differences in parents and patients satisfaction, perceived motoric development and quality of life related to severity and treatment with and without pelvic osteotomy.

Methods: 20 patients treated for bladder exstrophy between 2001 and 2014 were included retrospectively. Twelve patients had received a PO because of diastasis of the symphysis of ≥4 cm (1.5 inches) on X-ray. We reviewed the medical charts and the patient's parents answered a questionnaire regarding satisfaction with the overall medical care and outcome and quality of life.

Results: The length of hospital stay after surgery was nearly identical between the two groups treated with and without PO. Regarding health quality of life no differences were found, however, three patients treated with PO reported mild or moderate pain during physical activity. 4 parents of children treated with PO mentioned a slight delay in reaching the motoric milestones of their child. The patients parents were highly satisfied with the medical care including pain relief after surgical interventions and follow-up, however 30% wished to have more written information not only about the short-term consequences but even long-term consequences in adult life.

Conclusion: This study shows that PO does not prolong hospital stay after surgery or reduce quality of life. Pelvic osteotomy is performed on more severe cases of exstrophy, which could explain the somewhat higher pain affection during physical activity. Informative material about short and long-term consequences of bladder exstrophy should be made available for the parents early.

Significance: Patients treated with PO had a wide pubic symphysis diastasis. Despite this the overall patient and parent satisfaction and quality of life was equal in patients treated with PO compared to patients treated without PO. PO does not prolong the hospital stay and can still be seen as an option in order to re-orientate the pelvic and facilitate the reconstruction of the uro-genital tract. Information about long-term consequences of the malformation should be made available for the parents early.

Long Term Health-related Quality of Life in Achondroplasia

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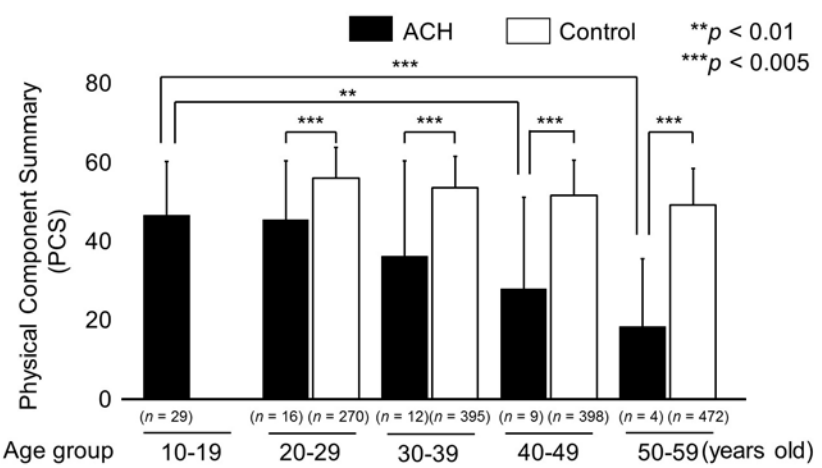
Purpose: Achondroplasia (ACH) is one of the most common skeletal dysplasias characterized with severe short stature, relative macrocephaly with frontal bossing, midface hypoplasia, foramen magnum stenosis, and spinal canal stenosis. The patients with ACH often have orthopaedic procedures, such as distraction osteogenesis, decompression of foramen magnum, and laminaplasty, during the childhood and adolescent. However, long term health-related quality of life (QOL) for the patients with ACH has rarely been documented. We assessed health-related QOL in adolescent and adult patients with ACH.

Methods: We sent a questionnaire to the patients registered on the two patients' associations of achondroplasia in Japan, who were older than 10 years old. The number of the eligible patients were 380 and 110 in each patients' association, respectively. Although the patients registered to both associations would receive the two same questionnaires, one patient returned the questionnaire once only. The health-related QOL was assessed by using the Short Form-36. We evaluated the Physical Component Summary (PCS), Mental Component Summary (MCS), and Role/Social Component Summary (RCS) among age groups of 10-19, 20-29, 30-39, 40-49, and 50-59 years. We employed norm data of age groups of 20-29, 30-39, 40-49, and 50-59 years from Japanese population as control groups. Additionally, PCS, MCS, and RCS were compared with two groups between distraction osteogenesis (DO)-treated patients and untreated patients.

Results: The 70 patients returned the questionnaire. We found that the PCS was significantly decreased in age groups of 20-29, 30-39, 40-49, and 50-59 years compared with control groups. Additionally, PCS was gradually decreased as getting older. In particular, PCS was significantly decreased in the age groups of 40-49 and 50-59 years compared with the age group of 10-19 years. On the other hand, MCS and RCS were similar to those of control groups in each age group. The average age of DO-treated patients and untreated patients was 26.1 ± 11.5 and 26.2 ± 17.2 years old, respectively (p = 0.97). There was no statistical difference in PCS, MCS, and RCS between DO-treated group and untreated group.



Conclusion: Physical ability was significantly decreased in ACH patients, especially deteriorated with age.

The health-related QOL regarding mental and social status in ACH compared favorably with that in healthy people. On the other hand, the treatment of DO did not affect the health-related QOL in ACH patients.

Significance: This study demonstrated long term health-related QOL in ACH.

Baseline Characteristics for the Multicenter Randomized Clubfoot Foot Abduction Brace Length of Treatment Study (FAB24)

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urpose: Although foot abduction bracing (FAB) is essential for preventing recurrence in clubfeet treated with the Ponseti method, the length of bracing required to prevent recurrence is unknown. We, therefore, sought to define to determine genetic and clinical risk factors that predict risk of recurrence in an attempt to allow individualization of clubfoot treatment in terms of length of time needed in the foot abduction brace.

Methods: The FAB24 trial is a prospective multicenter clinical randomized study the effectiveness of 2-year versus 4-year foot abduction bracing for the prevention of clubfoot recurrence. Participant enrollment for FAB24 was conducted at eight sites in North America and included enrollment and randomization of 139 participants with isolated clubfoot. The sample size calculation for this clinical trial assumed a 20% loss to follow-up. Patients were randomized in a 1:1 ratio using a formal probability model with a variable block size to ensure that there is no temporal bias. Temperature monitors were placed in all braces to measure compliance. Clinical variables including foot length/circumference ratio, peroneal activity, ability to dorsiflex and plantarflex the toes with stimulation, passive ankle motion, and degree of foot abduction in the FAB are recorded at every visit.

Results: Mean age at consent and brace fitting was 1.8 and 3.4 months, respectively. Clubfoot was unilateral in 50% of cases and 70% were male. Family history of clubfoot in a first-degree relative was present in 14%. Median Pirani and Dimeglio scores were 0.5 and 3.0. Peroneal function was absent on exam in 7%, slight in 42%. In unilateral cases, the calf circumference and foot length were significantly smaller on the affected side ($p<0.0001$), with greater fat foot index ($p<0.0001$).

Table. Descriptive Data
Table contains patient-level descriptive data for *randomized* participants, overall and by treatment group.

Variable		Complete Sample (N = 139)	By Treatment Group: 2-Year (n = 69)	By Treatment Group: 4-Year (n = 70)	p-value
Age at FAB24 consent (mo), mean ± SD (range)		1.8 ± 1.6 (0, 7.4)	1.8 ± 1.5 (0.3, 7.2)	1.8 ± 1.7 (0, 7.4)	0.83†
Age at brace fitting (mo)*, mean ± SD (range)		3.4 ± 2.6 (0.7, 26.2)	3.6 ± 3.2 (1.5, 26.2)	3.3 ± 1.7 (0.7, 8.4)	0.82§
Female gender, No. (%)		41 (30%)	23 (33%)	18 (26%)	0.32
Ethnicity, No. (%):	Hispanic or Latino	14 (10%)	7 (10%)	7 (10%)	0.98
	Not Hispanic or Latino	125 (90%)	62 (90%)	63 (90%)	
Race, No. (%):	American Indian/Alaska native	0 (0%)	0 (0%)	0 (0%)	n/a
	Asian	5 (4%)	1 (1%)	4 (6%)	
	Native Hawaiian/Pacific islander	1 (1%)	0 (0%)	1 (1%)	
	Black or African America	8 (6%)	4 (6%)	4 (6%)	
	White	116 (83%)	59 (86%)	57 (81%)	
	More than one race	7 (5%)	4 (6%)	3 (4%)	
	Unknown (not reported)	2 (1%)	1 (1%)	1 (1%)	
Family history of clubfoot in 1st degree relative, No. (%)		19 (14%)	10 (14%)	9 (13%)	0.78
Laterality of isolated clubfoot at enrollment, No. (%):	Unilateral	70 (50%) 33L, 37R	35 (51%) 14L, 21R	35 (50%) 19L, 16R	0.93
	Bilateral	69 (50%)	34 (49%)	35 (50%)	
Enrolled at what point in treatment, No. (%):	Before casting started	36 (26%)	16 (23%)	20 (29%)	0.23‡
	After casting started	95 (68%)	51 (74%)	44 (63%)	
	Day of brace fitting	8 (6%)	2 (3%)	6 (9%)	
No. casts participant received at the local site before brace fitting, including tenotomy cast*, median [IQR] (range)		6 [2] (2, 19)	6 [2] (2, 15)	5 [2] (2, 19)	0.89§
Time between study enrollment and brace fitting (mo)*, median [IQR] (range)		1.5 [1.0] (0, 23.2)	1.4 [1.0] (0, 23.2)	1.5 [1.1] (0, 5.7)	0.65§

mo = months; SD = standard deviation; No. = number of patients; n/a = not applicable; L = left side affected; R = right side affected; IQR = interquartile range.
Unless otherwise specified, p-value compares treatment groups by unpaired t-test (for continuous variables) or chi-square test (for categorical variables).
* Data missing for two 2-Year (two unilateral) and one 4-Year (bilateral) treatment group patients where brace fitting has not occurred.
† Data log-transformed prior to analysis.
‡ P-value by Fisher's exact test.
§ P-value by Wilcoxon's test.

Conclusion: Identification of clinical and genetic risk factors that predict risk of recurrence has the potential to allow individualization of clubfoot treatment in terms of length of time needed in the foot abduction brace. If effective, reducing the amount of time in the foot abduction brace may decrease health care expenditures by reducing bracing cost, medical complications (i.e. blistering and infections), and number of office visits.

Significance: This prospective randomized controlled clinical trial to determine the duration of abduction bracing in the treatment of isolated clubfoot has great potential to contribute to the practice of orthopaedics by providing evidence based data to improve patient care.

Effect of Split Posterior Tibialis Tendon Transfer on Foot Progression Angles in Children with Cerebral Palsy

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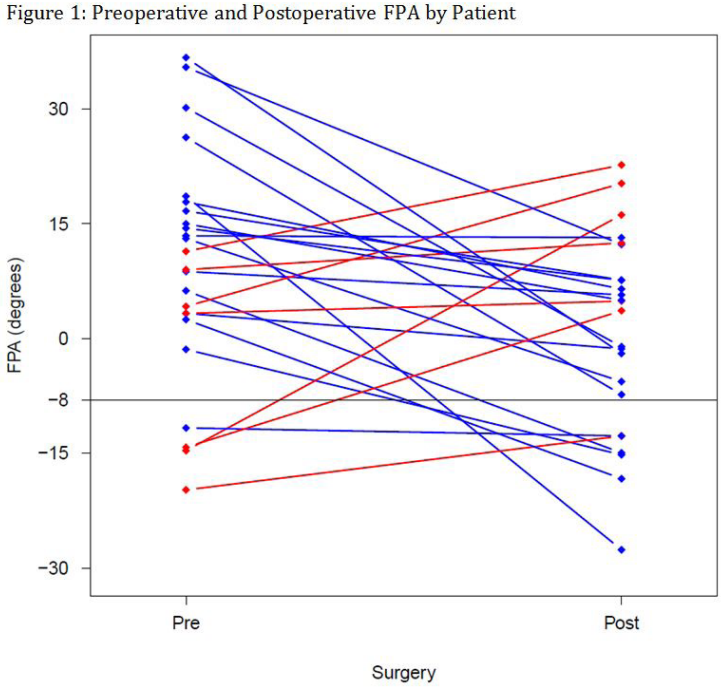
Purpose: The split posterior tibilais tendon transfer (SPOTT) has had mixed results on the efficacy in treating hindfoot varus and inversion deformities in children with cerebral palsy (CP). The deformity is due to over-activation of the posterior tibialis muscle, which SPOTT utilizes. In the past, goniometer angular measurements were used to quantify surgical correction but had a high risk of human error. Now with computerized gait analysis, precise measurements of kinematics and kinetics can be obtained. Using gait analysis, we evaluated the change in FPA following SPOTT that can be considered when correcting rotational deformities and lever arm disease.

Methods: We completed a retrospective chart analysis on 24 feet from 20 patients with a mean age of 7 (range 4-15). All patients had a diagnosis of CP and underwent SPOTT between 2006 and 2015. FPAs were measured both pre- and post-operatively via gait analysis. Patients that had rotational procedures other than SPOTT between gait analyses that would affect FPA were excluded. FPAs from pre- and post-op gait analysis were compared to the normative calculated average FPA of 8 degrees external rotation (-8) based on age-specific FPA data obtained at this institution. The absolute difference from pre- to post-op FPA was assessed via paired t-test.

Results: The mean of the preoperative FPA, 9.4 (95% CI: 3, 15.7), was significantly different from -8, $p<0.0001$. The mean of the postoperative FPA, 0.8 (95% CI: -4.7, 6.3), was also significantly different from -8, $p=0.003$. The mean of the differences from post to preoperative FPA from normal, -6.5 (95% CI: -12.5, -0.4), was significantly different from 0; $p=0.0383$. The average change in FPA was 8.6 degrees external rotation (-8.6) (95% CI: -16.5, -0.7) and was significantly different from 0; $p=0.035$.

Figure 1: Preoperative and Postoperative FPA by Patient



Conclusion: Our analysis revealed an average improvement in FPA of 9 degrees external rotation after SPOTT procedure. This can be used in calculating change in FPA when correcting axial deformities or lever arm disease.

Significance: While our results did not show a complete correction to normal FPA with SPOTT alone, we recommend utilizing SPOTT in conjunction with other rotational procedures for children with a diagnosis of CP who have hindfoot varus and inversion deformities with active posterior tibialis in swing. In addition, the utilization of computerized gait technology could allow for more precise, repeatable, and quantifiable data as a means to measure surgical outcomes.

Kinematics and Kinetics between Patients with Unilateral and Bilateral Recurrent Clubfoot

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Purpose: To identify differences in lower extremity kinematics and kinetics during gait between patients with unilateral versus bilateral recurrent clubfoot.

Methods: A retrospective review of patients seeking orthopaedic treatment for ongoing or new issues following previous clubfoot management was conducted. Joint kinematic and kinetic data from three-dimensional motion analysis using three AMTI force platforms were collected following standard protocols for all affected feet during barefoot walking. Single factor ANOVAs with an alpha of 0.05 were used to determine if there were significant differences between reference data collected at the same facility, unilateral clubfoot data and bilateral clubfoot data.

Results: A total of eighty-four affected feet from 42 patients with unilateral clubfoot (28 males, mean age 7.5±3.3 years) and 21 patients with bilateral clubfoot (15 males, mean age 7.0±2.8 years) were included.
Both clubfoot groups showed significantly more internal foot progression, external hip rotation, peak knee extension during single limb support, external pelvis rotation, and decreased peak ankle dorsiflexion during stance and swing compared to the reference group (Table 1). Additionally, compared to the reference group, the bilateral clubfoot group had significantly shorter step lengths, shorter stride lengths, and reduced peak plantar flexion during swing, and the unilateral clubfoot group had a significantly increased walking velocity and decreased peak knee power absorption during loading response.
There was a significantly decreased step length and increased peak dorsiflexion during stance in bilateral compared to unilateral patients (Table 1). Bilateral patients also had a significantly different mean sagittal knee moment during stance and increased peak knee power absorption during loading response compared to unilateral patients indicating an increased plantar flexor knee extension couple in the unilateral group.

Conclusion: Significant differences in gait parameters between unilateral and bilateral patients including step length, peak dorsiflexion during stance, mean knee moment during stance, and peak knee power absorption during loading response were noted. The unilateral patients showed decreased peak dorsiflexion in stance with an associated impact on ipsilateral knee kinetics in the form of an increased plantar flexion knee extension couple in comparison to the bilateral group.

Significance: Key gait parameters at the ankle and knee were significantly worse for the patients with unilateral versus bilateral recurrent clubfoot. This may have implications related to the frequency/extent of treatment needed in the patient with unilateral clubfoot. Consideration should be given to separate clubfoot patients into unilateral and bilateral groups in future research efforts due to these significant differences in their presentation.

Table 1. Summary of Clinical Exam and Gait Data for the Reference, Unilateral Clubfoot, and Bilateral Clubfoot Groups

	Reference Group	Unilateral Clubfoot Group	Bilateral Clubfoot Group	ANOVA Unilateral vs. Bilateral p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Clinical Exam - Range of Motion (ROM)		n=42 sides	n=42 sides	
Ankle Dorsiflexion ROM with the Knee Extended (Degrees)	≥ 5	0 ± 7	2 ± 8	0.3372
Manual Muscle Test		n=34 sides	n=38 sides	
Ankle Plantar Flexion Strength (Scale of 0 to 5)	5	Median = 3	Median = 3	N/A
Temporal & Stride	n=95 sides	n=42 sides	n=42 sides	
Step Length (Normalized to leg length, opposite limb used)	0.81 ± 0.08	0.8 ± 0.1	0.75 ± 0.1†	**0.0473***
Stride Length (Normalized to leg length)	1.62 ± 0.11	1.59 ± 0.2	1.52 ± 0.2†	0.0672
Walking Speed (Per second, normalized to leg length)	1.75 ± 0.26	1.86 ± 0.4†	1.77 ± 0.4	0.2804
Kinematics	n=95 sides	n=42 sides	n=42 sides	
Mean Foot Progression during Stance (°, +int/-ext)	-11 ± 8	5 ± 11†	3 ± 15†	0.1600
Mean Hip Rotation during Stance (°, +int/-ext)	1 ± 6	-10 ± 11†	-10 ± 8†	0.7387
Peak Ankle Dorsiflexion during Stance (°,+dorsi/-plantar)	14 ± 3	9 ± 5†	12 ± 6†	**0.0089***
Peak Ankle Dorsiflexion during Swing (°, +dorsi/-plantar)	4 ± 4	0 ± 5†	1 ± 6†	0.3540
Peak Ankle Plantar Flexion during Swing (°,+dorsi/-plantar)	-18 ± 7	-15 ± 6	-14 ± 8†	0.2825
Peak Knee Extension in Single Limb Support (°, +flex/-ext)	6 ± 6	0.1 ± 6.6†	2.6 ± 7.4†	0.0992
Peak Pelvis External Rotation during Gait Cycle (°, +int/-ext)	-6 ± 5	-10 ± 6†	-10 ± 7†	0.7101
Kinetics	n=95 sides	n=39 sides	n=36 sides	
Mean Sagittal Knee Moment during Stance (Nm/kg, +ext/-flex)	0.08 ± 0.11	-0.07 ± 0.1†	0.03 ± 0.1†	**0.0013***
Peak Knee Power Absorption during Loading Response (W/kg, +gen/-abs)	-0.83 ± 0.52	-0.5 ± 0.6†	-1.1 ± 1.1	**0.0013***
Peak Ankle Plantar flexion Moment during Stance (Nm/kg, +ext/-flex)	1.2 ± 0.2	0.9 ± 0.2†	0.8 ± 0.2†	0.2052
Peak Ankle Power Generation during Stance (W/kg, +gen/-abs)	3.35 ± 1.04	2.02 ± 0.7†	2.04 ± 0.8†	0.8940

†Significantly different compared to reference group ($p<0.05$)

*Significant difference between unilateral and bilateral clubfoot groups ($p<0.05$)

Results of the Ponseti Method of Clubfoot Treatment in Older Children (> 1 Year of Age)

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Purpose/Introduction: Very few reports are available in literature about the results of clubfoot treatment by the Ponseti method in walking children. The aim of our study was to document our results in older children.

Methods: 58 consecutive patients (83 clubfeet) older than 1 year of age from a cohort of 768 children treated in a dedicated Clubfoot Clinic as part of a nation-wide clubfoot program over a 5 year period (Aug 2011 – Jul 2016) were analyzed retrospectively. Variables studied were age at presentation, initial & final Pirani scores, total number of casts, tenotomy rate, rate of relapse and brace compliance.

Results: The mean age at presentation was 3.6 years (range 1 year – 18.2 years) and mean follow-up was 33 months (3 months – 60 months). 45 patients had been previously treated elsewhere by average of 4.3 casts (range 1 - 19 casts) and Tendo-Achilles tenotomies had been done in 23 feet (16 patients). 3 patients had undergone surgical procedures elsewhere. The mean Pirani score at start of treatment was 3.36 (0.5 - 6) and 0.1 (0 – 1.5) at final review. Average number of casts was 5.34 (1 to 17), 44 patients (63 feet) underwent percutaneous Tendo Achilles tenotomy with a tenotomy rate of 75.8%. 52 patients were compliant with foot abduction brace. Recurrences were seen in 27/83 feet in 19/58 patients (32.7%), which were treated by re-casting & bracing in all cases and Tibialis anterior tendon transfer in 11/27 patients (16/27 feet) and 3 underwent surgery. Using a clinical scoring system, we could achieve excellent result in 39 patients & good result in 19 patients. Significant correlation was seen between age and number of casts ($p=0.002$). No significant correlation was seen between age of patients and relapse ($p=0.609$) and compliance of brace with age ($p=0.822$)

Conclusions: Our study represents one of the largest series in literature showing that the Ponseti method can be successfully used even in walking age children. Though the relapse rate is high (32.7%), good results can be achieved in majority of cases without the need for surgical intervention.

Significance: We have the second largest series in resent literature and the have largest single centre series showing the results of ponseti in method in children of walking age group

Amount of Daily Brace Time Needed for Successful Outcomes in Ponseti-Treated Clubfeet

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Purpose: Once correction of an idiopathic clubfoot is achieved with Ponseti's method, 22 hour/day brace wear for three months followed by 12 hour/day brace wear for 2-4 years is considered necessary to maintain a successful outcome. The purpose of this study was to longitudinally observe the amount of daily orthosis wear time that was used to maintain correction at age two years, and to then use this information to determine the necessary minimum hours of wear to insure success.

Methods: To be included in this study, patients needed to have idiopathic clubfeet, be <3 months old when Ponseti treatment began, have maintained correction of their feet at age 2 years without the need for surgery (except heelcord tenotomy), and have data at every time interval listed below. The foot abduction orthoses had a temperature data logger embedded in a shoe which allowed objective assessment of the amount of time the brace was used. Four time intervals (in months) were monitored in every patient: 0-3, 4-6, 7-12, and 13-18. Parents rarely returned shoes to allow objective assessment of the 19-24 month interval. Families were not informed that hours of brace wear were being measured.

Results: 87 patients with 127 clubfeet were included. During the 0-3 month interval, wear time averaged 20.0 hours/day (range 0-23.9). Following this period of full-time use, the wear time for interval 4-6 months averaged 11.2 hours/day (range 0.6-19.1); for 7-12 months averaged 9.0 hours/day (range 0-13.8); and for 13-18 months averaged 8.0 hours/day (range 0-17.1). The detailed breakdown of the amount of daily hours in brace is shown in the table below.

		% Patients in brace		
	Hours	4-6 mo Interval	7-12 mo Interval	13-18 mo Interval
Daily Hours in the brace (12 hours recommended)	<6	9%	23%	34%
	6<8	7%	13%	14%
	8<10	16%	18%	14%
	10<12	24%	26%	14%
	≥12	44%	20%	24%

Conclusion: In patients evaluated at age two years whose clubfeet had successful nonoperative treatment, brace wear varied greatly. Some patients wore the brace in excess of the recommended 12 hours/day, and others much less. In fact, in the second six months of brace wear (7-12 months), approximately 40% of patients wore the braces less than 8 hours/day and beyond that (13-18 months), this percentage of brace wear <8 hours/day increased to approximately 50%.

With this information, and in the absence of a comparative unsuccessful group, we

are still unable to formally quantify the necessary minimum hours of brace wear to insure success.

Significance: Although the recommendation for 12 hours/day brace wear remains sound, it's important to recognize that successful outcomes can still be achieved in many patients who wear the brace 8 hours or less.

Quantification of Lateral Cuneiform Ossification in Unilateral Idiopathic Clubfoot: Implications on Appropriate Age for Anterior Tibialis Tendon Transfer

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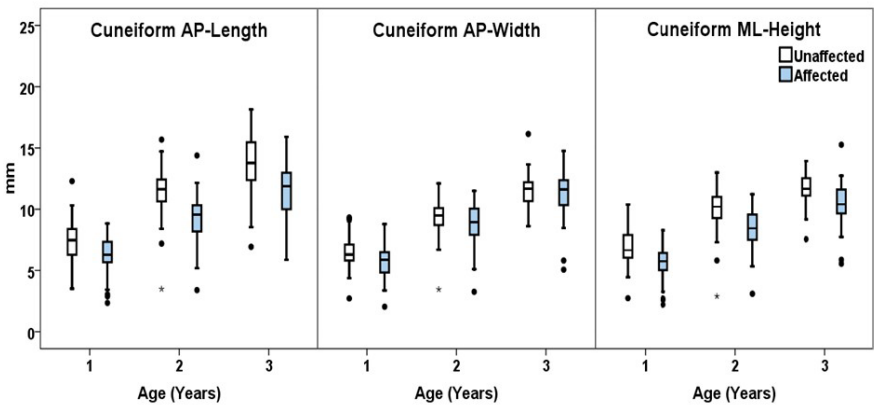
Purpose: As the Ponseti method of correction of congenital clubfoot has gained wide acceptance worldwide, a relapsed deformity following initial complete correction has become more prevalent. In selected patients, a relapse is managed by anterior tibial tendon transfer (ATTT) to the lateral cuneiform (LC). Some investigators have recommended that tendon transfer await sufficient ossification of the LC to facilitate bone to tendon healing and avoid potential damage to the cartilaginous anlage. The early timing of ossification of this structure has not been previously described. This study quantifies the ossification process of the LC in patients with idiopathic clubfoot between 1 and 3 years of age.

Methods: The length, width, and height of the LC were measured by two independent clinicians on standardized anteroposterior (AP) and lateral radiographs of both feet taken at 1, 2, and 3 years of age in 43 consecutive patients with unilateral clubfoot treated using the Ponseti method.

Results: The mean length, width, and height of the LC in the affected feet measured 6.17 mm (SD 1.61 mm), 5.62 mm (SD 1.51 mm), and 5.68 mm (SD 1.62 mm) at 1-year, respectively; 9.23 mm (SD 2.10), 8.72 mm (SD 1.73 mm), and 8.42 mm (SD 1.63 mm) at 2-years, respectively; 11.56 mm (SD 2.27mm), 11.11 mm (SD 1.99 mm), and 10.42 mm (SD 1.84 mm) at 3-years, respectively. On the 1-year and 2-year radiographs, the mean length, width, and height of the LC on the affected side were all significantly smaller than the corresponding dimensions of the non-affected side ($p \leq 0.001$). On 3-year radiographs, the length and height of the LC on the affected side were significantly smaller than the corresponding dimensions of the non-affected, side ($p < 0.001$), while the width values were similar ($p = 0.083$).



Conclusion: The ossification center of the LC may not be consistently large enough to accommodate a tendon transfer by 2 years of age. However, by 3 years, there is an ample volume of bone present to facilitate bone to tendon healing.

Significance: This is the first study to quantify the ossification pattern of the LC in clubfoot patients managed using the Ponseti method. If bone to tendon healing is deemed desirable, the ossific nucleus of the LC will be reliably of adequate size by 3 age years to accommodate a 3.2mm (3/8 inch) drill hole with a comfortable margin for error.

The Dorsal Subluxation of the Navicular in Clubfoot after Ponseti Treatment: Is Plantar Fasciotomy a Treatment Option?

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Purpose: Most of the children born with clubfoot do well after Ponseti treatment however a minority will develop a relapse with a deformity in supination, fore foot adduction, cavus foot or a combination of these deformities. It is common to see on the lateral radiogram of the foot a dorsal subluxation of the navicular leading to a rigidus cavus foot deformity in the adult.
Our hypothesis is that early plantar fasciotomy complemented or not by the transfer of the tibialis anterior to the 3rd cuneiform will be able to relocate the navicular.

Methods: After approval by the ethics committee of our both Institutions 21 children (24 feet) treated between 2009 and 2014 for a relapse clubfoot complicated by a cavus deformity with dorsal dislocation of the navicular were reviewed. 19 feet submitted to a plantar fasciotomy and 7 feet was associated a lateral transfer of the Tibialis Anterior. In 5 feet only a transfer of the tibialis anterior was performed. The patients were evaluated according o the age of the operation and image evaluation by standing AP view and lateral view (with the external border of the foot against the cassette in a standardised way).
On the lateral side it was evaluated (pre&post op) the angle between the axes of the talus with the axe of the 1st metatarsal, the distance between the lower border of the talus and the navicular (Migration Index) and the overlap of the fibula over the tibia (Rotational Index)

Results: 21 children (24 feet) were reviewed with a minimum follow-up of 2 years. The mean age at the time of the operation was 7,2 years (max 11 years, min 4 years). We found an improvement in all x- ray measurements on the lateral view (angle between the axes of the talus and 1st metatarsal - 16,35º pre-op and 9,41º post op, - Migration index with 27,12mmvs15,9 mm, rotational index - 18,45%vs23,69% but only the migration index was statistical significant (P<0,002).

Conclusion: The main idea of our work is to prove that if we intervene early enough this type of the deformity can be reversed in the majority of the cases as it was proved by the improvement of all the radiological parameters at the last follow up.

Significance: The plantar fasciotomy associated or not with an external transfer of the tibialis anterior is a valid option for the treatment of the cavus foot with dorsal subluxation of the navicular.

A Global Alliance to Eliminate Untreated Clubfoot: Capacity Through Partnerships

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Purpose: 80% of children born with clubfoot (~160,000) live in low and middle-income countries (LMIC) where treatment is either unavailable or ineffective. The Ponseti method, a low cost and effective treatment, makes it possible to treat clubfoot in the lowest resource settings.

In the past two decades the importance of addressing clubfoot in LMIC has been recognized. Coordinated programs have been established to provide services on a national level for children with clubfoot. In 2013, 36 programs in LMIC provided treatment to approximately 28% of all children born with clubfoot. This leaves over 70% of children left untreated in LMICs every year.

Methods: Predictive modeling was used to discover the attributes that make successful clubfoot programs in LMIC. Using an international clubfoot registry and demographic information from 30 clubfoot organizations, predictor variables, such as; population density near the clinic, number of staff, number of patients, internet access, cost and availability of braces and training workshops were compared to the numbers of new patients enrolled. Using multiple regression modeling, we found which prospective clinics will best be able to treat clubfoot patients. This allows informed decisions about which clinics will make for best investments in the future.

Results: 12 national programs in LMIC enrolled more than 75% of the estimated children born with clubfoot in their respective countries. The national programs used a model of public-private partnership, with national health authorities (i.e. ministry of health) providing resources such as clinic facilities, staff, and varying amounts of treatment supplies. Non-governmental organizations provided subsidized treatment supplies, training on the Ponseti treatment, awareness campaigns and patient support, capacity-building for coordination and administration, and measurement and evaluation.

Major components shared between these programs included a national training package, low cost brace options, and access to an international clubfoot database.

Conclusion: This study demonstrates that eliminating untreated clubfoot can be achieved through a global alliance and significant scaling of current activities. The study shows that allocating resources to reduce untreated clubfoot is economically justifiable through applying best practices to implement national programs.

Significance: Non-governmental organizations that focus on clubfoot treatment will aim to replicate and scale the program model in every LMIC with a primary focus on the 59 countries where at least 50 children are born with clubfoot annually.

Outcomes following Supination-Inversion Ankle Fractures in Children

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Purpose: The purpose of this study was to analyze clinical and radiographic outcomes following the most common ankle fracture pattern in children: Dias-Tachdjian supination-inversion injuries.

Methods: We performed a chart and x-ray review of patients who sustained supination-inversion type II injuries from 2003-2014. Inclusion criteria were skeletally immature patients with radiographic follow-up of: a) one year, or b) 6 months with obvious growth resumption as indicated by Park-Harris growth lines parallel to the physis. All injury films were examined, and fracture displacement recorded. Evidence of growth disturbance and other complications were sought. Patients were also contacted by phone to complete the FAOS (Foot and Ankle Outcome Score).

Results: There were 47 patients in the surgical group and 7 in the non-surgical group. The average age in the surgical group was 12 yrs (range 7-15 yrs) and the average age in the non-surgical group was 11 yrs (range 6-14.5 yrs). There was a 15% (7/47) major complication rate in the surgical group. Analysis via Fisher exact test revealed that there was a significantly ($p=0.025$) higher rate of complications in the non-surgical group (57%, 4/7), and there was a significantly higher ($p=0.019$) rate of complications in the surgical group when post-operative fracture displacement was $\geq$ 2 millimeters. No significant differences in FAOS scores were detected.

Conclusion: When comparing surgical and non-surgical treatment of supination-inversion type II injuries we found a statistically higher complication rate with non-surgical treatment.

Significance: Our study reasserts the value of modern surgical treatment of type II supination-inversion ankle fractures in children. The goal should be stable internal fixation with fracture fragments reduced with < 2 mm residual displacement.

Relationship between Dysplasia of Tarsal Bone at Neonate and Relapse in Congenital Clubfoot

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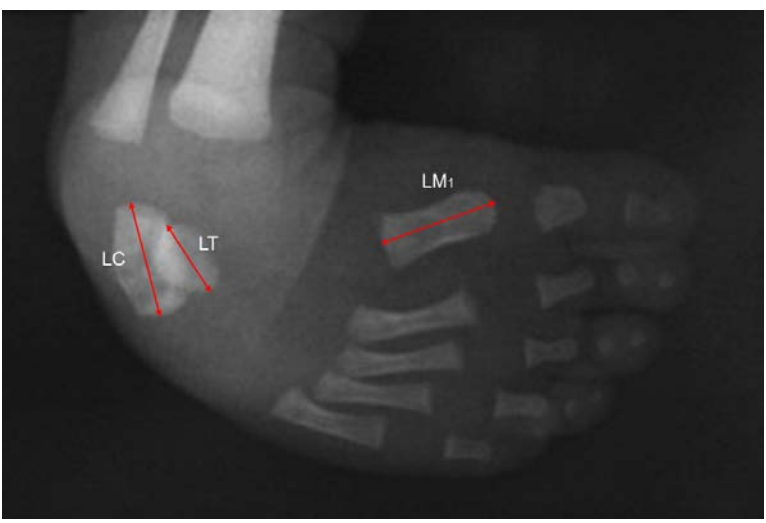
Purpose: The purpose of this study is to analyze the relationship between dysplasia of tarsal bone at neonate and relapse in congenital clubfoot.

Methods: Eighty-two feet in 57 patients with idiopathic clubfoot were retrospectively examined. They were initially treated by Ponseti method within a month after birth. All patients were followed at least through age six with good compliance of foot abduction brace with bar until the age of four. Twenty-five patients were affected bilaterally and 32 were unilaterally affected. Before treatment, antero-posterior radiographs of each foot were taken at the average age of 12 days after birth (range; 1-29 days). The longitudinal length of the 1st metatarsus (LM_1), the ossification center of talus (LT), and the ossification center of calcaneus (LT) of all feet were measured using measuring software (Synapse 3.2.1, SR356) on the digital radiographic image (figure). All feet were classified into three groups: 19 feet for which corrective surgery was performed due to relapse during follow-up periods (relapse group), 63 feet which were followed conservatively without relapse (no-relapse group), and 32 feet from the unaffected side in unilateral clubfoot (control group). To compare LM_1, LT, and LC among the three groups, the Wilcoxon rank sum test was used. All statistical analyses were carried out using JMP software (version 10; SAS Institute, USA).

Results: There were no statistically significant differences in the average of LM_1 among relapse, no-relapse, and control groups (12.2, 12.4, and 12.7mm, respectively). The average of LT (relapse group: 5.1, no-relapse group: 7.1, control group: 9.2mm) indicated statistically significant differences in all combinations of the three groups. The average of LC (9.2mm) in the relapse group was significantly shorter than those in the no-relapse and control groups (11.2 and 11.6mm, respectively). However there was no difference in the average of LC between the no-relapse group and control group.

Conclusion: It is generally said that noncompliance with brace after Ponseti method is associated with the risk of relapse in congenital clubfoot. However controversy remains on the relationship between the initial pathology and relapse in congenital clubfoot. From this study we concluded that the se-



verity of dysplasia of tarsal bones, especially in talus, at neonate is related to relapse after primary correction.

Significance: The longitudinal length of the ossification center of talus at neonate may be a predictive factor of relapse in congenital clubfoot. In addition it might be one of indices for evaluating objectively the severity of congenital clubfoot.

Prognostic Factor and Prognosis of Congenital Club Feet with Residual Deformity

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Purpose: To evaluate mid-term results of the treatment for congenital talipes equino-varus (CTEV) with Ponseti Methods.

Methods: We have treated 71 cases (101 feet) of CTEV between 1999 and 2015. All cases whom we could follow after the age of six were included in this study. These cases were divided into three series, without relapse (Group G: 28 feet), relapse by age 4 (Group E: 48 feet) and relapse beyond age 4 (Group L: 25 feet), respectively. Radiographical, clinical and treatment data were recorded for this study.

Results: There was no significant difference among three groups about the age at the first presentation, severity of deformity on Pirani's score before treatment and the number of initial casts. Compliance for foot abduction brace was worse in Group E compared to other group, Although intoeing gait was the most common symptom for relapse, equinus or heel varus deformity were found more frequently in Group E than in Group L. Sixty percent (Group E) and 28% (Group L) of cases were operated and there was no significant difference with type of operation. Radiographic findings did not statically change among three groups treated without operation. Radiographic results in final follow-up had some relationship with radiography at the age of four.

Conclusion: We could not determine the prognostic factor for the relapse of CTEV. We found that any conservative treatments could not change outcome beyond age 6. To achieve better final outcome, we should try to improve the results until the age of 4.

Significance: In this study, we revealed that we could not change natural history of CTEV with any treatment except for operation beyond age 6. To improve the final outcome of CTEV , we have to achieve better condition by age 6. Radiographic results at the age of 6 have some relevance to those at the age of 4. This result indicate that initial treatment might be precious for the treatment of CTEV with Ponset methods and we would not be able to recover the prognosis of fall-off cases in initial treatment of CTEV.

Clubfoot with Tethered Cord Syndrome: Are These More Difficult to Treat?

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Purpose: The purpose of this study was to determine if clubfoot associated with tethered cord syndrome (TCS) is more difficult to correct and maintain than isolated clubfoot.

Methods: An IRB-approved retrospective cohort study of subjects undergoing Ponseti treatment of clubfoot between 2002 and 2013 was conducted. A chart review was used to identify cases of clubfoot with radiographic confirmed TCS that required a tethered cord release. Subjects with syndromes or neural tube defects were excluded. Subjects with TCS were matched to subjects with isolated clubfoot (1:2) on the basis of laterality, date of birth, gender, and age at presentation. Subject demographics, number of casts placed (pre-and post-tenotomy), and recurrence data were collected. Difficulty of treatment was quantified by the total number of casts needed to achieve acceptable correction. Generalized logistic regression and linear mixed model regression analyses were used to compare occurrence of a recurrence within 2 years of the initiation of casting and the log number of casts needed to achieve an acceptable correction, respectively.

Results: Data from 24 subjects with clubfoot (12 bilateral; 12 unilateral) were analyzed. The isolated clubfoot group was the same age at presentation on average [21.9±4.7 days] as the TCS group [28.3±9.6 days] [p=0.55]. The number of casts required to achieve an acceptable correction was 54% higher [95% CI: 7.8 to 120.3%, p = 0.0217] in the TCS group compared to the isolated clubfoot group. The cumulative crude incidence of deformity recurrence within the first two years after casting initiation was 8% in the isolated clubfoot group compared to 42% in the TCS group. The odds of deformity recurrence in the TCS group were 5.6 [95% CI: 0.7 to 45.2, p = 0.1054] times the odds of deformity recurrence in the isolated clubfoot group. Furthermore, the incidence of deformity recurrence was higher among subjects that had a tethered cord release post-tenotomy (56%, 5/9) as compared to pre-tenotomy (0%, 0/3).

Table: Median number of casts required to achieve acceptable correction of clubfoot.

	Isolated Clubfoot (Q1 - Q3)	Clubfoot with TCS (Q1 - Q3)	P Value
n	24	12	-
Casts Total	7.0 (5.0 - 8.0)	9.5 (7.5 - 17.25)	0.02*
Casts Pre-Tenotomy	5.5 (4.75 - 7.0)	8.0 (6.5 - 16.0)	0.02*
Casts Post-Tenotomy	1.0 (1.0-1.25)	1.0 (1.0 - 1.25)	0.56

* indicates statistical significance

Conclusion: Clubfoot associated with TCS required more casts to achieve an acceptable correction. Subjects with tethered cord were also at an increased risk of deformity recurrence compared to subjects with isolated clubfoot.

Significance: The true prevalence of clubfoot associated with TCS is unknown and routine screening at presentation in otherwise healthy infants is not standard practice. Heightened awareness of a secondary diagnosis is essential in our effort to direct appropriate care, and decrease financial burden on families and our health care system.

Osseous Hypoplasia in Unilateral Clubfoot: The Influence of Ponseti Casting

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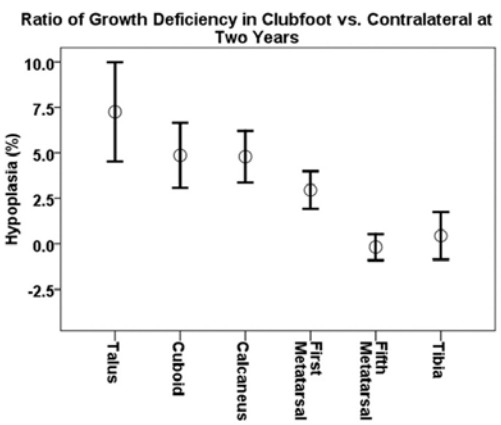
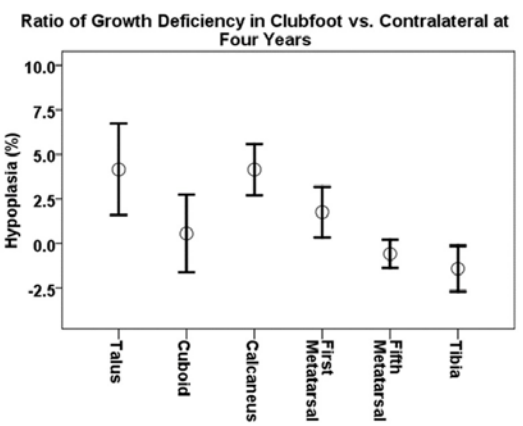
Purpose: Hypoplasia of the posterior and medial osseous structures is commonly found on the affected side of patients with a unilateral clubfoot, however, no studies have evaluated the early growth of these structures following Ponseti treatment. A previous study of foot radiographs of Ponseti-treated adults with unilateral clubfeet found that the talus was 5% smaller, and the calcaneus 4% smaller on the affected side. The purpose of our study was: to quantitate the degree of hypoplasia present in the bones of young infants with clubfoot, and to determine whether the amount of hypoplasia diminishes following treatment.

Methods: The radiographs of 66 patients with a unilateral clubfoot deformity, prospectively enrolled in a clubfoot database, treated using the Ponseti method, and followed for a minimum of 2 years were reviewed. We measured the length of the talus, calcaneus, cuboid, 1st metatarsal and 5th metatarsal on radiographs taken at 2 years of age, and on those patients who were followed to 4 years of age. The percent of hypoplasia was calculated for each patient by comparing measurements on affected and unaffected feet.

Results: At 2 years of age, the structures with the greatest percentage of hypoplasia were the talus (7.3%), cuboid (4.9%), and calcaneus (4.8%), followed by the 1st metatarsal (3.0%), distal tibial metaphysis (0.5%) and 5th metatarsal (-0.2%). At 4 years of age, the percentage of hypoplasia was: talus (4.2%), calcaneus (4.2%), and 1st metatarsal (1.8%), followed by the cuboid (0.6%), 5th metatarsal (-0.6%), and distal tibial metaphysis (-1.4%). Once clubfoot correction was achieved and maintained with post-corrective brace use, the percentage of hypoplasia of the posterior and medial osseous structures diminished between 2 and 4 years of age, but some hypoplasia persisted in the talus and calcaneus.





Conclusion: Following correction of an idiopathic clubfoot using the Ponseti method, the degree of hypoplasia in the posterior and medial osseous structures diminished

between 2 and 4 years of age, but both the talus and calcaneus remained 4.2% smaller in the clubfeet.

Significance: The results suggest that by 4 years of age, the relative size of the feet should be fairly constant in a patient with a unilateral clubfoot. Any increase in the proportional difference in foot length after this age may not be attributable to osseous hypoplasia alone, and should prompt a careful evaluation of the foot for components of a relapsed deformity, such as adductus or cavus, as possible contributing factors to the change in foot size.

Risk Factors for Surgical Intervention in Patients with Idiopathic Clubfoot Treated by Ponseti Method

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Purpose: The purpose of this study was to determine the risk factors associated with the need for surgical correction due to relapse in patients with idiopathic clubfoot treated by Ponseti method.

Methods: One hundred and two feet in 72 patients with idiopathic clubfoot were retrospectively examined. All patients were initially treated by Ponseti method and were followed at least through age five with good compliance of foot abduction brace with bar until the age of four. All feet were classified into two groups. The feet for which corrective surgery were performed due to relapse during follow-up periods were defined as surgical group and the other feet which were followed conservatively without any surgeries were defined as conservative group. The ratio of male or female patients, the ratio of bilateral or unilateral affection, the Dimeglio score at initial presentation, the period of serial casting, need for percutaneous Achilles tenotomy (PAT), and several parameters in the radiograph at the age of 9-month were compared between two groups.

Results: There were 29 feet in surgical group and 73 feet in conservative group. Eight of posterior release, 12 of posteromedial release, 8 of complete subtalar release, and 1 lateral transfer of tibial anterior tendon were performed. There were no statistically significant differences in the frequency of PAT (surgical group: 86.2%, conservative group: 83.6%), the ratio of bilateral or unilateral affection (surgical group was 65.5% and conservative group was 56.2% in the bilateral affection rate), and the period of serial casting (surgical group: 8.4 weeks, conservative group: 7.2 weeks) between surgical and conservative groups. However male patients were 2.4 times more likely to need surgery than female patients. The average score of Dimeglio at initial presentation was significantly higher (12.4 points) than those in the conservative group (10.7 points). The average of talo-calcaneal and tibio-calcaneal angles of the lateral radiographic view at the age of 9-month in the surgical group were worse than those in the conservative group.

Conclusion: Controversy remains except noncompliance with brace on the risk factors of relapse after initial correction in congenital clubfoot. From this study we concluded that male patients and those with higher Dimeglio score at initial presentation or insufficient correction after initial treatment were at increased risk for needing surgical intervention.

Significance: This information may be useful to identify a high-risk group for needing surgical intervention after initial correction.

3D-Fluoroscopy: A Useful Tool in the Operative Treatment of DDH

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Purpose: Surgical treatment of DDH is indicated when a nonoperative stable and atraumatic reduction of the hip cannot be achieved. Postoperative hip reduction is traditionally judged by CT or MRI. We aim to determine the value of intraoperative 3D-Fluoroscopy to confirm adequacy of hip reduction in children with DDH undergoing closed reduction, adductor longus and/or psoas tenotomy and spica cast.

Methods: Retrospective cohort study including children with DDH undergoing closed reduction, adductor longus and/or psoas tenotomy and spica cast, period 2012-2015. We included patients with intraoperative 3D-fluoroscopy and postoperative MR. We excluded patients who didn't have these investigations, presented syndromic/neuromuscular disease or had contralateral hip open reduction. We analyzed demographic characteristics of patients, DDH classification, prior Pavlik use, time between Pavlik cessation and surgery, hospitalization duration, radiation doses, adequacy of hip reduction, plaster changes after 3D-Fluoroscopy, time between surgery and MRI and adequacy of hip reduction in MRI. A significance level was considered for $p < 0.05$.

Results: 50 patients were elligible for this study, of which 13 were excluded (6 without 3D-Fluoroscopy, 4 without MR, 2 syndromic, 1 had contralateral open reduction). Of 37 patients enrolled, 24 had unilateral and 13 bilateral DDH, total 50 hips. Age at surgery was 8±4months, median admission time 2 days. There were 33 females , 25 Tönnis-2 hips, 33 left hips. In 19 hips initially Ortolani positive, Pavlik was applied and interrupted after median 15 days. In these cases, surgery was performed 52.1 ± 24,8 days afterwards. Under general anesthesia, all hips were Ortolani positive. Adductor longus tenotomy was performed in all cases, complemented by iliopsoas tenotomy in 28 hips. 3D-Fluoroscopy was performed after spica cast. In 2 cases, the reduction was considered eccentric: cast was changed. Total operative radiation dose 116.4 ± 57,7mGy.cm/patient, 3D-Fluoroscopy dose 104.5±53,6mGy.cm/patient and 3D-Fluoroscopy duration 76.5 ± 32,6seconds/patient. Patients underwent MR at 21.9±13,1 days postoperative: hip adequately reduced in all cases. There were no statistically significant differences between patients with bilateral or unilateral DDH, for radiation doses and times needed for 3D-Fluoroscopy.

Conclusion: 3D-Fluoroscopy has a positive predictive value of 100% to confirm adequate hip reduction, combined with a radiation dose/patient [116mGy.cm] lower than CT [130mGy.cm]. It allows intraoperative spica cast change in inadequate hip reductions.

Significance: 3D-Fluoroscopy is useful tool as part of surgical strategy in DDH operative treatment and may help to prevent post-operative hip redislocations.

Bilateral DDH-Closed or Open Reduction?

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Purpose: To investigate the best method of treatment of bilateral late-presenting Developmental Dysplasia of the Hip (DDH).

Methods: 45 patients with bilateral DDH (90 hips) underwent either Closed reduction (CR) or anterior open reduction (OR) over a 10 year time period. Outcome measures included osteonecrosis rate (ON), residual dysplasia, need for bony surgery, and Modified Severin grading at 6 years.

Results: Median follow-up was 5 years (1-12 yrs).
58 hips (29 patients) under 24 months underwent attempted CR. 43% of hips failed, with a bilateral failure rate of 34%. Tonnis 4 hips were significantly more likely to fail. 5 unilateral failed hips were maintained in cast to allow the contra-lateral successful reduction to stabilise. All failed closed reductions went on to have OR. Of 33 successful CRs, 5 required secondary bony surgery for acetabular dysplasia (15%). 4 successful hips (12%) developed significant ON.
54 hips in 27 patients underwent bilateral OR (including 10 patients with failed bilateral CR). Median age was 15 months (9-54 months). Immediate reoperation for resubluxation was required in 6 hips. Concomitant bony surgery was required in 24% of hips < 24 months undergoing OR, and in all older hips. 13.5% of hips developed significant osteonecrosis.
92% of successful bilateral closed reductions were Severin 1; 8% were Severin 2. In the 5 hips where one hip was splinted in dislocation to allow the contra-lateral hip to stabilise, no significant ON was seen, and 80% were Severin 1.
52% of hips following open reduction were Severin 1, unrelated to age at the time of surgery. 3 hips (10%) were Severin 3 due to osteonecrosis. Most of the Severin 2 hips were graded as such due to acetabular dysplasia.

Conclusion: Tonnis 4 bilateral hips have a high rate of failure with CR.
Hips treated with closed reduction require secondary bony surgery less often, and have a better outcome than hips of a similar age treated with primary open reduction, with a comparable risk of ON.
Splinting unilateral failed CRs to allow the contra-lateral hip to stabilise does not result in significant osteonecrosis and 80% in this series were Severin 1.

Significance: CR is worthwhile for all Tonnis 2 and 3 bilateral hips presenting under the age of 24 months, with a similar risk of Osteonecrosis but better outcome than OR. Previous failed CR does not prejudice the outcome of OR in these hips.

Can Brace Treatment be Successful for Dislocated Hips in Infants over Six Months of Age?

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Purpose: Bracing is the first-line of treatment for an infant with a developmental hip dislocation. However, previous studies claim that it is difficult to maintain the brace in active, crawling children over the age of six months and recommend closed or open reduction as initial management in these older children. The purpose of this study was to evaluate the outcomes of brace treatment for children who present over age six months with a developmental hip dislocation using a prospective, international, multicenter database.

Methods: Our inclusion criteria were infants over age six months, with dislocated hips (IHDI grade III or IV) that were treated with a brace, and had minimum one-year follow-up. We studied 12 hips (12 patients) with an average follow-up of 28.7±15.1 months. Treatment success was defined as a stable, concentrically reduced hip (IHDI grade I) at final follow up without requiring surgical reduction. There were three different initial treatment modalities used based on surgeon preference: Pavlik Harness (PH, 8 hips), Denis Browne brace (DB, 1 hip), and hip abduction brace (HAB, 3 hips). DB and HAB were combined into a "static brace" group.

Results: Ten hips presented as IHDI grade III, and two as IHDI grade IV (Table 1). Brace treatment failed in 6/10 IHDI III hips and 2/2 IHDI IV hips. PH treatment failed in 4/8 patients and static brace failed in 4/4 patients. Overall, brace treatment failed in 8/12 hips, all of which underwent closed reduction. One hip had a subsequent acetabular procedure. Two IHDI III hips developed avascular necrosis (AVN), both occurred after closed reduction. 4/4 hips treated successfully in a PH were IHDI I at final follow up and were braced an average of 270±82 days (range: 189 to 352 days).

Table 1: Demographics and outcomes of interest for entire cohort

		IHDI III	IHDI IV	Total
Number of subjects		10	2	12
Age at presentation (mos)	mean±std. dev.	9.0±2.4	11.8±7.2	9.4±3.3
	range	6.2 to 13.7	6.7 to 16.9	6.2 to 16.9
Treatment type	Pavlik Harness	7	1	8
	Static Brace	3	1	4
IHDI grade at final follow up	IHDI I	10	2	12
Subsequent surgery (acetabular or femoral)		6	2	8
AVN		2	0	2
Acetabular index at final follow-up	mean±std. dev.	24.3±5.3°	22.5±0.7°	24.0±4.9°
	range	16 to 35°	22 to 23°	16 to 35°
Follow up (mos)	mean±std. dev.	29.7±16.5	23.7±1.5	28.7±15.1
	range	12.0 to 60.3	22.6 to 24.7	12.0 to 60.3

Conclusion: Patients initially presenting with dislocated hips over age six months are difficult to treat with a brace with overall success in 4/12 hips. Although rarely attempt-

ed, successful brace treatment was achieved in 4/7 IHDI grade III hips treated with a Pavlik harness. Longer-term follow-up is required to determine the true incidence of AVN and future containment surgery and compare brace treatment to alternative approaches (i.e. closed reduction or open reduction).

Significance: This is the first, multi-center, prospective evaluation of brace treatment for infantile hip dislocations over age six months. In this cohort, 4/7 infants who present after age six months with an IHDI grade III hip dislocation were successfully treated with a Pavlik harness.

Growth Pattern in Slipped Capital Femoral Epiphysis (SCFE)

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Purpose: Evaluate if the growth pattern of children with SCFE is different from the normal population and compare the growth pattern of patients with stable and unstable SCFE to see if differences between them existed.

Methods: Two hundred and twenty patients treated in 8 different referral hospital were evaluated, the height, weight and BMI was recorded on admission to the hospital. Their data were compared with a normalized data for the general population. Furthermore the stable and unstable epiphysiolisis were analysed separately and their growth patters compared, to observe if differences existed.

Results: Of the 220 patients 179 (81.3%) were stable, while 41(18.6%) where unstable. Sixty-nine were women, the remainder were boys. The mean age in girls were 11 and in boys 13. The analysis was limited to boy's aged 12-14 because the other groups were to small to study.

At the age of 12 boys with stable SCFE had a height of 160 (p50 for normal population 1,51) weight was 62 Kg (p50 for normal 42,9), as for the BMI 61,5% were above the 90 percentile for the population. In the meantime, the unstable SCFE were shorter 1,43 than normal population and also overweight, all the patients were > percentile 80 for BMI.

At age 13 boys with stable SCFE still taller than their peers (165cm vs 158 for p50) and also heavier 67 Kg (49 Kg for P50). As for BMI 30% were below p75, however 43% were above the p90 BMI. In the unstable group the height was normal 1,59 , but they were overweight 61,3 only one patient had a normal BMI.

Finally at age 14 the stable group show average height of 160 (normal P50 167) and weight of 63 Kg being the P50; 60 Kg, with only 35% of the patients with a BMI above P90. They were too few unsatble SCFE in this group to be able to study them.

Conclusion: This study suggests that the growth pattern of children with SCFE is different of normal children, and that they grow taller and heavier earlier than the normal population. Unstable SCFE may be a different type of patient shorter than the normal SCFE.

Significance: As BMI, height and weight are highly variable in young population, studies in certain pathologies should stratify patients by age to observe differences that may be significant. Larger series will be needed, to find significant changes.

High Success in Closed Reduction Treatment for Graf Type IV Hips

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Purpose: High pavlik harness treatment failure is seen much more in Graf type IV dislocation of the hips. The purpose of current study was to to evaluate the treatment results of closed reduction and spica casting as the initial treatment for Graf type IV hips by comparing to the results of pavlik harness.

Methods: Retrospective analysis of patients with Graf type IV hips diagnosed by ultrasound in our hospital from January 2009 to May 2014 , those with complete clinical and radiologic data and more than 2 years follow-up were included. This study included 69 patients (79 hips), of those 11 were male and 58 female; The average age at treatment was (74.1 + 39.2) d , from 30 to 159 d. 42 patients (48 hips) were treated by Pavlik harness (PH group), and 27 patients (31 hips) were treated by Closed reduction and spica casting (CR group). We measured the Acetabular Index (AI), Wiberg OE Angle (point O was the middle point of proximal metaphyseal border) and Smith instability Index (SI; SI - c, the lateral displacement index; SI - h, the vertical displacement index) on the pelvic X-ray film at 2 ~ 3 years of age after successful reduction. Avascular Necrosis of femoral head was diagnosed by the Salter criteria. The reduction and radiologic measurement results were compared between groups with $P<0.05$.

Results: There were 36 reducible and 12 irreducible hips in PH group, whereas 22 reducible and 9 irreducible hips in CR group, with no significant difference ($P=0.692$). There also were no significant difference in sex and bilateral/ unilateral between the two groups ($P>0.05$). The success rate of reduction was much lower in PH group than CR group (29.2% vs. 90.3%; $p = 0.001$), and with significantly worse measurement of OE at the age of 2 ~ 3 years (PH:16.0±4.1°; CR:18.6±4.5°; $P=0.038$). The incidences of AVN of these two groups had no significant difference (CR 6.3% vs. PH 6.5%; $p = 0.745$).

Conclusion: Pavlik harness had limitations in treatment of Graf type IV hips with extremely low success rate of reduction. Closed reduction and spica casting has better treatment result in both success rate of reduction and subsequent hip development, and does not increase the risk of Avascular Necrosis of femoral head.

Significance: we need alternative strategy to pavlik harness for the treatment of Graf type IV hips. Our study confirmed that more stable spica casting after closed redution will benifit the redcution and subsequent development.

Is Preliminary Traction Effective to Reduce Avascular Necrosis (AVN) Incidence in Developmental Dislocation of the Hip (DDH) in a Series of Patients Surgically Treated Through a Medial Approach?

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Purpose: The validity of traction in developmental dislocation of the hip (DDH) has been called into question by some authors, whereas others have recently recommended it to reduce the AVN rate. The aim of our study was to assess the incidence of avascular necrosis (AVN) in a series of frank DDH treated by open reduction through a medial approach after preliminary traction.

Methods: Seventy-one hips (52 patients) were surgically reduced through a medial approach at an average age of 16 months, and followed up to an average age of 22 years. Preliminary traction was applied to all the patients for four weeks, and its effectiveness was assessed by staged radiographic controls according to Gage and Winter method, modified by us. Traction was considered not effective when the hip could not reach either the level of the acetabulum (plus-one) or two stations below the original station within 4 weeks with the maximum weight applied. From 1989 on, owing to the increased hospital costs, traction was applied as a day hospital procedure and maintained afterward at home. After surgery, the hips were immobilized in a hip spica cast in human position first and then in an abduction brace.

Results: The 71 hips that underwent open reduction were divided into three age groups: 3 to 12 months, 13 to 24 months and 25 to 36 months). In 68% of the dislocated hips, traction was effective whereas in the remaining 32%, usually high dislocations in older patients, traction was not effective. Avascular necrosis (AVN) developed mainly in the latter cases with an incidence of 30,4%, whereas in the other group in which the traction was effective, the incidence of AVN was 12.5%. There was a statistically significant correlation between the age group and traction effectiveness (p: 0.036).

Conclusion: The effectiveness of preliminary traction has never been radiographically assessed and compared to the AVN rate in previous studies on DDH with medial open reduction. In our series, AVN developed prevalently in cases in which traction was not effective. The correlation between the lack of traction effectiveness and AVN development was statistically significant (p: 0.0001). Traction has also been blamed for its high hospital cost, however, more than half of our patients had home traction without considerable adjunctive hospital cost.

Significance: According to our results, we propose to reconsider preliminary traction as a valid method to reduce the incidence of AVN in DDH undergoing open reduction.

Predictable Patterns of Pain in Adolescents with Slipped Capital Femoral Epiphysis

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Purpose: The purpose of our study was to prospectively evaluate pain as a predictor of a delay in the diagnosis of SCFE. By more fully characterizing the pain, we hoped to provide a detailed description for recognition of SCFE by health care professionals.

Methods: This was an IRB approved prospective study of 110 children who underwent surgery for SCFE at a tertiary children's hospital between 2009 and 2015. Typical pain was any pain that included the hip joint area. Atypical pain did not include the hip. Standardized pain diagrams were completed by 107 children. Analysis relating the location of pain and slip angle, stability, and Southwick angle severity was performed. Subgroup analysis was also performed looking for measures of association of hip pain and a delay in diagnosis.

Results: 122 hips were eligible for analysis. 70 hips (57.4%, 95% CI, 48.5%–65.8%) had hip pain present and were considered a typical pain pattern. Atypical pain was present in 52 hips (42.6%, 95% CI, 34.2%-51.5%), which included groin pain in 17 hips (13.9%, 95% CI, 8.8%-21.3%), thigh/leg pain in 43 (35.2%, 95% CI, 27.3%-44.1%), knee pain in 32 (26.2%, 95% CI, 19.2%-34.7%) and posterolateral pain of the hip and leg in

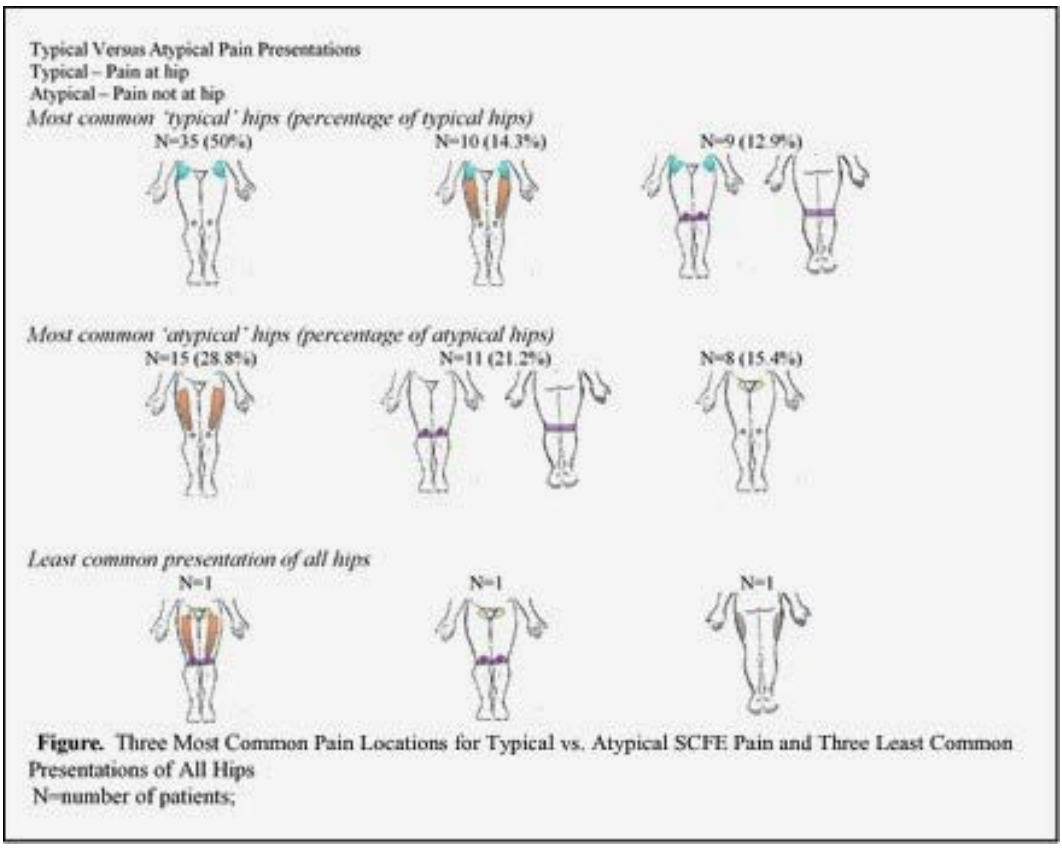

Figure. Three Most Common Pain Locations for Typical vs. Atypical SCFE Pain and Three Least Common Presentations of All Hips
N=number of patients;

13 (10.7%, 95% CI, 6.2%-17.5%). A combination of pain zones was present in 48 hips (39.3%, 95% CI, 31.1%-48.2%). In those with combination pain, hip and thigh pain were most common. Those with knee pain were more likely to perceive a delay in diagnosis (p=.02). Knee pain was more likely to have an increase in the Southwick angle (p=.03), as was combination pain (p=.01). The least common pain presentations had a longer duration of symptoms (p=.04) and more healthcare visits until a diagnosis was made (p=.04). The three most common pain locations for typical hips were hip, hip/thigh, and hip/knee pain (77.2% of hips with typical pain). The three most common pain locations for atypical hips were isolated thigh pain, isolated knee pain, and isolated groin pain (65.4% of hips with atypical pain) (figure).

Conclusion: Children in this prospective cohort with SCFE had atypical pain in 43% of hips, most commonly in the thigh. A combination of two or more different pain locations was found in 39% of the hips.

Significance: Recognition of these pain patterns may lead to earlier recognition and treatment of SCFE.

Salter Innominate Osteotomy for DDH in Childhood Does Not Predispose to Anterior Over-Coverage and Posterior Under-Coverage in Adulthood

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Purpose: Salter innominate osteotomy (SIO) is a surgical procedure to redirect the acetabulum in children with DDH. The redirection has a risk of anterior over-coverage or posterior under-coverage of the femoral head. The purpose of this study was to perform a three-dimensional morphological analysis of the hips in mature patients with DDH who had undergone SIO in childhood.

Methods: Forty-one skeletally mature patients with DDH who had undergone unilateral SIO at the age of 5-8 years old during 1992-2009 and 26 age- and gender-matched subjects without a history of hip disorders were included in this study. Mean ages were 14 years (range, 12-21 years) and 16 years (range, 12-29 years), respectively. Hips with deformity of the femoral head due to avascular necrosis, teratologic, or neuromuscular conditions were excluded. We performed comparison between 41 hips treated with SIO (SIO group), the contralateral hips (contralateral group), and 50 hips having center-edge angle >20° as control subjects (control group). Crossover sign (COS) was assessed with a pelvic radiograph. Acetabular coverage (AC) was analyzed using the software "ACX", originally developed by Konishi and Mieno (JBJS 1993). The ACX enables three-dimensional analysis of hip joint morphology from a two-dimensional anterior-posterior pelvic radiograph using geometrical calculations. COS, the total, anterior, and posterior AC, and the ratio of the anterior to posterior AC values were compared between the SIO group and the contralateral or control groups.

Results: The data are summarized in Table 1. A positive COS was observed more frequently in the SIO group (41%) than in the contralateral (17%, p<0.01) or control (16%, p=0.02) groups. The total and anterior AC in the SIO group were significantly larger than those in the contralateral group (p=0.02 and p<0.01, respectively), but similar to those in the control group. On the other hand, there were no significant differences in the posterior AC between the groups. With regard to the ratio of the anterior to posterior AC values, the SIO group was similar to the control group.

Table.1 Crossover sign and acetabular coverage analyzed with ACX

	SIO group (n=41) mean	Contralateral group (n=41) mean	Contralateral group (n=41) vs. SIO p-value	Control group (n=50) mean	Control group (n=50) vs. SIO p-value
Positive COS	18/41 (41%)	7/41 (17%)	<0.01*	8/50(16%)	0.02*
Total AC (%)	76.4	73.4	0.02*	77.9	0.73
Anterior AC (%)	71.8	67.3	<0.01*	72.8	0.80
Posterior AC (%)	81.0	79.5	0.17	83.0	0.30
A/P ratio (%)	88.5	84.4	0.02*	87.6	0.17

*p-value signify ($p < 0.05$)
SIO = Salter innominate osteotomy, COS = crossover sign,
AC = acetabular coverage, A/P ratio = anterior AC / posterior AC ratio

Conclusion: A positive COS was sometimes observed at skeletal maturity in the hips treated with SIO in childhood. How-

ever, they maintained good acetabular coverage without anterior over-coverage and posterior under-coverage at skeletal maturity.

Significance: The ACX enables three-dimensional analysis of hip joint morphology without high radiation exposure like CT scan. In patients with DDH undergoing SIO in childhood, a positive COS at skeletal maturity is not associated with anterior over-coverage and posterior under-coverage.

The Use of Preoperative 3D Modeling and Printing for Guiding Peri-Acetabular Osteotomy in Hip Dysplasia

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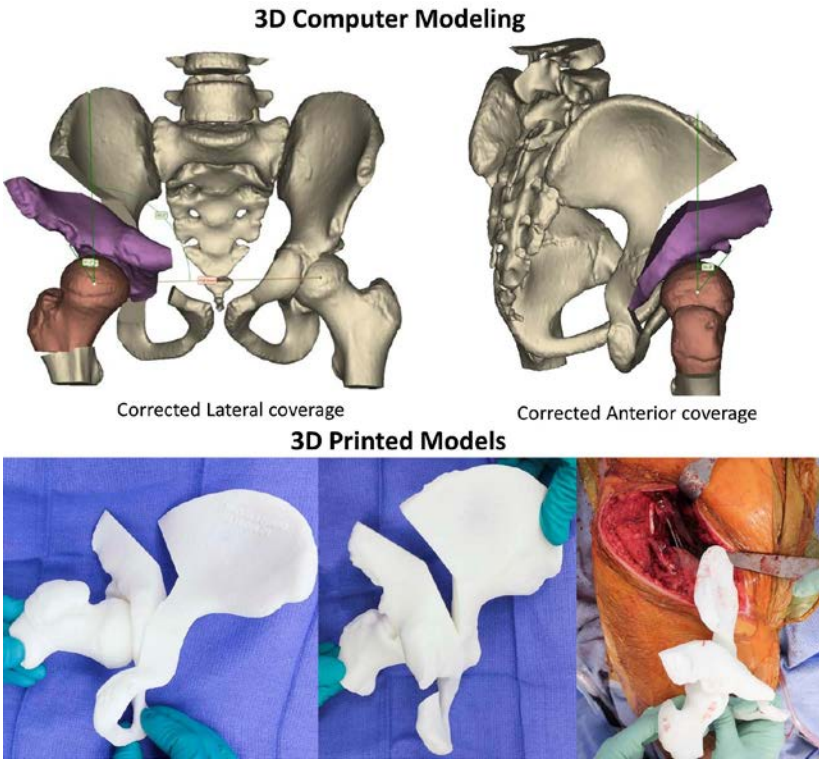
Purpose: Peri-acetabular Osteotomy (PAO) is a powerful surgical technique which reorients the acetabulum in multiple planes to correct deficient anterior and lateral coverage, and acetabular version, in hip dysplasia. Achieving appropriate correction is paramount when performing a PAO, as malposition may create impingement, instability, or incongruity. The purpose of this study was to determine if the utilization of preoperative and intraoperative 3D modeling could 1) predict postoperative hip coverage parameters 2) predict the need for femoral sided osteotomy.

Methods: A retrospective review was conducted on seven patients with hip dysplasia and one patient with acetabular retroversion that underwent a PAO. A preoperative CT of the pelvis was imported to a 3D modeling software and the four PAO cuts were simulated. The acetabulum was rotated both in the coronal plane until lateral center edge angle (LCEA) was greater 25 and less than 40 and rotated in the axial plan until the anterior-center edge angle (ACEA) was greater than 24 and there was no crossover sign. If these parameters were not able to be achieved, a femoral osteotomy was then simulated. A life size 3D model of the simulated osteotomy was printed utilizing 3D printer which was sterilized and available intra-operatively as a guide (Figure 1). Preoperative, simulated and postoperative ACEA and LCEA were measured and compared.



Results: The mean preoperative LCEA was 2.6 (range -16 to 40) and ACEA was 2.6 degrees (range -18 to 45). The 3D modeling simulated LCEA was a mean of 31 degrees (range 26 to 32) and ACEA was an average of 26 degrees (range 25 to 30). Postoperatively, mean LCEA was 28 degrees (range 26-31) and ACEA was a mean of 28 degrees (range 23-30). The 3D modeling simu-

lated LCEA was within mean of 2 degrees (range 0-6) of postoperative LCEA. The 3D modeling simulated ACEA was within mean of 3 degrees (range 1-6) degrees of post-operative ACEA. Two patients needed a femoral osteotomy and this was accurately predicted preoperatively by the 3D computer modeling.

Conclusion: Preoperative planning in orthopaedics has been essential in improving patient outcomes and avoiding complications. This study found that the 3D model can both accurately predict post correction coverage parameters and the need for femoral osteotomy.

Significance: This new technology has the potential to improve intra-operative decision making, and by setting concrete pre-operative objectives to reduce the learning curve associated with PAOs and ultimately to improve patient outcomes.

Body Mass Index (BMI) Affects Proximal Femoral but Not Acetabular Morphology in Adolescents

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Purpose: Slipped capital femoral epiphysis has been associated with childhood obesity. Therefore, it is possible that obesity would impact the morphology of the hip in adolescents. In this study we investigated the effect of BMI percentile on the proximal femoral and acetabular morphology in adolescents without a history of hip pathology.

Methods: After IRB approval, 128 random selected hips in 128 patients aged 12 to 18 years who underwent a pelvic computed tomography (CT) for evaluation of appendicitis were identified. There were 44 (34%) males and the average age was 15 years (±1.95). Age, sex and BMI values normalized for percentile for age and sex according to CDC growth charts and confirmation of no history of hip pathology were recorded. Femoral morphology was assessed by measurement of the alpha angle, the head-neck offset, tilt angle, epiphyseal angle and epiphyseal extension in the axial plane. The lateral center-edge angle (LCEA), acetabular depth, and acetabular extension were measured for assessment of acetabular morphology.

Results: Higher BMI percentiles were associated with femoral morphology but not acetabular morphology. Higher BMI percentile was associated with increased alpha angle ($p<0.001$) and epiphyseal angle ($p<0.001$) and decreased tilt angle (more posteriorly tilted, $p=0.02$), head-neck offset ($p<0.001$), and epiphyseal extension ($p=0.03$) (Table 2). There was no detected effect of BMI percentile on acetabular morphology including LCEA ($p=0.33$), Tönnis angle ($p=0.35$), acetabular depth ($p=0.41$) and acetabular extension ($p=0.96$) (Table 1). There was a consistent distribution of ages across the cohort (Figure 2) and no effect of age was detected with respect to the relationship between BMI percentile and either femoral or acetabular morphology.

Conclusion: Higher BMI percentile was associated with increased alpha angle, reduced head-neck offset and more posteriorly tilted epiphysis (decreased tilt angle) which resembles the morphology of the femur in slipped capital femoral epiphysis (SCFE). BMI percentiles had no association with measurements of acetabular morphology in this cohort of adolescents with no history of hip pathology.

Significance: Our data support an association between adolescent obesity and a femoral morphology that may increase the shear stress across the growth plate and be associated with SCFE development. This study adds to the current knowledge about the etiology of SCFE by providing evidence of an association of higher BMI with a more posteriorly tilted epiphysis in adolescents without a history of hip pain or pathology.

Comparison of the Management of Developmental Dysplasia of the Hip with a Pavlik Harness by Orthopaedic Surgeons, Pediatricians, and Advanced Practice Providers

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Purpose: Developmental dysplasia of the hip (DDH) is common, with high success rates of treatment in a Pavlik harness for children less than 6 months of age. Screening for DDH is performed by a pediatrician followed by referral to a specialist for treatment; however, given the paucity of pediatric orthopaedic surgeons, there is increasing need for advanced practice providers (APPs) to provide care for children with musculoskeletal ailments. The purpose of this study is to assess the need for additional bracing and operative management of patients with DDH managed with a Pavlik harness by orthopedic surgeons, orthopaedic-trained pediatricians, and APPs.

Methods: We performed a retrospective review of patients with DDH under 6 months of age treated with a Pavlik harness by orthopaedic surgeons, orthopaedic-trained pediatricians, and APPs during a 5 year period at a single institution. We compared treatment results by provider using Chi-square tests and z-scores for two population proportion tests.

Results: 308 patients were included in the study, with 103 patients (33.4%) treated by orthopaedic surgeons, 91 (29.5%) by pediatricians, and 114 (37.0%) by APPs. Average follow-up was 2.7±1.7 years. Patient distribution was similar in sex and age among the groups. 55 patients (17.9%) required additional bracing with an abduction orthosis. We found a statistically significant difference in use of additional bracing between surgeons and pediatricians (13.6% and 27.5%, respectively; p=0.008) and APPs and pediatricians (14.0% and 27.5% respectively) p=0.008. 23 patients (7.5%) later required reduction and casting, with 11 patients requiring open reductions. 4 patients underwent additional procedures, including an open reduction after a failed closed reduction or osteotomies. There was no significant difference in patients requiring operative procedures of any kind by initial provider type. 8.7% of patients treated by orthopaedic surgeons, 8.8% of patients treated by mid-level providers, and 5.5% of patients treated by pediatricians required operative intervention, p=0.62.

Conclusion: The results of our study indicate that there is no difference in progression to operative reduction or osteotomies among DDH patients treated in a Pavlik harness managed by orthopaedic surgeons, pediatricians, or APPs.

Significance: This study suggests that first-line management of DDH with a Pavlik harness can be effectively performed by orthopaedic-trained pediatricians and APPs and not limited to orthopaedic surgeons.

Femoral Nerve Palsy is a Mythic Complication of Pavlik Harness Treatment for Developmental Dysplasia of the Hip

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Purpose: Femoral nerve palsy (FNP) is reported as a potential complication of Pavlik harness treatment for developmental dysplasia of the hip (DDH). It is known to be transient, as it often resolves following strap adjustment to decrease hip flexion which may jeopardize treatment success. The purpose of this study was to report the incidence of this potential complication and its risk factors.

Methods: A retrospective chart review was conducted on all DDH patients who underwent Pavlik harness treatment for DDH between August 1997 and June 2015 by a single physician. Our treatment protocol (3 months in average) includes bi-weekly visits to the clinic for strap adjustment and evaluation of bilateral active knee extension as an indirect indicator of femoral nerve palsy. Femoral nerve palsy (FNP) was defined as a partial or total deficit in active knee extension anytime during or following the completion of Pavlik harness treatment. In unilateral cases, the DDH hip was compared to the non-affected side. All hips with femoral nerve palsy were compared to the remaining hips of the series and any possible risk factor for paralysis was recorded, including age, patient's size, severity according to Tonnis, and hip flexion angle in the harness. Statistical analysis was undertaken.

Results: Fifty-three cases of femoral nerve palsy of various severity were identified from a group of 473 children with 527 hips treated for DDH (10%) at an average age of 3.9 months. Ninety-three percent of them presented during the first 2 weeks of treatment. FNP was more common in older and larger children with the most severe Tonnis type, and a hip flexion angle in the harness above 90 degrees ($p<0.01$ for all). All of them resolved spontaneously before completion of treatment without any release of the harness straps other than those required regularly in the absence of femoral nerve palsy. None of them necessitated treatment discontinuation because of FNP. We found no correlation between the presence of FNP or the time taken for spontaneous resolution and treatment failure using the harness.

Conclusion: FNP was found to be more frequent with higher Tonnis types, but its presence by itself is not predictive of treatment failure. The most significant risk factors for FNP seem to be DDH severity and hip flexion angle in the harness.

Significance: FNP resolves spontaneously before completion of treatment without any specific measures, and therefore does not require any strap release or harness discontinuation.

Hip Containment Surgery after Arthrodiastasis in Severe Perthes' Disease

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Purpose: The outcome of Perthes' disease is hard to predict. There are several surgical treatment options dealing with the preservation of the hip containment, which constitutes the main therapeutic goal. Assumption for these techniques is a good hip movement without hinge abduction. We examined whether arthrodiastasis improves hip movement so that further hip preserving operations are possible in the case of initial hinge abduction.

Methods: 11 patients were treated by arthrodiastasis of the hip as preparation for second stage surgery in Perthes' disease between 2004 and 2015. Inclusion criteria were severe restriction of hip movement and a hinge abduction proved by arthrography. The age of patients at the time of diagnosis ranged from 4.2 to 11.0 years with a mean age of 8.5 years. The mean age at the point of arthrodiastasis was 9.1 ± 1.9 (mean ± SD) years. Nine boys and 2 girls were treated for 1.4 ± 0.5 months by external fixation. The mean follow up after surgery was 39.2 ± 25.1 months. All patients were treated with second stage hip containing operations if possible. If hinge abduction persisted in intraoperatively performed arthrograms, a salvage procedure was done. Assessment included the clinical hip abduction, radiographic measurements like the uncoverage percentage, the epiphyseal index before surgery and at last follow up, the epiphyseal quotient, and the Herring and Caterall classification. Statistical analysis was performed.

Results: The range of abduction was significantly increased in all patients after the removal of the external fixateur. Hinge abduction was eliminated in 9 of 11 patients. In 8 patients a varisation of the proximal femur could be performed, in 6 of them in combination with pelvic osteotomies (5 Salter, 1 Shelf). One patient had a single Salter osteotomy. In 2 cases of observable persistent hinge abduction, a salvage operation with a single Shelf procedure was done. After second stage surgery the hip abduction was not significantly reduced compared to abduction after arthrodiastasis and increased in comparison to preoperative range of motion. The radiological indices showed a significant improvement of the coverage of the femoral head after treatment at the latest follow up.

Conclusion: Our results show that arthrodiastasis significantly improves hip abduction and that arthrodiastasis is able to elude hinge abduction in most cases.

Significance: Arthrodiastasis in Perthes' disease seems to be a valid preparing treatment option for subsequent hip preserving surgical intervention in the case of hinge abduction.

Pediatric Obesity is Associated with Short-Term Risks after Pelvic Osteotomy

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Purpose: Pelvic osteotomies in pediatric patients have had success in treating hip dysplasia; however, the risk factors for increased morbidity following these procedures are poorly understood. Childhood obesity is one potential risk factor that has received increased national attention in recent years. The purpose of the present study is to characterize differences in adverse events, operative time, length of stay, and readmission following pelvic osteotomy with or without femoral osteotomy for obese and non-obese patients.

Methods: The prospectively collected Pediatric National Surgical Quality Improvement Program registry was queried to identify pediatric patients that underwent pelvic osteotomy procedures from 2012 through 2014. Patients with body mass index (BMI) greater than the 95th percentile BMI-for-age were categorized as obese in accordance with Centers for Disease Control and Prevention (CDC) guidelines. Demographic and comorbidity variables were compared between obese and non-obese groups using chi-squared analysis. Operative time and length of stay were compared between groups using bivariate and multivariate linear regression. The relative risk (RR) of adverse events, blood transfusion, and 30-day readmission for obese patients was determined using multivariate Poisson regression with robust error variance.

Results: A total of 996 patients were identified. Average age was 8.0 ± 4.6 years (mean ± SD). Fifteen percent of patients had BMI above the 95th percentile-for-age and were classified as obese. A total of 5.72% of patients had any adverse event, 27.31% had a blood transfusion, and 3.21% were readmitted within 30 days. On multivariate analysis (Table 1), there was an increased risk of blood transfusion (RR 1.4, p = 0.007) and

Table 1. Comparison of adverse outcomes after pelvic osteotomy for obese and non-obese patients

	Bivariate analysis		Multivariate analysis*	
	RR	p	RR	p
Any adverse event	0.8	0.498	0.8	0.678
Any severe adverse event	0.9	0.791	1.0	0.969
Unplanned intubation	0.7	0.719	1.3	0.777
Surgical site infection	2.2	0.181	2.2	0.152
Sepsis	1.1	0.935	1.6	0.660
Return to the operating room	1.0	0.954	0.9	0.916
Any minor adverse event	0.8	0.640	0.9	0.831
Pneumonia	0.4	0.327	0.5	0.489
Blood transfusion	**1.4**	**0.008**	**1.4**	**0.007**
Readmission	2.0	0.062	**2.3**	**0.026**

RR = relative risk
Bolding indicates statistical significance ($p < 0.05$). Only outcome variables with at least one event in both groups were tested.
* Each line represents a separate multivariate Poisson regression for each outcome variable in order to give an adjusted relative risk and p-value by controlling for patient characteristics.

readmission (RR 2.3, p = 0.026) within 30 days for obese patients. Obesity was not associated with significant differences for either operative time (p=0.108) or length of stay (p=0.616). The most common reason for readmission was surgical site infection (16% of readmissions).

Conclusion: Obesity was identified as an independent risk factor for blood transfusion and readmission following pelvic osteotomy in pediatric patients.

Significance: This study identifies a potentially modifiable risk factor for transfusion and readmission following pediatric pelvic osteotomy. These data can facilitate patient counseling by physicians and informed decision-making by patients and families when planning for pelvic osteotomy.

Perthes Hips Classified as Lateral Pillar Group B/C Border: Is MRI Predictive of Later Deformity in these Hips?

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Purpose: To find prognostic information on plain radiography and MR imaging that is associated with later femoral head deformity in Perthes hips classified as lateral pillar group B/C border.

Methods: We reviewed 44 children (39 boys and 5 girls) who were treated in a tertiary children's hospital between Nov. 2010 and Aug. 2014. The inclusion criteria were unilateral Perthes hip classified as lateral pillar group B/C border, available contrast-enhanced and diffusion MR imaging taken at the late avascular or fragmentation stage, a minimum follow-up of 2 years after symptom onset, and the late reossification or residual stage at the final follow-up. The candidate prognostic variables were age at symptom onset, plain radiographic findings (sclerotic border of the lateral pillar, subchondral bone plate juxtaposing the physis of the lateral pillar, and extent of physeal involvement), and MRI indexes [contrast-enhancement ratio and apparent diffusion coefficient (ADC) ratio at the epiphyseal and metaphyseal areas of the proximal femur]. The outcome variable was Stulberg type of femoral head deformity. Univariate analysis and then logistic regression analysis were performed.

Results: The mean age at symptom onset was 7.2 years (2.9 to 11.6) and the hips were in the residual (n=20) or reossification (n=24) stages at a mean 3.2-year follow-up (2.0 to 5.6). The good prognosis group included 26 Stulberg type II hips, and the poor prognosis group included 18 hips (16 type III and 2 type IV). Statistically significant variables in univariate analysis were the age at symptom onset (p=0.007), contrast-enhancement ratio at the metaphysis (p=0.009), and ADC ratio at the metaphysis (p=0.009). Logistic regression analysis revealed that contrast-enhancement ratio at the metaphysis was statistically significant (p=0.018) and the age at symptom onset showed a marginal significance (p=0.067). ROC curve analysis showed that the optimum cut-off value of the contrast-enhancement ratio at the metaphysis was 20.2% (AUC 0.818), and the prognostic performance of contrast-enhanced MRI at this point was as follows; accuracy 0.73, sensitivity 1.00, specificity 0.54, positive predictive value 0.60, and negative predictive value 1.00.

Conclusion: Contrast-enhanced and diffusion MR imaging are of prognostic value in Perthes hips classified as lateral pillar group B/C border.

Significance: Prediction of femoral head deformity in lateral pillar group B/C border, of which prognosis is still known to be vague, could be the basis for evaluating the effect of any forms of new treatment in early disease stage, such as bisphosphonate medication and early containment surgery.

Subsequent Surgery Rates Following Closed and Open Reduction of the Developmentally Dysplastic Hip in New York State

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Purpose: No population-level studies describing outcomes following open and closed hip reduction in DDH exist, with most studies comprising series of < 200 patients. The purpose of this study was to describe incidence rates of open and closed reductions and to assess concurrent surgeries, and subsequent surgery rates.

Methods: Children aged < 3 with DDH and open or closed hip reduction performed between 1997 and 2013 were identified in the New York State SPARCS database. Index (first occurrence of) closed and open reduction procedures, as well as current and subsequent procedures, were identified through CPT-4 and ICD-9 procedure codes. Using NY State Census data, incidence rates were calculated. Patient age, sex, race/ethnicity, and insurance status were collected. Surveillance for subsequent surgical procedures was continued out to 2014 such that all patients had minimum 1-year follow-up. Rates of concurrent and subsequent surgeries were calculated. Incidence rates of closed and open reductions were assessed over time. A linear trend line was generated to determine if the incidence rates of open or closed reductions have changed over time.

Results: 368 index closed reductions and 259 open reductions were identified. The incidence rate of hip reductions was 932/100000 for < 1 year old, 374/100000 for 1-year-olds, 129/100000 for 2-year-olds, 60/100000 for 3-year-olds. 76.1% of closed reductions were performed in infants <1 year. Characteristics of closed and open reductions are presented in Table 1. Mean age at time of subsequent pelvic osteotomy was 3. The incidence rate of closed reductions increased slightly over the study period, while the rate of open reductions has been constant.

Conclusion: Subsequent surgery rates are substantial for both closed and open reductions. Families of infants undergoing closed or open reductions for DDH should be counseled that there is a high likelihood of requiring subsequent surgery.

Significance: This is the first study to identify on a population level the rate of closed and open reductions and to report on a population level the risk of subsequent pelvic osteotomy and other major hip surgery in infants/children treated with open or closed reduction for DDH.

	Open Reduction		Close Reduction		Total		
	N	%	N	%	N	%	P-value
Total	259	41.0%	368	58.3%	631		
Median age at reduction	7 months		9.3 months				<0.001
Sex							0.004
Female	187	72.2%	301	81.8%	488	77.3%	
Male	72	27.8%	67	18.2%	139	22.0%	
Race							0.050
White	159	61.4%	212	57.6%	371	58.8%	
Black	21	8.1%	15	4.1%	36	5.7%	
Other	70	27.0%	120	32.6%	190	30.1%	
Unknown	9	3.5%	21	5.7%	30	4.8%	
Femoral osteotomy at time of index reduction	76	29.3%	3	0.8%	79	12.5%	<0.001
Pelvic osteotomy at time of index reduction	40	15.4%	5	1.4%	45	7.1%	<0.001
Subsequent revision closed reduction after index reduction	0	0.0%	20	5.4%	20	3.2%	<0.001
Subsequent revision open reduction after index reduction	20	7.7%	41	11.1%	61	9.7%	0.155
Subsequent pelvic osteotomy reduction after index reduction	32	12.4%	41	11.1%	73	11.6%	0.641
Total subsequent major surgery rate (pelvic osteotomy, arthrotomy, arthroplasty, femoral osteotomy)	107	41.3%	126	34.2%	233	36.9%	0.071

The "Unstable" Graf Type IIA in DDH. How to Identify the Hips That Will Require Treatment?

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Purpose: Ultrasound (US) is universally accepted as a screening tool for DDH in the newborn. Yet, it is still debatable if US screening should be universal at birth or selective at 6 weeks, according to clinical findings and risk factors. According to Graf, hips classified as type IIa are considered immature and will normalize by 12 weeks. However, Omeroglu (2013)* suggested that some will not normalize. Thus, our objective was to search US signs that identify Graf IIa hips that will need treatment.

Methods: After Ethics Committee approval, we retrospectively evaluated clinical files from children observed in the outpatient clinic with DDH diagnosis, during the year 2010. All patients were submitted to an US (linear transducer of 7.5 MHz) using the Graf technique, at 4-6 and 12 weeks. During the US, measurements were made: alpha/beta angles, % of femoral head coverage and acetabular rim and roof shape. Patients were divided in two groups according to "NO need" for further treatment (group A) or "NEED" to start treatment at 12 weeks, due to residual dysplasia (group B).

Results: In 2010, 244 children were observed in the outpatient clinic with DDH diagnosis. US identified 51 Graf type IIa hips (20,9%) in the initial evaluation. Thirteen of these babies (25.4%) started treatment at 12 weeks, with a Pavlyk harness, due to persistent dysplasia.
No risk factors were identified in both history and clinical exam. However, upon evaluation of US measurements we observed that patients in group B presented lower alpha angle (mean of 51,2º vs 55,2º), higher beta angle (mean of 51,7º vs 47,3º), lower acetabular coverage (mean of 39% vs 44,5%) and higher percentage of irregularities of the roof and acetabular rim (69% vs 36%), when compared with group A. Nevertheless, t-student and the Mann-Whitney tests were only statistically significant ($p<0.05$, CI 95%) for irregularities of the roof and acetabular rim.
All children presented a radiological normal hip at 5 year follow-up.

Conclusion: Initiating treatment in US Graf IIa hips may seem exaggerated. However, if the surgeon is able to identify hips at risk in the initial US, treatment could be started earlier. We were able to identify that Graf IIa hips with roof and acetabular rim irregularities are at risk for developing residual dysplasia.

Significance: We suggest that Graf IIa hips with irregularities of the roof and acetabular rim should start treatment with an abduction brace at 6 weeks of age.

The Contralateral Uninvolved Hip in Patients Presenting with Unilateral SCFE has a More Posteriorly Tilted Epiphysis with Higher Mean Values of Alpha Angle and Reduced Offset Suggesting a Slip-Like Cam Morphology

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Purpose: To compare the morphology of the contralateral uninvolved hip in patients presenting with unilateral SCFE with matched controls.

Methods: Following IRB approval, 39 patients (20 females, 19 males, mean age 15 years, range 9 – 24 years) with SCFE with pelvic computed tomography (CT) were compared to 39 subjects (controls) without history of hip disease who underwent CT for suspected appendicitis. Subjects between cohorts were matched by age and sex. From radially reformatted CT we measured alpha angle, head-neck offset, epiphyseal extension and tilt angle in the anterior (axial), anterior-superior, and superior (coronal) planes. The contralateral uninvolved hips were compared to control hips using Paired t-tests.

Results: Mean alpha angles were higher in the anterior-superior (50.7° ± 5.6° versus 48.2° ± 7.0°, p = 0.04) and superior (46.7° ± 7.4° versus 42.3° ± 3.1°, p < 0.001) planes in contralateral hips of SCFE patients compared to controls while mean head-neck offset was lower in these planes (anterior-superior: 4.9 mm ± 1.5 mm versus 5.6 mm ± 1.6 mm, p = 0.009 and superior: 5.9 mm ± 1.6 mm versus 6.9 mm ± 1.1 mm, p < 0.001 superior). In the anterior (axial) plane, the contralateral uninvolved hip in patients presenting with unilateral SCFE revealed a more posterior epiphyseal tilt angle (7.9° ± 5.96° versus 4.6° ± 2.8°, p = 0.046) than controls. No difference was found for epiphyseal extension between groups.

Conclusion: We assessed the morphology of the proximal femur in asymptomatic contralateral uninvolved hip in patients presenting with unilateral SCFE and compared it to asymptomatic control hips. The contralateral uninvolved hip has on average a more posteriorly tilted epiphysis with higher mean values for alpha angle and reduced head-neck offset suggesting a cam-deformity associated with

Table 1. Femoral measurement across 3 planes for affected and control hips.

	SCFE		Control		
All patients (N=39)	Mean	± SD	Mean	± SD	P
Head-neck offset					
Anterior	6.9	± 1.62	7.1	± 1.48	0.60
Superior-anterior	4.9	± 1.45	5.6	± 1.64	0.009
Superior	5.9	± 1.62	6.9	± 1.06	<0.001
Alpha angle					
Anterior	44	± 5.34	43	± 5.11	0.33
Superior-anterior	50.7	± 5.57	48.2	± 7.01	0.04
Superior	46.7	± 7.41	42.3	± 3.13	<0.001
Open physis only (N=11)	Mean	± SD	Mean	± SD	P
Epiphyseal extension					
Anterior	24.9	± 4.01	25.7	± 3.28	0.67
Superior-anterior	30.7	± 3.59	30.6	± 4.06	0.93
Superior	30.7	± 3.60	29.8	± 3.76	0.66
Epiphyseal tilt angle					
Anterior	7.9	± 5.96	4.6	± 2.80	0.046
Superior-anterior	10.1	± 5.37	10.9	± 2.96	0.64
Superior	13.2	± 3.73	13.8	± 3.37	0.77

SCFE, slipped capital femoral epiphysis; SD, standard deviation.

slip-like morphology. As we noted no differences in epiphyseal extension but more posteriorly tilted epiphyseal angle in the contralateral uninvolved hips this might be due to mild subclinical slippage of the contralateral hip rather than an idiopathic cam morphology.

Significance: Our data suggests that pathologic changes of the contralateral uninvolved hip may be present at time of unilateral SCFE presentation. Close surveillance or prophylactic pinning to prevent progression of slip-like deformity and femoroacetabular impingement (FAI) are currently accepted strategies to manage the contralateral hip in unilateral SCFE. Future long-term studies will be necessary to demonstrate the efficacy of such strategies to prevent FAI and osteoarthritis development.

The S Sign: A New Radiographic Tool to Aid in the Diagnosis of Slipped Capital Femoral Epiphysis

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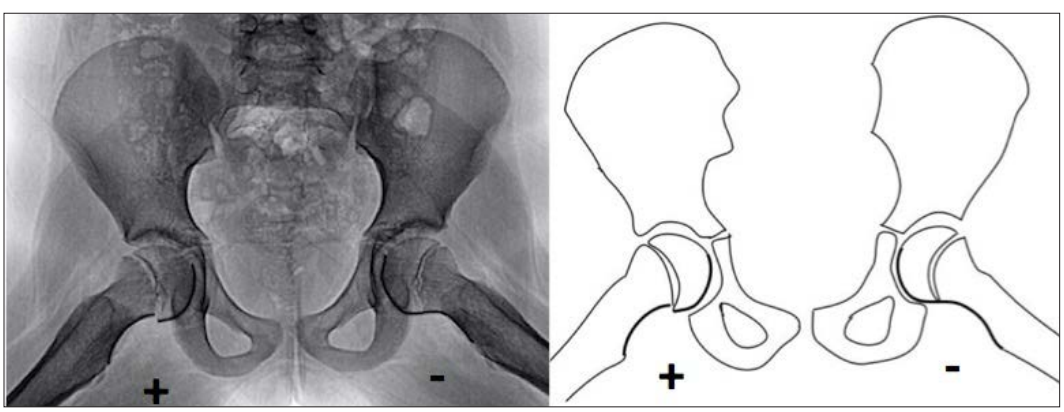
Purpose: Children and Adolescents with slipped capital femoral epiphysis (SCFE) are often seen by an array of medical professionals prior to diagnosis. Patients with mild slips, slips with knee pain rather than hip pain, or bilateral slips can present a diagnostic challenge and increase the risk of a delay in diagnosis leading to adverse outcomes which may include hip impingement, avascular necrosis, and chondrolysis. The purpose of our study is to introduce a new radiographic parameter, the S-sign, which is a curvilinear line created on a frog leg lateral radiograph and analyze its utility compared to Klein's line for the diagnosis of SCFE.

Methods: Twenty observers reviewed AP pelvis and frog leg lateral radiographs from 35 patients with SCFE on two separate occasions. Observers diagnosed a SCFE using Klein's line on AP pelvis radiographs and the S-sign on frog leg lateral radiographs. Any breakage or asymmetry in the S-sign was recorded as a positive test (Figure). Their accuracy in diagnosis was assessed. Statistical analysis included intra-observer and inter-observer reliability using Cohen's kappa coefficient.

Results: The S-sign was more accurate in identifying a SCFE compared to Klein's line (89.0% versus 68.3% respectively). Sensitivity and specificity was greater for the S-sign compared to Klein's line (89.0% and 95.2% versus 68.3% and 89.0% respectively) and was statistically significant ($p<0.001$). The Cohen's kappa coefficient for intra-observer reliability for the S-sign and Klein's line ranged from 0.608 to 1 and 0.487 to 1 respectively. The Cohen's kappa coefficient for inter-observer reliability for the second set of observations was 0.825 for the S-sign and 0.582 for the Klein's line.



Conclusion: Our study shows that the S-sign is a better diagnostic tool compared to Klein's line in terms of accuracy, sensitivity, and specificity. Observers were more consistent and had better concordance using the S-sign compared to Klein's line. Our data mirrored the work from Klein with a reported accuracy of 68.0% for Klein's line. The S-sign also outperformed comparable literature using a modified Klein's line with a reported sensitivity of 79.0% compared to our sensitivity of 89.0% with the S-sign.

Significance: The S-sign can serve as a radiographic aid in the diagnosis of slipped capital femoral epiphysis. With application of the S-sign, practitioners may more reliably and accurately assess frog leg lateral radiographs for a SCFE compared to the currently used Klein's line, hopefully arriving at an earlier time to diagnosis for children presenting with mild to moderate degrees of SCFE.

Ultrasound Characteristics of Clinically Dislocated but Reducible Hips in Infantile DDH

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Purpose: Although ultrasound (US) is frequently used in the diagnosis and management of infantile developmental dysplasia of the hip (DDH), precise ultrasonographic parameters of what constitutes a dislocation, subluxation, etc. remain poorly defined. The purpose of this study was (1) to describe the ultrasonographic characteristics of a large cohort of clinically dislocated but reducible hips and (2) to begin to develop reasonable ultrasonographic definitions for what constitutes a hip dislocation for the purposes of future research.

Methods: The prospectively collected database for an international multi-center study group on DDH was queried for all patients under six months of age with hip(s) that were dislocated at rest but reducible (i.e. Ortolani positive) based on initial physical exam. Femoral head coverage (FHC), alpha angle (α), and beta angle (β) were measured on pre-treatment US by the individual treating surgeon, and were recorded directly into the database.

Results: Based on 327 Ortolani positive hips, the median FHC was 10% with an interquartile range of 0% - 25%. 126/327 hips (38.5%) demonstrated 0% FHC. The 90th percentile was found to be at 35% FHC. Of 264 hips with sufficient alpha angle data, the median α angle was 43° with an interquartile range from 37° to 49°. 163 hips had documented beta angles with a median of 66° and an interquartile range of 57° to 78.8°.

Conclusion: Analysis of a large cohort of patients with dislocated but reducible hips, reveals a median percent FHC of 10%, α angle of 43°, and β angle of 66° on initial pre-treatment US. Using a threshold at the 90th percentile, a sensible ultrasonographic definition of a dislocated hip appears to be FHC≤ 35%, implying that FHC between 35-50% may be reasonably termed a subluxation. Although these findings are consistent with previous, smaller reports, further prospective research is necessary to validate these thresholds.

Significance: Although US is frequently used in the care of infants with DDH, there remains considerable confusion in the literature regarding how best to define a hip as dislocated on ultrasound. Our study provides important baseline ultrasonographic data for dislocated/reducible hips and provides the foundation for a reasonable ultrasonographic definition of a hip dislocation for the purposes of future research.

Borderline Hip Dysplasia: Preoperative Clinical Characteristics Differentiating Hip Instability and Femoroacetabular Impingement

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Purpose: The pathophysiology of borderline acetabular dysplasia is not well understood. Borderline dysplasia is generally defined by a lateral center-edge angle (LCEA) between 20° and 25°. However, a portion of this population has primarily hip instability-based symptoms consistent with symptomatic acetabular dysplasia, while others have primarily impingement-based symptoms consistent with femoroacetabular impingement (FAI). The purpose of this study was to examine a cohort of patients with borderline acetabular dysplasia in order to identify the preoperative clinical characteristics and imaging features that differentiate patients with hip instability from patients with hip impingement.

Methods: A retrospective cohort study of patients with borderline acetabular dysplasia was performed. Utilizing our institutional hip preservation database, patients who underwent hip preservation surgery from January 2008 through June 2016 in the setting of borderline acetabular dysplasia. Medical records were reviewed to determine patient demographics, details of clinical presentation, patient-reported outcome scores, physical exam findings, plain radiographic findings, and the operative procedures performed. Statistical analyses were used to compare the clinical features and imaging parameters of the symptomatic acetabular dysplasia and FAI subgroups.

Results: Of the 211 hips in the cohort, 29.9% (n = 63) had the diagnosis of symptomatic acetabular dysplasia while 70.1% (n = 148) had the diagnosis of femoroacetabular impingement. The acetabular dysplasia subgroup was more likely than the FAI subgroup to present with lateral hip pain (44.4% vs. 27.7%; $p = 0.018$). Patients with acetabular dysplasia presented with significantly greater disability, as indicated by the mHHS, UCLA activity, SF-12 physical function, and HOOS scores (all $p \leq 0.02$). The acetabular dysplasia subgroup had significantly greater range of motion in terms of internal (IRF) and external rotation (ERF) in flexion ($p<0.002$ and $p = 0.017$, respectively). Hips with acetabular dysplasia (compared to FAI) had significantly lower ACEA (22.9° vs. 27.7°, $p < 0.001$), higher AI (11.8° vs. 8.9°, $p < 0.001$), and lower maximum alpha angle (54.2 vs. 63.3°, $p < 0.001$).

Conclusion: Patients with a diagnosis of symptomatic acetabular dysplasia tend to have lateral hip pain, greater functional limitations, higher range of motion, and a greater AI, while FAI patients tend to more limited range of motion (especially IRF), a greater ACEA and alpha angle.

Significance: There are significant differences in the clinical characteristics and imaging features of the symptomatic acetabular dysplasia and FAI subgroups within the borderline dysplasia cohort.

Defining the Anterior Center-Edge Angle on Sagittal CT: A Study of 640 Normal Hips Ages 10 to 35

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Purpose: The anterior center-edge angle (ACEA) is a quantitative measurement used to describe anterior acetabular coverage on a false profile radiograph. ACEA guides the diagnosis and treatment of hip dysplasia and pincer-type femoral acetabular impingement (FAI). However, discrepancies in the measurement of ACEA on false profile occur due to variabilities associated with pelvic tilt, radiographic projection, and identifying an accurate anterior edge for measurement. Such discrepancies can misdirect the diagnosis, treatment, and degree of surgical correction in hip dysplasia and pincer-FAI. Computed tomography (CT) is often utilized to overcome the limitations of 2D imaging. However, ACEA on sagittal CT has been shown to poorly correlate with the same measurement on false profile radiograph and therefore the normal range of ACEA on CT remains unknown. The purpose of this study was to 1) Define the normal variation of ACEA measured on Sagittal CT and 2) Assess inter-observer reliability of the ACEA on CT.

Methods: A retrospective review was conducted on patients that underwent CT for non-orthopedic related issues. A thorough chart review was conducted to ensure no exam findings or history of hip pathology, inflammatory disease, global developmental disease, or chronic illness. The pelvic tilt was measured by the angle between the anterior superior iliac spine and pubic symphysis. The ACEA was measured on a sagittal slice corresponding to the center of the femoral head on the axial slice and adjusted based on a presumption of pelvic tilt of 0. This technique is similar to the correction of pelvic inclination in measuring the lateral center edge angle. Intraclass Correlation (ICC) was conducted on 50 ACEA and pelvic tilt measurements among three observers.

Results: 320 patients' CTs (640 hips) were evaluated from ages 10-35. ACEA averages were defined for different age groups and gender with overall average 50°±8° (Table 1). The ACEA mean remained relatively similar between ages and gender after 10-11 age group. ICC for pelvic tilt of 0.98 and 0.95 for ACEA demonstrated excellent inter-observer reliability.

Table 1

Age Range	Female Hips	Male Hips	Female Pelvic Tilt Mean	Male Pelvic Tilt Mean	Female ACE Mean	Male ACE Mean	Female ACE Adjusted for Pelvic tilt Mean ± Standard Deviation	Male Correct ACE Adjusted for Pelvic tilt Mean ± Standard Deviation
10-11	20	20	1	0	44	49	44±6	49±6
12-13	20	20	1	-4	52	54	52±7	50±7
14-15	20	20	-4	-6	55	54	52±8	48±8
16-17	20	20	-2	-5	52	54	50±6	49±7
18-20	20	20	-1	-7	52	54	51±7	47±6
21-25	20	20	-2	-6	56	55	54±7	49±6
26-30	20	20	-1	-7	51	56	50±8	48±10
31-35	20	20	0	-4	56	55	56±9	51±7
10-35	160	160	-1	-5	52	53	51±8	49±7

ACE=Anterior Center Edge Angle, all measurements are degrees

Conclusion: The ACEA can be reliably measured on sagittal CT

and can be adjusted for varying pelvic tilt. The Normal range of ACEA within 1.5 standard deviation of mean was 38°-62°. We purpose that an ACEA measurements above 62° or below 38° represent anterior over and under coverage.

Significance: Understanding the normal variation of ACEA on CT can help better improve diagnosis and preoperative planning in surgical treatment of hip dysplasia and FAI.

Effect of Surgeon Performance in Salter Innominate Osteotomy on Long-Term Outcome

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Purpose: Salter innominate osteotomy (SIO) has been identified as an effective additional surgery for the dysplastic hip. This surgical procedure is simple, and well performed in many institutes. However, only few attempts have been made to date because of the complexity of conducting this procedure accurately. This study aimed to investigate whether we accurately perform SIO and whether an incorrect surgical procedure could be a risk factor associated with an unfavorable long-term outcome.

Methods: In this study, data on 97 hips of 88 patients who underwent SIO for the developmental dysplasia of the hips were retrospectively reviewed. Patients with skeletal immaturity at the final visit, and those with neuromuscular disease were excluded. The average age at surgery was 4.4 years (2.0 - 8.6 years) and the average age at the most recent follow-up was 20.8 years (18.0 - 28.5 years). Anteroposterior radiographs of patients were investigated at 6 weeks after surgery (after cast removal) and the movement of the distal fragment was classified as follows (Fig.1): Type I, distal fragment is moved laterally (original SIO). Type II, distal fragment is not moved (only angulation); and Type III, distal fragment is moved medially. The treatment outcome was evaluated as satisfactory (Severin grade I or II) or unsatisfactory (Severin grade III or IV) at the final visit.

Results: The outcome at the latest visit was satisfactory in 75 hips (77%) and unsatisfactory in 22 (23%). Using our classification system, 64 hips (66%) were classified as Type I, 28 (29%) as Type II, and 5 (5%) as Type III. A significant difference was not observed in the pre-operative center-edge angle (CEA) and the ratio of the hips with aseptic necrosis (Kalamchi II, III, and IV) in each group (CEA, p=0.609; aseptic necrosis, p=0.317). The ratio of satisfactory outcome was 53/64 (83%) in Type I, 21/28 (75%) in Type II, and 1/5 (20%) in Type III. The hips in Type III showed a significantly worse outcome than those in the other groups.

Fig 1: Classification of surgical procedure for lateral displacement of the distal fragment

Type I — Distal fragment is moved laterally (original SIO)

Type II — Distal fragment is not moved (only angulation)

Type III — Distal fragment is moved medially

Conclusion: Although our long term outcome was reasonable, correct movement of the distal fragment (original SIO) was obtained in only 64 hips (66%). Insufficient fixation may cause the loss of correction. Our results suggested that a poorly performed surgery predisposes the operated hip to a worse radiological outcome at skeletal maturity.

Significance: When we discuss the radiological outcome of SIO, we need to describe whether the surgical procedure was performed accurately.

Externally Validating Quantitative Measures of Femoral Head Shape in Perthes' Disease

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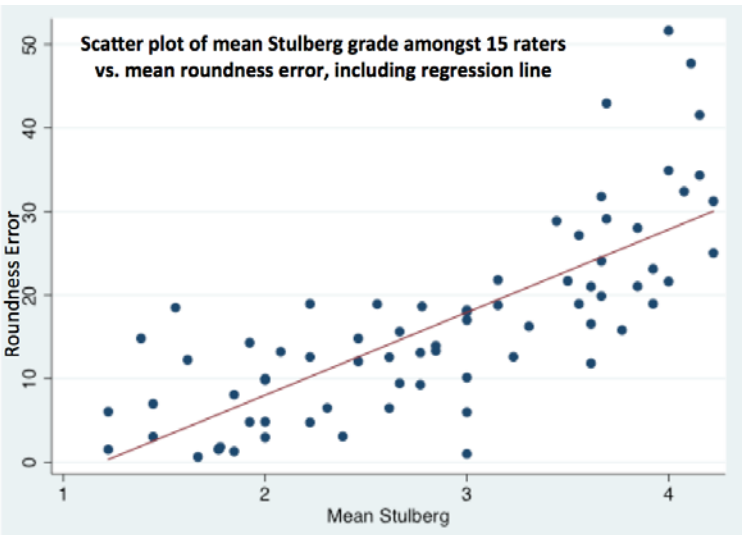
Purpose: The common radiographic outcome used Perthes' disease of the hip is the Stulberg grade; an ordinal descriptive classification of head shape at maturity. When planning clinical trials the use of ordinal outcomes are less powerful than continuous outcomes requiring an increased sample size to demonstrate an intervention effect. Roundness error, a component of sphericity deviation score, has been proposed as a quantitative measure of assessment of femoral head shape in Perthes' disease on AP radiographs. The aim of our study was to externally validate the utility of roundness error against the Stulberg's classification.

Methods: 15 consultant paediatric orthopaedic surgeons from different UK centres, members of the BOSS Collaborative, were asked to rate a series of 100 healed AP radiographs of hips affected by Perthes' Disease from the Liverpool Perthes Disease Register using the Stulberg's grading. Two independent observers categorised roundness error using Digitimizer™ software. Kappa scores was used to determine the interobserver concordance amongst the 15 observers in terms of the reporting of Stulberg, and Lin concordance was used to determine the reporting of roundness error. The relationship between the two outcomes was explored graphically, and statistically; considering the mean Stulberg grade recorded by the 15 observers as a continuous outcome.

Results: There was moderate to fair agreement regarding the Stulberg's grading among the Consultant surgeons with an overall Kappa error of 0.377 (95% 0.353 - 0.393). The Lin concordance between the two independent observers evaluating roundness error was 0.50 (95% CI 0.36-0.64) . There was a strong correlation between the Stulberg grading and roundness error measurement. Using a box and whisker chart the roundness error correlated well with modal Stulberg grade.

Conclusion: Roundness error appears to be a useful tool to offer a quantitate measure of hip shape. It correlates well with surgeon-reported hip shape.

Significance: Roundness error appears to be a useful radiographic measure of hip shape in Perthes' disease offering a continuous estimate of hip deformity. This is a useful tool in clinical trials.



Guided Growth for Coxa Valga in Developmental Dysplasia of the Hip

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Purpose: Coxa valga is a common sequel after open reduction for developmental dysplasia of the hip (DDH). Varus osteotomy is a common treatment to prevent secondary hip dysplasia, however, guided growth by one transphyseal screw at the proximal femur offered a less-invasive way for deformity correction. The purpose of this study is to report preliminary results of guided growth in femoral structure and hip development.

Methods: Children who underwent guided growth for coxa valga in unilateral DDH were reviewed for cases with minimum 2 years of follow-up. Surgical indications were center edge angle less than 25° and increased head shaft angle by 10° than normal side. Outcome measurements included acetabulum trochanteric distance (ATD), physeal inclination angle (PI), neck shaft angle (NSA), head shaft angle (HSA), acetabular index (AI), center-edge angle (CEA), and femur length. The difference between lesion side and normal side was compared by paired t test. Changes among pre-operation and post-operative 12, 18, and 24 months were compared by repeated ANOVA.

Results: Nine children underwent guided growth surgery at mean age of 8.6 years between 2011 and 2014. The tip of screws usually back up to metaphyseal area in 18-24 months after insertion. Significant decrease of ATD (36.7 mm to 31.1 mm), HSA (161.2° to 156.8°), and increase of PI (13.1° to 20.3°) were observed in 2 years follow up. The CEA was significantly less than normal side (18.6° vs. 25.4°) before guided growth and became comparable between both hips at last follow up.

Conclusion: We observed significant improvement in ATD, PI, and HSA following guided growth of femoral neck.

Significance: Guided growth not only corrected coxa valga, but also restored hip dysplasia to be comparable to the contralateral normal side.

Radiographic Outcomes in Legg-Calve-Perthes Disease after Petrie Casting

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Purpose: Numerous treatment methods have been attempted to maintain sphericity in children with Legg-Calve-Perthes. Particularly challenging is the patient with whole head involvement and has developed restricted motion where abduction is significantly limited. Our aim was to objectively evaluate the role of Petrie casting in this patient population on achieving femoral head sphericity.

Methods: An IRB-approved, retrospective study was performed identifying patients with unilateral Perthes disease who underwent Petrie casting between 2000 and 2012. Indications for Petrie casting were radiographic appearance of the femoral head coupled with limited abduction ≤25°. Patient demographics were recorded and radiographic data obtained incuded: lateral pillar classification, Stulberg classification at the last follow-up, % femoral head uncoverage, femoral head enlargement, sphericity deviation score, femoral congruency arc, Sharp's angle, and femoral neck growth inhibition.

Results: 42 patients (34 Males, 8 Female) were included in final analysis. Mean age at casting was 7.8±1.8years with a mean duration of casting of 110±72 days and average follow-up of 5.5±2.6years. 7 patients were considered overweight and 14 obese based on their BMI percentiles. 5 patients had undergone no previous treatment, 5 had previous treatment that did not include traction (NWB, tenotomy), 32 had undergone traction and 10 of those patients also had other treatments. Complications occurred in 8 patients and were casting issues. Worst lateral Pillar classification consisted of 9 type B, 7 type B/C, and 26 type C. 23 hips were in early fragmentation and 19 in late fragmentation at the time of casting. At the latest follow-up visit 15 patients had reached skeletal maturity, 17 were healed and 10 were in the late reossification stage. Average abduction increased from 21.9° to 38.5°. Stulberg classification at final follow-up consisted of 3 type 2s, 23 type 3s, and 16 type 4s. Average radiographic measurements at the final follow-up were: sphericity deviation scores 40.6±17.9; femoral congruency arc 243.8±69; Sharp's angle 46.1±4.2; femoral neck growth inhibition of 31.5±40.6; and femoral head enlargement 45.4±34.3. Post-casting hip abduction significantly correlated with the sphericity deviation score (r=-0.376). Femoral neck growth was significantly greater for the normal weight group than the overweight/obese group.

Conclusion: Petrie casting resulted in greater hip abduction which correlated with greater femoral head sphericity. No other demographic or clinical factors were associated with sphericity.

Significance: This is the largest reported series of Petrie casting in Perthes disease and demonstrates an improvement of hip abduction which correlates with greater sphericity of the femoral head.

Side-to-Side Differences in Femoral Torsion are Increased in Patients with Unilateral as Compared to Bilateral Symptomatic FAI

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Purpose: Femoroacetabular impingement (FAI) involves a complex and dynamic relationship between the bony morphologies of the acetabulum and femur. Acetabular and proximal femoral morphologies as well as femoral torsion contribute to this relationship, and can be asymmetric between hips in the same patient. The purpose of this study was to examine the association between acetabular and proximal femoral morphology and femoral torsion and the development of symptomatic FAI by comparing differences in these parameters from side to side in patients with unilateral symptoms. To provide a control group, side to side differences among patients with bilateral symptoms were also examined.

Methods: Demographic (age, gender, BMI) and radiographic (lateral center edge angle (LCEA), anterior center edge angle (ACEA), neck shaft angle (NSA), Tonnis angle, femoral torsion, alpha angle, and acetabular version) measurements were retrospectively collected from adolescent and young adult patients who underwent treatment for unilateral or bilateral FAI. The absolute value of the side-to-side differences in the radiographic variables was calculated. Wilcoxon rank sum tests were used to compare the absolute value of the side-to-side differences in the unilateral and bilateral cohorts.

Results: There was no difference in age [p=0.7717], BMI [p=0.4377], or gender [p=0.6643] between the unilateral (N=46) and bilateral (N=36) group. The median side-to-side differences in acetabular version (2.0°, 2.0°), alpha angle (3.0°, 3.0°), NSA (2.0°, 3.0°), Tonnis angle (2.0°, 1.0°), LCEA (3.0°, 2.0°), and ACEA (3.0°, 3.0°) were not statistically significant between the symptomatic and asymptomatic sides in unilateral patients or hips in bilateral patients respectively. Side to side differences in these parameters were similar when comparing the unilateral and bilateral symptomatic groups ($p > 0.05$). However, side-to-side differences in femoral torsion were significantly higher in the unilateral group (5.0°) compared to the bilateral group (2.0°) ($p = 0.0026$).

Conclusion: Side-to-side differences in acetabular and proximal femoral morphology were similar between hips in patients with both unilateral and bilateral symptomatic FAI, and no single variable was associated with the presence of symptoms. In contrast, femoral torsion was associated with significantly higher side-to-side variability in patients with unilateral symptomatic FAI compared to those with bilateral symptoms, suggesting that femoral torsion is an important factor in the development of symptoms of FAI.

Significance: Although many factors play a role, femoral torsion appears to be an important factor in the development of symptoms in FAI. Addressing abnormal femoral torsion may help guide treatment in these patients.

Triple Pelvic Osteotomy in Patients with Severely Affected Legg-Calvé-Perthes Disease (LCPD)

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Purpose: LCPD patients with severe clinical and radiological risk factors, in particular progressive hip subluxation, are candidates for surgical containment treatment. Triple pelvic osteotomy offers the most efficacious corrective potential.

Methods: 42 patients with 44 affected hips, all at risk due to restriction of motion, age, progressive subluxation, Catterall group III and IV and Herring group B, B/C and C were included in this consecutive case series of severely affected patients. All hips were treated with a triple pelvic osteotomy, 14 in combination with an intertrochanteric varus osteotomy (IVO), five following an IVO. Timing of surgery was rated according to the modified Waldenström classification. The radiological outcome was assessed by using the Stulberg criteria. The statistical analysis íncluded Fisher's exact test and logistic regression analysis for further factors.

Results: There were 36 boys and 8 girls with two girls being affected bilaterally. The average age at surgery was 7,93 ± 1,65 years. There were 27 Catterall III and 17 Catterall IV hips. The Herring grouping revealed 19 B, 6 B/C and 19 C hips. 27 hips were operated in Waldenström stage II (early) and 17 in Waldenström stage III (delayed). Generally the Stulberg class at final follow-up showed 12 Stulberg II, 22 Stulberg III and 10 Stulberg IV/V hips. When operated early (Waldenström II) the outcome was significantly better ($p < 0,0001$) compared to delayed surgery in Waldenström stage III. Stulberg II outcome was only observed in early operated Walldenström II hips. Catterall and Herring classification were predictive for the determination of the Stulberg class at follow-up.

Conclusion: Triple pelvic osteotomy seems to be a good tool for treating severe LCPD in the early phase of the disease, but not in the more advanced stage III.

Significance: This study supports the principle of early containment treatment for LCPD. Even the most powerful tool for femoral head covering surgery yields good results only if used as containment, and not as salvage method.

Dynamic Deformation of the Femoral Head Occurs on Weight Bearing in Early Fragmentation of Perthes Disease

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Purpose: This study utilizes a unique open MRI scanner to image hips in children affected by Legg-Calve-Perthes Disease (LCPD). The aim is to assess for any change in femoral head shape when the child is weight bearing compared to supine.

Methods: Protocols have been previously developed in this unique open MRI scanner in healthy adult and child volunteers. Satisfactory image acquisition is possible with Coronal T1 GFE sequences, both hips in Field of View. 2.5min scans were performed with the child standing first, then supine. Digital measurements were made and statistics performed using Microsoft Excel (2007).

Results: Hips in five patients, all in the early fragmentation stage of LCPD were imaged both supine and standing. One child could not tolerate the scan, resulting in images too blurred for measurement.

A dynamic deformity of the femoral head on weight bearing was demonstrated in the remaining four patients. Femoral epiphysis height decreased on standing (mean 6.9 to 6.3mm, p=0.03, Students t-test), width increased on standing (mean 18.0 to 20.7mm, p=0.04) and lateral extrusion increased on standing (mean 4.7 to 6.0mm, p=0.03). Differences were thus demonstrated in all parameters of femoral epiphyseal height, width and lateral extrusion when the child stood and loaded the LCPD hip (Figure 1). Contra-lateral unaffected hips did not deform.

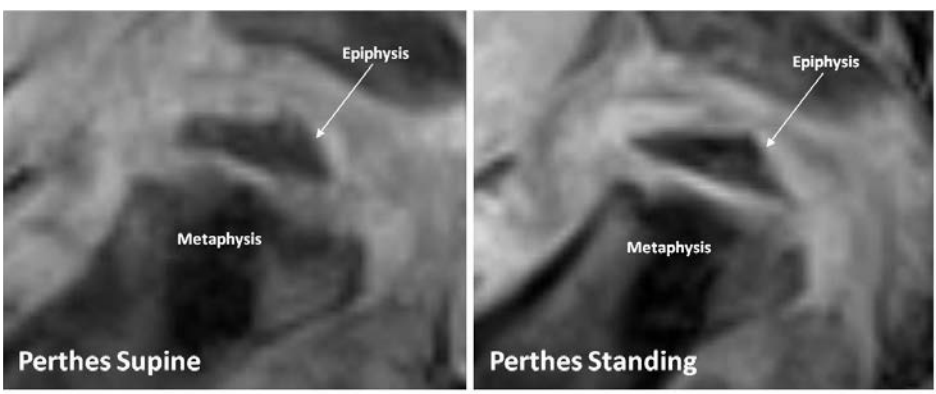

Figure 1: Comparative coronal MRI (TI GFE) of the right hip of a 5year old with LCPD in early fragmentation. The dynamic deformity of flattening, widening and increased lateral extrusion is demonstrated.

Conclusion: This is the first reported use of standing weight bearing MRI in LCPD. A dynamic deformity has been demonstrated in the early fragmentation stage, with flattening, widening and worsened lateral extrusion on weight bearing. Numbers are small thus caution must be applied when interpreting the statistical significance.

Significance: These unique findings may have implications on treatment strategies and weight bearing advice in early stage LCPD.

Intra-articular Physeal Fractures of the Distal Femur: A Frequently Missed Diagnosis in Adolescent Athletes

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Purpose: Intra-articular physeal fractures of the distal femur are an uncommon injury pattern with a high incidence of complications. The purpose of this study was to improve understanding of the clinical presentation and outcome of these fractures, as well as to assess risk factors for complications.

Methods: A retrospective review of patients presenting to three level-one pediatric trauma centers with an intra-articular physeal femur fracture between 2006 and 2016 was performed. Patient demographic and injury data was documented, including age, gender, skeletal maturity, mechanism of injury, concomitant injuries, sports participation, and whether the fracture was missed upon initial evaluation. Radiographs were evaluated for fracture classification, location, and displacement. Surgical data was recorded including surgical approach, stabilization technique, and post-operative protocol. Patient outcomes included healing, time to union, return to sports, and complications. Factors significantly associated with complications were identified utilizing chi-square test and analysis of variance.

Results: 49 patients were identified with a mean age of 13.5 years (range 7-17). The majority were male (88%) and had a Salter-Harris III fracture (84%) involving the medial femoral condyle (88%). Greater than 90% of the injuries were the result of a contact injury and 50% occurred while playing football. The initial diagnosis was missed in 36% of cases. Advanced imaging revealed more displacement than plain radiographs (6mm vs. 3mm, $p=0.007$). Concomitant ACL and meniscus injuries were present in 12%. All patients underwent surgical fixation with 59% utilizing an arthrotomy, 29% utilizing a percutaneous technique, and 12% using arthroscopic assistance. At a mean follow up of 1.6 years, all patients had returned to sport and all had "good to excellent" results. Leg length discrepancy was identified in 14% (mean 17mm) and angular deformity was identified in 8% (2 varus/2 valgus). 12% required a second procedure for their resultant leg length discrepancy or angular deformity. Complications were more common in patients with open growth plates, patients with fractures involving the lateral femoral condyle, and patients that were casted post-operatively ($p<0.05$).

Conclusion: These fractures were missed in just over 1/3 of the cases and fracture displacement may be under-reported on plain radiographs. Patients with residual growth, fractures involving the lateral femoral condyle, and patients treated with a cast have a higher incidence of complications. Nevertheless, surgical outcomes are good with high rates of return to sport.

Significance: Clinicians evaluating skeletally immature adolescent athletes with acute knee injuries need to keep a high index of suspicion for an intra-articular physeal fracture.

Figure 1: 15 year-old football player with a Salter-Harris III distal femur fracture that was initially missed. CT images revealed 5 mm of joint displacement. Subsequent open reduction and fixation led to anatomic healing with no complications and uneventful return to sports 3 months post-operatively.

Proximal Femoral Remodeling and Growth Two Years after Threaded Screw Stabilization in Slipped Capital Femoral Epiphysis

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Purpose: In situ fixation of a stable slipped capital femoral epiphysis (SCFE) is successfully achieved utilizing a long partial or fully-threaded cannulated screw. However, questions remain whether adequate growth and remodeling occurs with this type of fixation and recent reports suggest a benefit to smooth constructs that allow continued growth. Our purpose is to demonstrate the effect a single, threaded screw has on future deformity and growth following in situ stabilization of stable SCFE.

Methods: This is an IRB-approved, multi-center, retrospective study of children who presented with stable SCFE between the ages of 5 and 16 and underwent stabilization with a single, long partial or fully-threaded screw. Patients with endocrine, metabolic or neoplastic disorders were excluded. Pre- and post-operative demographics as well as clinical outcomes were obtained. Various radiographic indices were measured on AP and Frog Lateral radiographs at pre-operative, post-operative, and 2-year time points to assess proximal femoral deformity, longitudinal growth, and appositional growth. The Fisher's exact test and the paired t-test were used to compare categorical and continuous data respectively.

Results: A total of 31 hips in 30 patients (19 male, 11 female) met inclusion criteria and were 12.0±1.2 years at the time of surgery. All hips underwent stabilization with a single screw, and 28/31 were successfully placed in the center-center position (Figure 1). With regard to proximal femoral remodeling, there was a significant reduction of the slip angle (25.6° to 14.5°, $p<0.001$). However, there was not significant change in the alpha angle (60.5° to 65.3°, $p=0.061$) or a decrease in the presence of a cam lesion indicated by the triangular index (24/31 vs 22/31, $p=0.772$). The proximal femoral anatomy changed with an increase in greater trochanteric height (2.5 to 10.2mm, $p<0.001$), and a reduction in the neck-shaft angle (136.6° to 131.7°, $p=0.006$). There was an increase in femoral neck width (40.0 to 47.6 mm, $p<0.001$), but no evidence of longitudinal growth as femoral neck length, screw tip distance from the physis, and number of screw threads across the physis did not change.

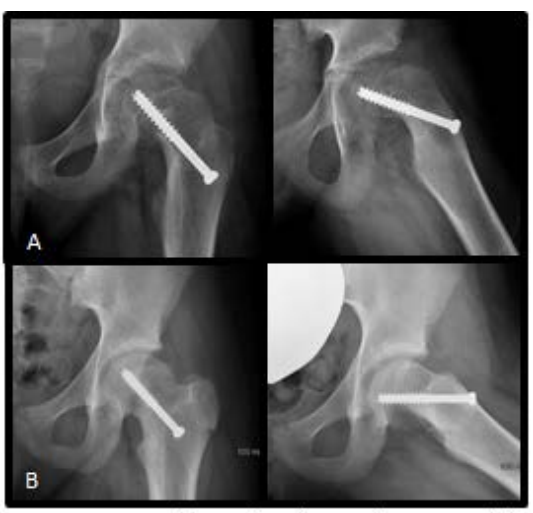

Figure 1: AP and lateral radiographs post-op (A) and 2-years (B) after screw fixation of SCFE

Conclusion: This study demonstrates that a single threaded screw for stable SCFE allows remodeling of the slip angle without affecting cam impingement or alpha angle. Longitudinal

growth of the femoral neck does not occur, however our data showed greater varus and a higher greater trochanter.

Significance: Proximal femoral remodeling occurs after a single, threaded screw in SCFE; significantly reducing the slip angle. However, growth of the proximal femur is halted.

Fibular Hemimelia: Early Radiological Signs Predicting Final Ankle Deformity

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Purpose: The major functional deficits in fibular hemimelia are severe shortening of the extremity and valgus deformity of the ankle. Furthermore, valgus deformity of the ankle, if present, worsens with tibial lenghtening. The purpose of this study is to find early radiological predictors of developing a valgus deformity of the ankle.

Methods: Retrospective study. The first and last lower extremity radiographs obtained before surgical treatment were analyzed (average age 5 and 9.8 years old respectively). The following items were measured: LLD, length of the fibula (percentage of contralateral length), proximal migration of the physis of the fibula in relation to distal tibia, shape of the distal physis of the tibia, height of the lateral part of distal epiphysis of the tibia, ankle deformity, length of both femora, number of foot rays and genu valgum.

Results: 49 patients with an average age of 16 years (SD 6) were included: 70% Kalamchi IA, 10% IB and 20% II. The development of a valgus deformity of the ankle was related to: shorter relative length of the fibula (74% vs 92%, p=0.012), when distal physis of the fibula was,at the level of the distal metaphysis of the tibia (p=0.036), "V" shape of distal physis of the tibia (p=0.001), presence of fibula anlage (p=0.024), higher LLD expressed as percentage (12% vs 5%, p=0.010), and higher predicted final LLD (10cm vs 4cm; p=0.005). Valgus deformity of the ankle was not related to absence of foot rays (p=0.622), Kalamchi IA or IB (p=0.187), shortness of femur (p=0.096), or genu valgum (p=0.769). LLD expressed as a percentage (p=0.136), predicted final LLD (p=0.099), level of the distal physis of the fibula related to the tibia, and length of the fibula expressed as a percentage of the length of the contralateral fibula (p=0.362) did not change between the first and last radiographs.

Conclusion: Development of a valgus deformity of the ankle in fibular hemimelia is related to shortness of the fibula, proximal migration of distal fibula related to distal

tibia, shape of the distal physis of the tibia and amount of leg length discrepancy.

Significance: Development of a valgus deformity of the ankle in fibular hemimelia can be predicted and taken into account when planning treatment.

Bilateral Hip Reconstruction Improve Hip Stability, Pelvic Balance and Mobility Function in Children with CP

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Purpose: This study aims to report the outcome of bilateral hip reconstruction with varus derotation osteotomy and shortening of the proximal femur combined with or without Dega pelvic osteotomy in correcting hip displacement, pelvic obliquity and improving mobility function of children with spastic diplegia and quadriplegia.

Methods: This study was a prospective cohort of patients with spastic diplegia and quadriplegia who underwent bilateral hip reconstructive surgery since 2011.The inclusion criterion are patients who have at least one side of hip displacement (Migration Percentage ≥ 40%),hip contracture, and bony hip dysplasia and the patients presented a minimum follow up period of 24 months with clinical and radiological documentation at pre-operative point, 1 year and 2 years post-operative point.We exclude adolescent patients who have severe deformation of femoral head, structural scoliosis and unhealthy enough for operation.
Radiographic assessment was performed with use of the MP(migration percentage of Reimers), the MPD(migration percentage difference) and the PT (pelvic tilt).
Mobility function was collected into the mobility functional form consisted of sitting, standing and walking ability.

Results: 49 patients met the criteria underwent bilateral reconstruction by the same operative team and returned for following up at least 24 months.The average age of patients who had surgery was 7.63 years old (2.7-19.5).Thirty five patients were classified in GMFCS level V, nine patients in GMFCS IV, four patients in level III and one in level II. The mean of the MP,the MPD and the PT were significantly decreased after 1 or 2 years operation. 86%(42 in 49) of patients had normal migration percentage of both hips. 4.5% of patients had loss of MP correction. 45%(18 in 40) of patients who had pelvic obliquity were corrected to pelvic equality.There were no any contra lateral hip displacement or ipsilateral failure in 11 patients with unilateral hip displacement. 89%(44 in 49) of patients have improvement of mobility function especially in sitting function.

Conclusion: One stage bilateral hip reconstruction can effectively correct unstable hip, pelvic obliquity and also improve mobility function most of patient with spastic diplegia and quadriplegia.
There are no any contra lateral hip displacement in the patents with unilateral hip displacement.

Significance: Bilateral hip reconstruction should be considered in both spastic diplegia or quadriplegic patients even though the centra lateral hip is no any displacement but the hip has clinical contracture or hip dysplasia.

Modified Waldenstrom Classification Less Than II-B Associated with Better Surgical Results in Severe Legg-Calve-Perthes Disease

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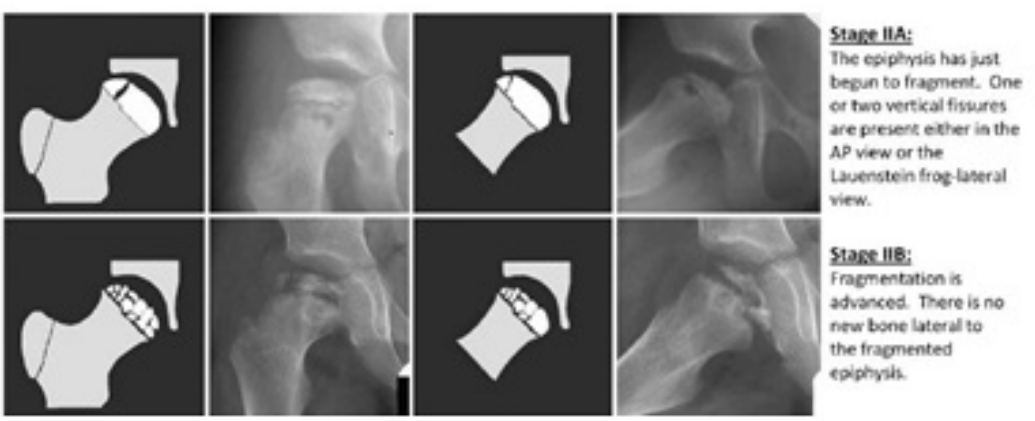
Purpose: The purpose of this study was to analyze the impact of disease stage (as measured by the modified Waldenstrom classification) on surgical outcomes in severe Legg-Calve-Perthes disease.

Methods: Seventy-seven patients with severe Legg-Calve-Perthes disease (100% with stiffness, 75% hinge abduction) underwent a staged containment protocol (medial release with Petrie casting, followed by Salter osteotomy and/or shelf acetabuloplasty) and were retrospectively reviewed. Our primary outcome variable was Stulberg classification which was dichotomized into ≤ Stulberg II and ≥ Stulberg III. Potential predictor variables that we analyzed included modified Waldenstrom classification, patient age, gender, and lateral extrusion. Univariate (Fisher exact test) and multivariate statistical analysis (logistic regression) was performed.

Results: There were 47 pts (33 male, 14 female) in the < II-B group with an average age at surgery of 7.1 yrs (range 3.4 to 10.6), while there were 30 patients in the ≥ II-B group (26 male, 4 female) with an average age at surgery of 8.1 (range 3.8 to 11.9). Univariate analysis revealed a significantly (p=0.019) higher rate of Stulberg ≤ II (68% 32/47) in the modified Waldenstrom < II-B group as compared to ≥II-B (40% 12/30). Multivariate analysis of potential predictor variables (modified Waldenstrom, age at surgery, lateral extrusion, and gender) revealed that modified Waldenstrom (p=0.019) and gender (p=0.021) were significant.

Conclusion: In this cohort of patients with severe Legg-Calve-Perthes disease subgroup analysis revealed significantly better results (Stulberg I & II) in patients with modified Waldenstrom < II-B.

Significance: In patients with severe Legg-Calve-Perthes disease it appears to be advantageous to operate early. These findings are consistent with those previously reported by Ben Joseph.



Are Post Tenotomy Radiographs in Ponseti Treated Clubfeet Predictive of Recurrence

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Purpose: Non operative treatment with the Ponseti method is the current standard of treatment for clubfoot deformity. The clinical value of early radiographs obtained after tenotomy is unknown.

Methods: A retrospective cohort study investigating the predictive value of early radiographs after tenotomy was performed after local IRB approval (Level III evidence). Inclusion criteria included a diagnosis of idiopathic clubfoot deformity, treatment with Ponseti casting followed by heel cord tenotomy, lateral radiographs of the foot and ankle with feet held in maximum dorsiflexion within 29 days after tenotomy, and minimal follow up of 5 years. The radiographs of the foot were assessed by measure of the lateral tibio-calcaneal angle (TiCA) and the lateral talo-calcaneal angle (TaCA). Measurements were made by two independent examiners. Subsequent treatment was based on the clinical appearance, range of motion, and dynamic loading of the foot and ankle during gait. Results at follow-up were rated as good (required no additional treatment), fair (required limited surgery such as anterior tibialis transfer or posterior release), or poor (required extensive posteromedial release). Group differences were evaluated using the Kruskall-Wallis nonparametric test while pairwise comparisons were evaluated using the Mann-Whitney nonparametric test.

Results: From 2/1/02 to 1/1/07, 134 cases were identified. Twenty three feet had insufficient follow up, leaving 111 feet (72 patients). The average age at first visit was 44 days (0-234), at tenotomy 91 days, and length of follow-up 9.8 years (5.7-13.2). Inter-observer reliability was excellent for both measures (ICC= 0.88 TiCA, 0.92 TaCA). Outcomes were good for 56 feet (51%), fair for 47 feet (42%), and poor for 8 feet (7%). Significant variability was noted in the radiographic measures for all outcome groups (Table). Post-tenotomy talo-calcaneal angles were statistically different between good and fair (40.8 degrees versus 35.1 degrees, p=0.0387), and good and poor outcome groups (40.8 degrees versus 26.0 degrees, p=0.0061, but not statistically different between fair and poor. Tibio-calcaneal angles were statistically different only between good and poor outcome groups (79.9 degrees versus 96.0 degrees, p=0.0285). (Table).

CLINICAL RESULTS (feet)		ALL	GOOD	FAIR	POOR
		100%	51%	42%	7%
Post TAL Results	N=	111	56	47	8
	LAT Talocalcaneal angle	37	41	35	26
		(1-69)	(8-69)	(10-65)	(1-50)
	LAT Tibiocalcaneal angle	84	80	86	96
		(42-128)	(42-127)	(53-128)	(70-120)
Minimum 5 years Follow-up Results					
	LAT Talocalcaneal angle	29	30	28	30
		(13-71)	(13-46)	(14-71)	(21-36)
	LAT Tibiocalcaneal angle	79	78	80	76
		(61-96)	(64-90)	(61-96)	(71-85)
STATISTICAL COMPARISONS		Postop		Follow-up	
		(ave 22 days)		(ave 9.8 years)	
		TaCA	TiCA	TaCA	TiCA
	Good to Fair	0.0387*	0.0927	0.3545	0.1107
	Good to Poor	0.0061*	0.0285*	0.9185	0.4494
	Fair to Poor	0.0766	0.1137	0.7264	0.1934

Conclusion: In this study, approximately 50% of Ponseti treated feet required additional surgical treatment. Radiographs after te-

notomy did not adequately distinguish feet that maintained correction versus those that would later require additional surgical intervention.

Significance: Post tenotomy radiographs did not predict which feet would experience successful outcomes. Early radiographs are not necessary in the management of clubfoot deformity.

Valgus Slipped Capital Femoral Epiphysis: Is the Outcome of Treatment Comparable to that of Varus Slips?

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Purpose: There is limited available information regarding characteristics and outcome of treatment of patients with valgus Slipped Capital Femoral Epiphysis (SCFE). We evaluate a relatively large cohort of patients with valgus SCFEs, hypothesizing that the outcome of surgical treatment of valgus and varus SCFE is comparable.

Methods: We performed an IRB-approved, retrospective analysis of 154 patients with 184 SCFE's that were treated with in-situ fixation at our institution between 2005 and 2016. Valgus displacement was seen in 22 cases (11.5%) (**Group 1**) and varus displacement in 162 cases (88.5%) (**Group 2**). The 154 patients had mean age of 12 years, mean weight of 72 kg, and mean follow-up of 108 weeks (24 to 354). All surgeries were performed in a flat-top table. Pre- and post-operative clinical and radiographic information was collected, including the rate of complications, impingement, and final hip ROM. Predictors of valgus SCFEs were identified. The influence of multiple clinical and radiographic factors on the outcome was analyzed.

Results: Overall, the mean length of symptoms prior to admission was 13 weeks. Logistic regression showed that gender (Odds Ratio [OR] 3.4, p=0.01), weight (OR 1.0, p=0.05), and age (OR 0.6, p<0.0001) were related to the presence of a valgus SCFE. In general, patients in **Group 1** were predominantly female (62% vs. 32%, p=0.009), younger (10.6 vs. 12.1 years, p=0.0001), lighter (65.4 vs. 73.0 Kg, p=0.02), and had a smaller Southwick angle at the time of presentation (27 vs. 34 degrees; p=0.07) than patients in **Group 2**. The mean length of surgery was shorter for patients in **Group 1** (48 vs. 56 min, p=0.02). The final ROM of the affected hip was comparable in both groups (p>0.05). Complications were seen in 8 patients (6%), including AVN (2.1%) and the need for subsequent surgery (3.9%). The rate of AVN in **Groups 1 and 2** was 0% and 2.5%, respectively (p=0.6). Rates of impingement (24% and 30.0%, p=4), and need for secondary surgery (4.8% vs. 3.7%, p=0.60) were similar in **Groups 1 and 2**, respectively.

Conclusion: This study suggests that valgus SCFEs are relatively rare. It appears that valgus SCFEs are more commonly seen in females, in younger and lighter patients, and tend to be associated with smaller pre-operative deformities. The outcome of valgus SCFEs appears to be comparable to that of the more common varus SCFEs.

Significance: This study provide insight on the outcome of treatment of valgus SCFE, a topic that has received little attention in the available literature.

Does Body Mass Index Influence Outcomes of Internal Limb Lengthening in Children?

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Purpose: The current obesity epidemic affects children as well as adults. Obesity may have detrimental effects on orthopedic procedures. Currently, there is no research on the effects of obesity on intramedullary (IM) limb lengthening in the pediatric population. The purpose of this study is to compare the consolidation/distraction indices and complication rates in patients who underwent IM limb lengthening and had normal/average body mass index (BMI) percentiles to those who had overweight/obese BMI percentiles.

Methods: A retrospective study was conducted that included 90 patients (100 segments, 85 femora, 15 tibiae) who underwent IM femoral/tibial lengthening at our institution between January 2003 and June 2015. Consolidation was defined as radiographic evidence of healing in 3 of 4 cortices. Average age was 14.4 years (range, 7.2–20.0 years). Normal/average group had BMI values ≤ 85th percentile. Based on Centers for Disease Control guidelines, the overweight/obese group had BMI values >85th percentile.

Results: Mean duration of follow-up was 1.7 years (range, 1.0–3.5 years). Of the 100 bone segments, 62 segments were in the normal/average group and 38 segments were in the overweight/obese group. Average BMI percentile (± standard deviation) in the normal/average group was 46.1 ± 25.4 compared with 91.8 ± 4.6 in the overweight/obese group. Consolidation index for the normal/average group was 35.8 days/cm versus 31.6 days/cm in the overweight/obese group (p=0.33). Average distraction index in the overweight/obese group was 1.4 mm/day compared to 1.5 mm/day in normal/average group (p=0.45). Fifty patients experienced 76 complications: 42 (55.3%) complications in the normal/average group and 34 (44.7%) in the overweight/obese group.

Conclusion: In this cohort, overweight/obese pediatric patients did not have significantly more complications or a slower healing rate when compared with the normal/average group.

Significance: Overweight/obese pediatric patients who are undergoing limb lengthening may not necessarily present a higher risk for complications. Surgeons should carefully assess their patients' risks beyond their BMI in order to assure the best outcomes after limb lengthening procedures.

Effect of Amputation Level on Quality of Life and Subjective Function in Children

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Purpose: Our aim was to discern if children with amputations have differences in subjective function based on amputation level. We sought to delineate whether patient-reported outcomes progressively worsened as the lower extremity amputation was more proximal. We hypothesized that children with a more proximal amputation would report poorer function and quality of life.

Methods: An IRB-approved, retrospective chart review of patients aged 0-21 years old with lower extremity amputations was performed. Demographic information, type of amputation, type of prosthesis, and the Pediatric Outcomes Data Collection Instrument (PODCI) was collected from parents and children (>10 years old). Patients were divided into three groups based on the level of amputation (ankle; transtibial; knee/transfemoral), and PODCI scores were compared between groups using Analysis of Variance (ANOVA). PODCI subscores were also compared between unilateral vs. bilateral amputations, high vs. low demand prostheses, and congenital vs. acquired amputations using indepdendent t-tests.

Results: We identified 103 patients for analysis (112 limbs; 50 ankle, 20 transtibial, and 42 knee/transfemoral amputations). The sports/physical functioning subscale of the PODCI demonstrated the only statistically-significant difference between amputation level and outcome with ankle-level amputations reporting higher scores than knee/transfemoral-level amputations (75.8 ± 18.6 vs. 63.0 ± 24.2, p=0.04). Although not significantly different from either the ankle or knee/transfemoral groups, patients with transtibial amputations reported intermediate scores (70.2 ± 27.2). There were no significant differences among amputation level for PODCI transfers, pain/comfort, global function, or happiness subscales. In subgroup analysis, same-level congenital amputees had similar scores to acquired amputees (p>0.05). When compared to unilateral knee amputations patients, patients with bilateral knee amputations had significantly worse transfer (62.4 vs. 88.3, p=0.02), sports/physical functioning (34.2 vs. 66.2, p=0.01), and global domains (58.4 vs. 80.5, p=0.02). Prosthesis design showed no significant correlation with PODCI scores between same-level amputees (p>0.05).

Conclusion: Subjective sports and physical functioning of pediatric amputees was significantly worse following knee/transfemoal amputation when compared to ankle level amputations. Although not statistically significant at all levels, our data suggests a graded decline in sports/physical functioning with higher level amputations. Amputation level did not affect patient global function, pain, happiness, or transfers.

Significance: This data does support the concept that a biological knee and longer lever arm correlates with greater function; however, children with amputations have a remarkable ability to adapt and demonstrate resilience in their daily activities.

Hemiepiphyseodesis for Tibia Vara with Percutaneous Transphyseal Screws

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Purpose: In juvenile and adolescent tibia vara patients with sufficient growth remaining, implant-controlled hemiepiphyseodesis, or guided growth, can be used to correct deformity. Recent reports have described frequent hardware failure of certain hemiepiphyseodesis implants in morbidly obese patients with tibia vara. We describe our experience using transphyseal screws to correct deformity in this patient population.

Methods: A retrospective chart and radiograph review was conducted of all juvenile and adolescent tibia vara patients who underwent lateral proximal tibial transphyseal screw hemiepiphyseodesis. Charts were queried for pre- and post-operative mechanical axis deviation, medial proximal tibia angle, lateral distal femoral angle, as well as post-operative complications or need for further surgery.

Results: Ten children (7 males) with 14 affected limbs underwent proximal tibial transphyseal screw hemiepiphyseodesis. Average chronologic age at implantation was 11.1 years and average body mass index (BMI) was 33.4. At average 20 month follow-up, the average mechanical axis deviation improved from 4.8 to 0.8 cm (p=0.002), with an average correction of 80%. The average medial proximal tibia angle improved from 81.2 to 90.1 degrees (p=0.001). In patients older than chronologic age 12.5 at time of implantation, mechanical axis improved significantly in all but one limb (9%). No limbs required further surgery to correct residual deformity. There were no complications associated with the transphyseal screws.

Conclusion: Hemiepiphyseodesis using transphyseal screws is an effective technique to correct deformity in morbidly obese juvenile and adolescent tibia vara patients with sufficient growth remaining, and is most successful when implanted in patients younger than age 12.5.

Significance: Percutaneous transphyseal screws can be used safely to correct deformity in juvenile and adolescent tibia vara patients with few complications and with minimal risk of mechanical failure.

Ossification Variants in the Femoral Condyles and Trochleae are Caused by Subclinical OCD in Children

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Purpose: The genesis of OCD lesions has been thought secondary to primary bone necrosis. This theory has been challenged recently, as histological studies from mammals, have revealed that ischemic necrosis of epiphyseal cartilage (rather than bone) is the precursor lesion of osteochondrosis dissecans (OCD). The earliest lesion identified histologically in mammals is osteochondrosis (OC) latens, in which the area of necrosis is confined to epiphyseal cartilage. As the ossification front advances, the area of necrosis causes a delay/failure in endochondral ossification that is visible radiographically and is termed OC manifesta. Juvenile osteochondritis dissecans (JOCD) in children has many similarities to OCD in animals; however, subclinical disease in children has not been studied due to the invasive nature of this work and the difficulty in obtaining appropriate specimens. Lesions of OC latens are not recognized in children, and lesions resembling OC manifesta identified by CT are often considered to be normal ossification variants. Our aim was to determine if skeletally immature human knees contained histological evidence of delayed endochondral ossification occurring secondary to ischemic necrosis of epiphyseal cartilage, or OCD Precursor lesions.

Methods: Eleven sites containing suspect OC manifesta lesions identified on CT from five male children (age range 7-11 years) were decalcified in 10% EDTA, and processed for histologic analysis. All sections were examined by four veterinary pathologists/radiologists with extensive experience in the study of OC in pigs and horses.

Results: All human sites/specimens examined contained at least one section containing histological evidence of one or more areas of OC manifesta. Lesions were evidenced by focal failure of endochondral ossification accompanied by remnants of necrotic blood vessels, chondrocyte necrosis with matrix degeneration and other findings consistent with the development of OC manifesta lesions as seen in horses and pigs.

Conclusion: Similar to other mammals, human OCD lesions appear to develop as a primary defect secondary to avascular necrosis of epiphyseal cartilage, rather than primary avascular necrosis in bone. Our findings strongly support a common pathogenesis of OCD in humans and mammals.

Significance: Our histologic findings suggest that 'ossification variants' may in fact be delayed presentations of a continuum of OCD lesion development that starts years earlier. Some lesions may progress to healing, but many may progress to 'osteochondritis dissecans'. These 'ossification variant' lesions identified on xray or MRI require close follow-up.

Orientation of Cut Angle in Distal Tibia Derotation Osteotomy Can Create Unintended Sagittal and Coronal Plane Deformity at the Ankle

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Purpose: Distal tibial osteotomy is commonly used when surgically correcting external and internal tibial torsion. While the effect of oblique osteotomies are well described with the Rab osteotomy of the proximal tibia, minimal data exists regarding how variation of distal tibial osteotomy cut angle affects final ankle alignment. The goal of this study was to assess how changes in the orientation of the cut angle in distal tibial osteotomies affect ankle alignment in specimens with existing rotational deformities.

Methods: Using a historical cadaveric collection of preserved human tibia specimens, we screened 579 skeletons and identified ten specimens with the greatest degree of rotational deformity ranging from 23° external to 32° internal deviation from the mean. We surface scanned the specimens to produce a three-dimensional image of each tibia. Digitally, we made transverse and a 10° angled osteotomies five centimeters above the distal tibial articular surface, simulating distal tibial osteotomies oriented perpendicular to the shaft versus parallel to the distal joint surface. Specimens were then three-dimensionally printed and cross pinned at 0°, 20° and 40° of internal or external rotation. Anterior-posterior and lateral X-rays were obtained at each degree of rotation and used to calculate the anterior distal tibial angle (ADTA) and lateral distal tibial angle (LDTA) for analysis of variance (ANOVA).

Results: Mean angle measurements for transverse and angled distal tibial osteotomies are listed in Table 1. Repeated measures ANOVA showed no statistical difference in LDTA or ADTA measurements was appreciated between 0°, 20° and 40° of rotation in transverse osteotomies. For angled osteotomy cuts, there was a statistically significant difference in LDTA and ADTA between 0° and 40° in both external and internal rotation and 20° and 40° in internal rotation.

Table 1: Angle Measurements in Straight and Angled Distal Tibial Osteotomies

		0°	20°	40°	0°	20°	40°
LDTA	External Rotation	89.8±3.1	88.2±2.8	88.7±4.3	90.1±2.2	93.7±3.7	98.1±4.6
	Internal Rotation	89.4±2.5	89.7±2.9	86.3±2.6	90±2.2	83.7±3.6	80.4±1.0
ADTA	External Rotation	81.9±2.6	81.8±3.0	81.4±3.0	82.1±2.3	80.8±2.6	84.1±3.6
	Internal Rotation	84.2±2.5	83.8±2.5	84.4±2.1	83.3±2.2	85.6±3.2	88.9±3.5

Conclusion: Our results demonstrate that a distal tibia osteotomy cut parallel to the distal joint surface can result in unanticipated coronal and sagittal plane deformity, while a cut perpendicular to the axis of the tibial shaft did not cause unintended deformity.

Significance: An understanding of these effects will aid surgeons in avoiding unin-

tended angulation following derotational distal tibial osteotomies while also providing a guide in cases when a surgeon wishes to purposely add subtle corrections for angular deformity when correcting rotational deformity.

The Novel Use of Technology in CP Hip Surveillance

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Purpose: Hip screening protocols for patients with cerebral palsy (CP) have resulted in decreased dislocations with an associated decreased need for salvage surgery. The purpose of our study was to examine the viability of a CP hip surveillance protocol utilizing an interactive iPad application for recording, storing and following surveillance data.

Methods: A CP hip surveillance and treatment protocol was initiated in 2012 and implemented by 3 fellowship-trained pediatric orthopaedic surgeons at a tertiary referral center. An iPad application developed at our center was utilized for monitoring hip status over time. Hip range of motion and radiographic migration percentage (MP) were input into the application and made part of the medical record. The iPad application allowed for tracking of hip status overtime in each included patient. Decision analysis was based on age, GMFCS, hip range of motion and radiographic MP. Simple statistics were used to determine the rate of hip soft tissue surgery, osseous reconstruction and salvage surgery in this cohort. Rates of hip subluxation and dislocation were calculated to determine overall effectiveness of this screening and treatment protocol.

Results: From the initiation of our iPad-based screening protocol in 2012, we followed 3331 patients with CP with an average age of 10.89 years (range: 0-26). Over this 4 year period, we performed 309 soft tissue surgeries for hips at risk, 151 osseous reconstructive surgeries and 10 salvage procedures. In total, 470 (14.1%) patients required surgical intervention for hip subluxation/dislocation, which resulted in an overall post-operative average MP of 16.25% at final follow-up. Of those with a recorded MP (n=268 hips), at final-follow-up, there were 204 (76.1%) located hips (MP <30%), 61 (22.8%) subluxated hips (MP between 30-99%) and 3 (1.1%) dislocated hips (MP 100%).

Conclusion: Although there are demonstrable gaps in the gathered data, the novel use of technology for hip surveillance in the CP population results in a very low hip dislocation rate and decreased need for salvage surgery in this population.

Significance: Our interactive iPad application is a useful tool in hip surveillance in the CP population. However, while the application allows for streamlined recording, storing and tracking of hip surveillance data, it requires a dedicated team of caregivers to diligently enter and utilize that data for successful hip management.

Treatment of Patellar Instability in Children and Adolescents with Cerebral Palsy

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Purpose: Children and Adolescents with Spastic Cerebral Palsy often have knee pain associated with patellar instability. This can affect patients throughout the GMFCS spectrum. Nonoperative treatment is often unsatisfactory and there is little information on the outcomes of different surgical treatments. This study seeks to review the outcomes of various surgical corrections of patellar instability in this patient population.

Methods: This is a retrospective study patients with Cerebral Palsy who presented with patellofemoral pain and/or instability. The patients had standardized outcome measures as well as radiographic measurements. All study participants were seen as part of routine clinical care. Followup was also performed as routine clinical care in which patients are seen on a routine at least yearly basis.

Results: There were a total of 480 patients with complaints of patellofemoral pain. Of these, 86 had pain with associated patellar instability. Surgery was offered to 75 of these patients. There was a total of 27 knees (18 right 9 left) of 20 patients (11 female and 10 males) with a mean age of 16 + 7 years-old (ranging 11 to 19 years) who had surgery. Seven patients had bilateral surgery. Five patients were GMFCS V, three were GMFCS IV, six were GMFCS III, three are GMFCS II and three GMFCS I. All the knees that only had the proximal and distal realignment (Insall Procedure) (twelve knees) still have patella alta. Eight patients had tibial tubercle osteotomies (Fulkerson AMZ). Fifteen patients had medial patellofemoral ligament reconstructions in addition to tibial tubercle surgery . One patient had a V-Y quadricepsplasty and eight had a reefing of the patellar tendon. 24 of 27 patients were all free of pain in the last follow up. Nine of the patients who had the Insall procedure had patellofemoral arthritis at their latest followup (mean 82 months) . On the last follow-up sixteen knees still have patella alta. On the last follow up 2 patients have hyper mobile patellae (3 knees). All of the patients were prescribed patellofemoral centralizing braces but it was not possible to judge compliance.

Conclusion: There are many different surgical treatments for patellofemoral instability associated with pain in children and adolescents with cerebral palsy. Many different approaches have been tried. The combination of tibial tubercle transfer, patellar tendon shortening (reefing), and medial patellofemoral ligament reconstruction appears to have the best intermediate care outcomes.

Significance: This retrospective study demonstrates good intermediate (82 month) outcomes with a combination surgical approach to patellar instability.

Differences in Body Composition According to Gross Motor Function in Children with Cerebral Palsy

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Purpose: Few studies have evaluated body composition according to function ability levels in those with cerebral palsy (CP) using the bioelectrical impedance analysis (BIA) method. Therefore, this study was performed to assess differences in body composition according to gross motor function in children with CP compared to a healthy control group. Additionally, we evaluated the factors that significantly affect the body composition measurements.

Methods: One hundred consecutive patients (mean age 11.5 ± 4.2 years) with CP who were admitted for orthopedic surgery between May 2014 and March 2016, and 26 typically developing children (TDC) (control group) were included. BIA was used to measure body composition, including body fat, soft lean mass (SLM), fat free mass (FFM), skeletal muscle mass (SMM), body cell mass (BMC), bone mineral content (BMC), and basal metabolic rate (BMR). Body composition measures were compared according to the gross motor function classification system (GMFCS) level, and between children with CP and TDC using one-way analysis of covariance; data were corrected for the effect of age.

Results: Children with CP classified as GMFCS levels IV and V had a lower height, weight, and body mass index than those classified as GMFCS levels I, II, and III. Children with CP classified as GMFCS levels IV and V had a significantly lower SLM, SLM index, FFM, FFM index, SMM, SMM index, BCM, BMC index, BMC, and BMC index than those classified as GMFCS levels I to III and TDC. The GMFCS level significantly affected SLM and BMC.

Conclusion: Body composition analysis using the BIA method is a feasible nutritional assessment tool to use in patients with CP. Children with CP, especially those who had severely impaired motor function, had a significantly lower FFM, SLM, SMM, BCM, and BMC than TDC.

Significance: The authors found that children with more severe gross motor impairments had lower fat free mass and BMD. However, few studies have evaluated body composition according to function ability levels in those with CP using the BIA method. Our study demonstrated that the BMC and BMC index were lower in non-ambulatory children than in ambulatory children with CP and TDC. In addition, our multiple regression analysis showed that the GMFCS level significantly affected BMC. Therefore, evaluating bone health status and providing effective interventions, including calcium and vitamin D supplementation, and bisphosphonate medication, should be considered in patients with CP who have severely impaired motor function.

Table. Partial correlation between body composition measures after adjusting age, sex, BMI and GMFCS level

		Body fat	SLM	FFM	SMM	PBF	BCM	BMC	WHR	VFA
SLM	*r*	**-0.304**								
	p-value	**0.003**								
FFM	*r*	**-0.273**	**0.952**							
	p-value	**0.007**	**<0.001**							
SMM	*r*	**-0.323**	**0.947**	**0.984**						
	p-value	**0.001**	**<0.001**	**<0.001**						
PBF	*r*	**0.662**	**-0.660**	**-0.648**	**-0.694**					
	p-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**					
BCM	*r*	**-0.322**	**0.947**	**0.983**	**1.000**	**-0.693**				
	p-value	**0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**				
BMC	*r*	-0.090	**0.717**	**0.796**	**0.768**	**-0.403**	**0.768**			
	p-value	0.384	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**			
WHR	*r*	**0.482**	0.102	0.125	0.033	0.046	0.031	0.013		
	p-value	**<0.001**	0.325	0.225	0.750	0.655	0.764	0.899		
VFA	*r*	**0.837**	-0.114	-0.087	-0.182	**0.442**	-0.182	0.047	**0.777**	
	p-value	**<0.001**	0.267	0.399	0.076	**<0.001**	0.076	0.651	**<0.001**	
BMR	*r*	**-0.271**	**0.952**	**0.999**	**0.982**	**-0.646**	**0.982**	**0.796**	0.129	-0.083
	p-value	**0.008**	**<0.001**	**<0.001**	**0.001**	**<0.001**	**<0.001**	**<0.001**	0.209	0.420

BMI, body mass index; GMFCS, Gross Motor Function Classification System; *r*, correlation coefficient;
SLM. Soft lean mass; FFM, fat free mass; SMM, skeletal muscle mass; PBF, percent body fat; BCM, body cell mass;
BMC, bone mineral content; WHR, waist-hip ratio; VFA. visceral fat area; BMR, basal metabolic rate

Does a Baclofen Pump Complicate Posterior Spine Fusion in Patients with Cerebral Palsy?

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Purpose: In assessing outcomes following surgical procedures, appropriate risk stratification is important. Children with Cerebral Palsy (CP) are known to have higher rates of complications during spinal fusion compared with normal developing children. However, it is unknown whether the presence of a pre-existing intra-thecal baclofen (ITB) pump results in more difficult surgery and higher rates of complications in similarly affected children with CP.

Methods: Over a 15-year period, we retrospectively compared a consecutive series of CP patients undergoing posterior spine fusion (PSF); study groups included 19 patients with ITB and 49 patients without ITB. We compared demographics, comorbidities, and curve magnitude. Intraoperative measures included levels of PSF, fixation techniques, OR time, antifibrinolytics use, amount of blood loss/administration, spinal cord monitoring, and epidural placement. Post-operative measures of complications, including infection; length of ICU/hospital stay; drain utilization and drainage amount; and need for further surgery were also compared.

Results: When comparing between groups; age, co-morbidities, number of levels fused and fixation techniques during PSF were not significantly different. ITB patients were more likely to have PSF with osteotomy (p-value, 0.022) and receive antifibrinolytics (p-value, 0.052). A ten-fold increase in intra-operative neurosurgical consultations was found for patients with ITB (42.1% versus 4.0% ; p-value, <0.001). The average EBL was 1400ml for those with ITB and 900ml for those without (p-value, 0.093). Volume of blood administered was 1183 ml in those with ITB vs. 858 ml for those without (p-value, 0.074). Mean surgical time was 1.2 hours greater in patients with ITB (6.7 vs. 5.5 hrs, p-value .039). Length of ICU/

Outcomes	No Pump (n=49)	Pump (n=19)	P-value
Planned Neurosurgical Consult	1 (2.0%)	7 (36.8%)	< 0.001
Unplanned Neurosurgical Consult	1 (2.0%)	1 (5.3%)	0.484
Volume of Blood Loss	900 (250 - 7500)	1400 (300 - 4500)	0.093
Volume of Blood Loss per Levels Fused	61 (16 - 536)	88 (20 - 300)	0.158
Volume of Blood Administered	858 (0 - 4900)	1183 (0 - 5400)	0.074
Volume of Blood Administered per Levels Fused	55 (0 - 350)	74 (0 - 386)	0.111
Fibrinolytics Use	39 (81.2%)	19 (100.0%)	0.052
Ponte Smith-Peterson Osteotomies	7 (14.3%)	8 (42.1%)	0.022
Nights in PICU	2 (0-13)	3 (0-4)	0.362
Nights in Hospital Total	7 (3 - 26)	6 (5 - 9)	0.085
Complications	43 (87.8%)	15 (78.9%)	0.448
Infection	5 (10.2%)	0 (0.0%)	0.312
Further Surgery Needed for PSF	7 (14.3%)	2 (10.5%)	1
Operating Room Time - hrs	7.3 (4.9 - 14.7)	8.5 (5.3 - 14.3)	0.039
Anesthesia Set Up Time - hrs	1.4 (0.6 - 4.6)	1.3 (1.0 - 5.0)	0.757
Surgical Time - hrs	5.5 (3.4 - 10.7)	6.7 (4.0 - 12.2)	0.039

Hospitalization was similar between groups. Post-surgical complications were present in 78.9% of patients with ITB and 87.8% of those without ITB (p-value, 0.448).

Conclusion: This study compares CP patients with ITB and CP patients without ITB who underwent PSF; the groups were well matched. We found that almost half of the patients with ITB needed help from a neurosurgeon and the surgical time was over an hour longer. Although not statistically significant, those with ITB had higher EBL and blood transfused despite being significantly more likely to have antifibrinolytics. Despite the more challenging surgical course; there was no difference in complications or hospitalization time.

Significance: With this information, we can advise families of patients with CP and ITB requiring a PSF that surgery will be longer and may require more transfused blood. The treating surgeon would be well advised to have a neurosurgeon available to manage issues with the ITB.

Fate of Stable Hip after Prophylactic Femoral Varization Osteotomy in Patients with Cerebral Palsy

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Purpose: This study was performed to investigate the outcomes after prophylactic femoral varization osteotomy (FVO) in stable hip with cerebral palsy in terms of radiographic parameters and the influencing factors. In addition, we investigated the outcomes after hip reconstructive surgery in displaced hip to compare with those after prophylactic FVO.

Methods: This study included the 119 CP patients (mean age of 8.9 years) who underwent hip reconstructive surgery including FVO for hip instability. Migration percentage (MP), neck-shaft angle (NSA) and head-shaft angle (HSA) were measured at preoperative and periodic follow-up hip radiographs. All of hips were divided into the stable hip group (MP ≤33%) and displaced hip group (MP>33%) according to the preoperative hip radiographs. For stable and displaced hip groups, annual changes in the radiographic indices after FVO were analyzed with use of a linear mixed model.

Results: A total of 224 hips (80 stable hips and 144 unstable hips) were finally included in this study, and 1569 radiographs were evaluated. In stable hip group, MP was not significantly increased by the follow-up duration (p=0.057) after prophylactic FVO. In unstable hip group, MP was significantly increased by the follow-up duration (1.6% per year, p<0.001). MP was significantly decreased by the concomitant Dega pelvic osteotomy in both stable hip (14.5%, p<0.001) and displaced hip (18.9%, p<0.001). HSA was not significantly increased by follow-up duration in stable hip group (p=0.451), but significantly increased in displaced hip group (0.8 degree per year, p=0.039). NSA was significantly increased by follow-up duration in both stable (0.9 degree per year, p=0.005) and displaced hip group (1.9 degree per year, p<0.001).

Table. Factors affecting migration percentage after prophylactic femoral varization osteotomy in stable hip

	Estimate (%)	95% CI	SE	P-value
Intercept	8.7	-0.0 to 17.5	4.5	
Follow-up duration (year)	0.5	-0.0 to 1.0	0.3	0.057
Age at surgery	-0.4	-0.9 to 0.2	0.3	0.218
Sex	1.2	-2.0 to 4.5	1.7	0.459
GMFCS level III-IV	-2.0	-6.8 to 2.8	2.4	0.405
GMFCS level III-V	-2.8	-8.1 to 2.5	2.7	0.308
Anatomical type	2.2	-2.1 to 6.5	2.2	0.322
Laterality	-2.3	-4.9 to 0.2	1.3	0.073
Concomitant Dega osteotomy	14.5	10.6 to 18.5	2.0	<0.001

CI, confidence interval; SE, standard error; GMFCS, Gross Motor Function Classification System; SDR. Selective dorsal rhizotomy
A linear mixed model was used to estimate factors affecting migration percentage.

Conclusion: Prophylactic FVO in stable hip in patients with CP showed good surgical outcome without the risk of hip displacement by the follow-up duration, while displaced hip showed the change of increase of hip displacement after hip reconstructive surgery.

Significance: To our knowledge, this investigation was the first to evaluate the outcome after prophylactic FVO for stable hip in patients with CP. The present study demonstrated that there was no annual increase in MP after prophylactic FVO in stable hip with CP, but there was significant increase after FVO in displaced hip.

Functional Status and Amount of Hip Displacement Independently Affect Acetabular Dysplasia in Cerebral Palsy

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Purpose: Acetabular dysplasia is the one of main causes of hip displacement in patients with cerebral palsy. Although several studies have shown a relationship between hip displacement and acetabular dysplasia, relatively few have evaluated the association between quantitative acetabular dysplasia and related factors, such as the Gross Motor Function Classification System (GMFCS) level. In this study, we quantitatively investigated acetabular dysplasia using three-dimensional (3D) reconstruction computed tomography (CT) and factors related to dysplasia in patients with CP.

Methods: We performed a morphometric analysis of the acetabulum in patients with cerebral palsy using multiplanar reformation of computed tomography data. The three directional acetabular indices (anterosuperior, superolateral, and posterosuperior) were used to evaluate acetabular dysplasia. Consequently, linear mixed models were used to adjust for related factors such as age, gender, GMFCS level, and migration percentage.

Results: A total of 176 patients with cerebral palsy and 55 normal controls were enrolled in this study. Statistical modeling showed that all three directional acetabular indices independently increased with GMFCS level ($p < 0.001$) and migration percentage ($p < 0.001$).

Conclusion: Acetabular dysplasia was independently affected by both the amount of hip displacement and the GMFCS level. Thus, physicians should consider not only the migration percentage but also three-dimensional evaluation in patients with high GMFCS levels.

Significance: Most hip reconstructive surgeries have generally been performed based on the migration percentage. Although several studies have shown a positive relationship between acetabular dysplasia and migration percentage, relatively few studies have evaluated the direct correlation between quantitative acetabular dysplasia and related functional factors, such as GMFCS level.
In the present study, we quantitatively assessed acetabular dysplasia in patients with CP using 3D acetabular indices measured with the multi-planar reformation technique on 3D reconstruction CT. Results showed that acetabular dysplasia increased according to each migration percentage and GMFCS level.
Our study demonstrated that acetabular dysplasia was independently aggravated according to increased migration percentage and GMFCS level. We recommend consideration of the functional level and three-dimensional evaluation as well as assessment of plain radiographic changes of the acetabulum when deciding the pelvic osteotomy during hip reconstructive surgery in patients with CP.

Table. Factors Affecting Acetabular index of 3-dimensional hip CT

		Coefficient	95% CI	*p*
AS Index				
Gender	Female	1.0	-0.5 to -2.4	0.19
Age		-0.2	-0.4 to 0.0	0.08
GMFCS	Control			
	I-II	2.9	-0.5 to 6.4	0.10
	III	7.7	4.9 to 10.4	**<0.001**
	IV	4.1	1.9 to 6.4	**<0.001**
	V	2.4	0.1 to 4.7	**0.04**
Migration percentage(%)		0.2	0.1 to 0.2	**<0.001**
SL index				
Gender	Female	-0.8	-2.1 to 0.6	0.26
Age		-0.4	-0.6 to -0.2	**<0.001**
GMFCS	Control			
	I-II	7.2	4.0 to 10.4	**<0.001**
	III	7.9	5.3 to 10.4	**<0.001**
	IV	7.0	4.9 to 9.1	**<0.001**
	V	7.3	5.1 to 9.5	**<0.001**
Migration percentage(%)		0.3	0.2 to 0.3	**<0.001**
PS Index				
Gender	Female	-5.8	-8.0 to -3.6	**<0.001**
Age		-0.9	-1.2 to -0.6	**<0.001**
GMFCS	Control			
	I-II	6.9	1.8 to 12.1	**0.01**
	III	11.7	7.6 to 15.9	**<0.001**
	IV	10.3	6.9 to 13.7	**<0.001**
	V	8.2	4.8 to 11.7	**<0.001**
Migration percentage(%)		0.1	0.1 to 0.1	**<0.001**

GMFCS = Gross Motor Function Classification System.

AS index = Anterosuperior index; SL index = Superolateral index; PS index = Posterosuperior index

Pediatric Cervical Spine Swelling After Fracture – Are the Current Guidelines Effective?

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Purpose: Radiographic guidelines for pediatric prevertebral soft tissue (PVST) thickness have been adopted to aid clinicians in diagnosing cervical spine injuries. However, these guidelines have not been validated in children with identified cervical spine injuries. The purpose of this study was to investigate the sensitivity and specificity of current PVST thickness in a cohort of children with known cervical fractures or dislocations.

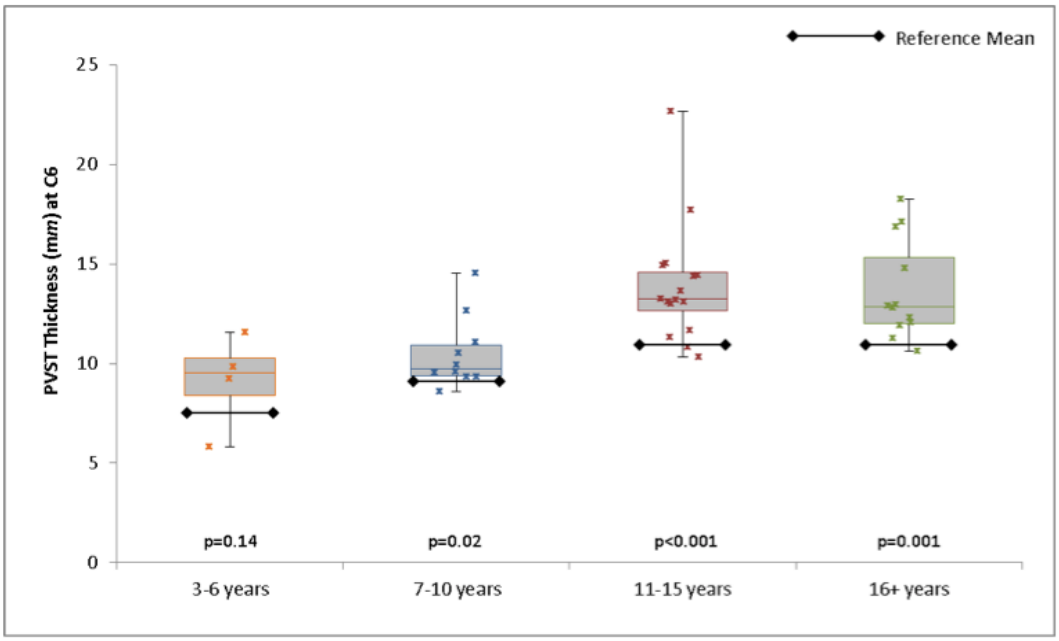
Methods: Forty-three children (mean age 12.4 years, range 3.6 to 17.6 years) with documented cervical spine injury (fracture or dislocation) and 52 children (mean age 12.1 years, range 3.6 to 17.9 years) without cervical spine injury were included in this analysis. Two independent reviewers measured PVST thickness at C2, C3 and C6 for all patients. Interrater reliability was assessed by estimating intraclass correlation coefficients (ICCs) along with 95% confidence intervals. Cervical spine measurements were compared across age groups using analysis of variance. Student's t test was used to compared results between the injured and control groups. Sensitivity and specificity was estimated on normal reference mean values for all children by age group.

Results: There was no significant difference in age distribution between the two groups. Inter-rater reliability was excellent for all measurements (ICC=0.97) between the two reviewers. PVST thickness at C2 did not vary across age groups (p=0.35) with average measurements ranging from 4.8 to 6.2. Similarly PVST thickness at C3 did not vary across age groups (p=0.23) with averages ranging from 4.7 to 7.4. At C6, however, PVST thickness exhibited variation by age group (p<0.001) with average measurements ranging from 9.1 to 13.9 (Figure 1). There were no differences in age distribution or in PVST thickness measurements at any level between subjects with cervical injury and those without. Finally the sensitivity and specificity for PVST thickness at C2 was 69.8% and 50%; at C3 was 60.5% and 63.5% and at C6 was 88.1% and 13.5% respectively.

Conclusion: PVST thickness is not an accurate predictor of cervical spine injury in children with upper cervical spine injury, particularly in children under 7 years of age. PVST at C6 may be the most sensitive indicator of cervical injury in children over 7 years of age.

Significance: While radiographic guidelines exist for PVST thickness in adults, these guidelines may not be accurate for children and if clinical suspicion exists alternate imaging should be pursued.

Figure 1. PVST thickness at C6 by age group. P-values are based on a t-test comparing the average PVST thickness measurement against the reference mean for each age group.



Are Intercondylar Fractures of the Humerus at Increased Risk of Complications and Poor Outcome?

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Purpose: The main objective of the study was to retrospectively evaluate clinical, functional and radiographic outcome of displaced intercondylar fractures (ICF) of the humerus in children and adolescents, and to evaluate upper extremity function with the short version of the Disabilities of the Arm, Shoulder and Hand outcome questionnaire c(Quick DASH). The secondary aim was to compare outcome between patients undergoing closed reduction and percutaneous fixation (CRPF) with those treated by open reduction and internal fixation (ORIF) for displaced ICF.

Methods: A retrospective review was performed to identify all children and adolescents who underwent surgical treatment for displaced ICF of the humerus (September 2011–September 2015). All patients underwent regular clinical and radiographic follow-up for at least 12 months after their index surgery. Patients with non-displaced ICF of the humerus, or with pathologic fracture, as well as patients treated conservatively were not included.

Results: Eighteen patients met the inclusion criteria and were included in the study. The mean age at time of injury was 11.9±2.5 years (range 7.5–15.8 years). CRPF was performed in 4 (22%) cases. Among the 14 patients (78%) who underwent ORIF, combined medial and lateral approach was performed in 5 (36%) cases and posterior (triceps split) in 9 (64%) cases. After surgery, the upper limb was immobilized in a in a posterior long-arm splint for a period of 4 to 8 weeks. The overall complication rate was 61%. The mean QuickDASH score at final follow-up was 9 and five patients (28%) showed a QuickDASH score of 18.2 or more. Complications rate was 25% among patients who underwent CRPF and 71% among patients who underwent ORIF ($p<0.05$) and all cases of loss of elbow extension/flexion were observed in ORIF group ($p<0.05$).

Table 1 shows mean QuickDASH scores and complications rates observed in previously published study evaluating outcome of different surgically treated pediatric elbow and humerus fractures and mean QuickDASH scores and complications rates observed in this study

Fracture location	N° of patients	Mean QuickDASH	Complication rate
Proximal Humerus	52	1,2	0
Humeral Shaft	38	3	11%
Distal MDJ of the humerus	14	0,8	14%
Olecranon	22	2,7	18%
ICF of the humerus - CRPF	4	0	25%
ICF of the humerus - ORIF	14	7,6	10%

MDJ = Metaphyseal-Diaphyseal Junction

Conclusion: Patients undergoing surgical treatment for displaced ICF of the humerus have a poorer functional outcome compared to with other humerus and elbow fractures surgically treated (Table1). Minimally displaced ICF of the humerus with intraarticular displacement less than 2 mm can be safely managed with CRPF. In presence of severe displacement, ORIF is required. However, high rate of complications and poor outcome should be expected. Patients and families should be warned of the increased risk for elbow loss of motion and poor functional outcome in about 35% of the cases.

Significance: Displaced ICF of the humerus requiring ORIF have significantly less favorable outcome, compared to ICF of the humerus treated with CRPF and to other surgically treated upper limb injuries (Table1).

High Frequency Ultrasonography has the Great Value in the Diagnosis of Elbow Occult Fracture in Children

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Purpose: To report and assess the usefulness of ultrasound (US) findings for occult fractures of growing bones.

Methods: For two years, US scans were performed in children younger than 16 years who were referred with trauma-related local pain and swelling of the extremities. As a routine US examination, the soft tissue, bones, and adjacent joints were examined in the area of discomfort, in addition to the asymptomatic contralateral extremity for comparison. Twenty occult fractures in 20 children (age range, five months-11 years; average age, 5.5 years) were confirmed by initial and follow-up radiograms.

Results: The most common type of occult fractures was supracondylar fracture of humerus (n = 9, 45%), followed by the olecranal fracture (n = 4, 20%), fracture of neck of radius (n = 3, 15%), The fracture of lateral condyle of humerus (n = 3, 15%), fracture of medial condyle of humerus (n = 1, 5%). On the retrograde review of the routine radiographs, 13 out of the 20 cases showed no bone abnormalities except for various soft tissue swelling. For the US findings, cortical discontinuity (direct sign of a fracture) was clearly visualized in 19 cases (95%) and was questionable in one (5%).

Conclusion: Performing US for soft tissue and bone surfaces with pain and swelling, with or without trauma history in the extremities, is important for diagnosing occult or missed fractures of immature bones in pediatric-aged children.

Significance: Performing US for soft tissue and bone surfaces with pain and swelling, with or without trauma history in the extremities, is important for diagnosing occult or missed fractures of immature bones in pediatric-aged children.

Long-Term Functional Results of Pink Pulseless Supracondylar Fractures in Children When Vascular Injury is Managed Conservatively

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Purpose: No consensus exists regarding the vascular management of perfused, pulseless supracondylar humeral fractures in children. There is a controversy on whether or not an early surgical revascularization is mandatory and if it has any impact on function when children grow and increase their activity level. The aim of the study is to investigate the long-term functional results of these fractures when the vascular injury is managed conservatively.

Methods: 14 adults who sustained a pink pulseless type 3 supracondylar fracture during childhood were reviewed at an average follow-up of 13.5 years (SD 4.3). The average age at the time of fracture was 7 years (SD 1.9) and mean age at the latest follow-up was 20 years (SD 4.3). Patients were managed with closed reduction of the fracture, percutaneous pinning and strict supervision of the vascular status without surgical revascularization. Physical examination included range of motion, carrying angle, elbow stability, grip strength, pinch strength, endurance, discriminatory sensation, length and circumference of the arm and forearm, the wrist brachial index, radial pulse, capillary refill time, and oxygen saturation in both upper limbs. Clinical outcomes were evaluated with the MEPS and the quick-DASH questionnaires. Patients were asked about cold intolerance and exercise-induced ischemic symptoms.

Results: All patients were satisfied with their result. All the scores showed excellent results in all cases. No patient referred pain. Nine patients performed sports, five of them at a competitive level. There was no elbow instability in any case. Thirteen patients showed a normal endurance test with both hands. There were significant differences between the injured and uninjured upper limb regarding flexion (134º vs. 140º; p=0.005), carrying angle (8º vs. 6º; p=0.017) and pinch strength (13kg vs. 15.5 kg; p=0.005). However, there were no significant differences between injured and uninjured sides regarding extension (p=0.317), pronation (p=0.102), supination (p=0.102), grip strength (p=0.168), capillary refill (p=0.317), wrist brachial index (p=0.214), length of the arm (p=0.803) and forearm (p=0157), circumference of the arm (p=0.346) and forearm (p=0.482), or oxygen saturation (p=0.132). Radial pulse was present in all patients. Discriminatory sensation was normal in all patients. One patient referred a Raynaud's phenomenon in his 4th and 5th finger induced by cold or exercise that was not painful and did not limit his activity.

Conclusion: Strict supervision of pink pulseless supracondylar fractures without surgical revascularization provides satisfactory results result in the long-term when patients reach adulthood.

Significance: Pink pulseless supracondylar fractures can be treated without surgical revascularization

Management of Neglected Traumatic Hip Dislocation in Children

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Purpose: Neglected traumatic hip dislocation in children is uncommon and there is no consensus on appropriate management. Previous studies report high rates of avascular necrosis. We report a series of six consecutive cases who underwent operative reduction following neglected hip dislocation.

Methods: All six children sustained posterior dislocations and had no treatment prior to presentation at our institution. An associated marginal acetabular fracture was present in two cases. One additional patient was excluded from the study due to complete loss of articular cartilage that precluded open reduction. The mean time prior to surgical intervention was 16.1 months (6-36) with a mean age of 7.2 years (4-10.8). All children underwent pre-operative skeletal traction for 10-14 days. An extended postero-lateral approach was used in all cases. The acetabulum was cleared of scar tissue and a femoral shortening performed as required (four cases). Minor erosion of the articular cartilage of the posterior aspect of the femoral head was noted in 3/6 cases. Following reduction, a posterior capsulorrhaphy was performed and the patient immobilised in a hip spica for 6 to 12 weeks.

Results: The mean follow-up was 18.7 months (10-28). All patients had a good or excellent functional outcome with a mean Harris Hip Score of 98.3. No hip subluxed or dislocated post-operatively. The radiographs at last follow-up showed no evidence of avascular necrosis in 83% (5/6) of cases. One patient had evidence of partial femoral head collapse.

Conclusion: At short-term follow-up, open reduction with a postero-lateral approach, posterior capsulorrhaphy and femoral shortening as required produces a satisfactory outcome with a stable, congruent reduction. Good clinical function can be expected

6 yr 10m female, 8 months post injury. F/u 28 months

6 year 9m male, 2 years post injury. F/u 21 months

7 yr 9m male, 11 months post injury, F/u 10 months

4 year old male, 6 months post injury. F/u 16 months

with a low incidence of avascular necrosis.

Significance: This study describes a promising treatment regimen for this uncommon but challenging condition.

Minimally Displaced Lateral Humeral Condyle Fractures - Optimizing Follow up and Minimizing Cost

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Purpose: The aim of this study was to evaluate the risk of redisplacement in non-operatively treated minimally displaced LHC fractures and to try and optimize the follow-up visits and radiographs.

Methods: We retrospectively reviewed clinical and radiographic parameters of all patients had minimally displaced (less than 2mm) LHC fractures seen at our institution from 2009-2015. All patients treated non-operatively to start were included in the study. We excluded patients treated operatively with percutaneous pinning at the onset. We calculated the number of visits within the first 4 weeks as well as the number of radiographs in the first 4 weeks. We also analyzed practice variation amongst the various (>10) treating surgeons. Number of children with subsequent displacement needing operative fixation was measured.

Results: 159 children with non-displaced lateral humeral condyle fractures seen at our institution from 2009-2015. Two were excluded due to lack of adequate radiographs. There were 96 boys and 61 girls and the average age was 5.3 years (6 mo-13 years). Only one child was taken to the operating room 9 days post injury for closed pinning of a fracture with 2.5mm gap at the fracture site.
Within the first 4 weeks, the average number of visits was 2.7 (Range 1-5, median 3) and the mean number of radiographs was 10.3 (range 3-20, median 10).

Conclusion: Minimally displaced LHC fractures can be treated non-operatively. The risk of subsequent displacement in a recent systematic review (Knapik et al POSNA 2016) was 14.9% and 87% of these displaced within the first week. In our study we found an extremely low risk (0.63%) of redisplacement in appropriately selected patients with minimally displaced LHC fractures.
The optimal follow up in cast is not well defined in literature. There was tremendous variability in follow up patterns between surgeons. Optimizing and standardizing this follow up to one follow up visit at about 10 days and another at around the 4-6 week mark with radiographs at these visits would result in appropriate identification of displacement and healing but avoid unnecessary office visits, time out of school and work and radiation exposure as well as cost.

Significance: Loss of position in appropriately selected LCH fractures treated non-operatively was rare. The data from this cohort questions the need for multiple visits and radiographs in the first 4 weeks. Optimal follow up would result in considerable saving in terms of time, finances as well as radiation exposure.

Type IV Supracondylar Humerus Fractures: Can We Predict These Before the Case Starts?

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Purpose: In 2006, Leitch et al. modified the Gartland classification to include type IV which has multidirectional instability. They are frequently more challenging to reduce. Previously, a diagnosis of multidirectional instability was only possible intraoperatively as no reliable preoperative radiographic markers have been previously identified to distinguish types III and IV SCH fractures. We hypothesize that there are radiographic markers that aid in diagnosis of multidirectionally-unstable supracondylar humerus fractures. Secondary objectives were to assess differences in operative times and other historical markers on presentation.

Methods: We retrospectively reviewed skeletally immature patients with operatively treated SCH fractures at two centers from 2008 to 2016. Multidirectionally-unstable (Type IV) fractures were defined intra-operatively by the surgeon. We matched these 2:1 with type III fractures, resulting in 67 type III and 33 type IV fractures. We analyzed patient demographics, neurovascular compromise, and preoperative radiographic markers including AP and lateral angulation and displacement of the distal fragment, diaphyseal extension of the fracture, and bony apposition between the proximal and distal fragment. Variables of interest were compared using Chi-squared test or Fisher's exact test where appropriate followed by multivariate analysis by logistic regression.

Results: Operative times were significantly longer (82.9 minutes versus 59.4 minutes, p=0.007) and open reduction occurred more frequently (12% versus 0%, p=0.01) in patients with type IV fractures compared to patients with type III fractures. On univariate analysis of radiographic findings [**Table 1**], all factors were found to be significantly different except presence of bony apposition of the proximal and distal fragment. On multivariate analysis, comminution was the only variable that was found to be significantly associated with type IV fracture (p=0.02). There were no significant differences in mean age, sex, weight, laterality of injury, operative procedure type, neurological or vascular complications, or patient comorbidities observed between types III and IV fractures.

Conclusion: Radiographic findings suggesting multidirectionally-unstable SCH fractures include comminution, extension of the fracture line into the diaphysis of the proximal segment, flexion of the distal fragment, and comminution. Factors found more commonly in type III fractures, but absent in type IV fractures, include medial translation and varus angulation of the distal fragment. Only comminution remains significantly associated with type IV fractures on multivariate analysis.

Significance: This study will improve preoperative evaluation of fractures to anticipate those which may pose additional treatment challenges.

Table 1. Univariate analysis of preoperative radiograph findings observed in 100 Patients with Type III or Type IV Supracondylar Humerus Fractures at two centers

	Type III	Type IV	p-value
Comminution with at least 1 substantial fragment	16.4%	40.6%	0.009*
Extension of fracture line into diaphysis	4.5%	21.2%	0.014*
Angulation of distal fragment relative to anterior humeral line			<0.0001*
Anterior	0.0%	32.3%	
Neutral	7.5%	19.4%	
Posterior	92.5%	48.4%	
Presence of bony apposition of proximal and distal fragments	65.7%	78.1%	0.21
Presence of varus or valgus angulation on AP radiograph			0.002*
Varus	58.1%	9.1%	
Neutral	53.0%	36.4%	
Valgus	19.7%	54.5%	
Translation of distal fragment on AP radiograph			0.01*
Medial	45.5%	15.2%	
Neutral	27.3%	36.4%	
Lateral	27.3%	48.5%	

* Denotes statistical significance

Outcome of Conservative versus Surgical Treatment of Humeral Shaft Fracture in Children and Adolescents: Comparison Between Nonoperative Treatment, External Fixation and Elastic Stable Intramedullary Nailing

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Purpose: The main objective of this study was to retro- spectively evaluate the clinical and radiographic outcomes of displaced humeral shaft fractures in children treated by Desault's bandage (DB), external fixation (EF), and elastic stable intramedullary nailing (ESIN).

Methods: 36 consecutive children with displaced humeral shaft fracture were treated by DB (Group A), EF (Group B) or ESIN (Group C). One year after the index surgery, patients were asked to answer the short version of the Disabilities of the Arm, Shoulder and Hand outcome questionnaire (Quick DASH).

Results: Ten patients (27.8%) were in Group A, 11 (30%) in Group B, and 15 (41.7%) in Group C. Mean age at the time of injury was 10.8 ± 2.3 years (range, 8 to 15.2 y), 11.7 ± 2.5 years 37 (range, 6.8 to 15.9 y), and 12.7 ± 2.2 years (range, 6.9 to 15.3 y) in Groups A, B, and C, respectively (P=0.08). Groups A, B and C did not differ significantly in their demographics (P > 0.05). Surgical treatment (Groups B and C) provided a better radiologic outcome than nonoperative treatment (Group A) (P = 0.05). No statistically significant differences were ob- served for preoperative, postoperative and at last follow-up mean displacement between Groups B and C (P > 0.05). Overall, 9 of 36 patients developed a complication. Mean Quick DASH score was 3 ± 8.6 (range, 0 to 27.3), 1.4±2.9 (range, 0 to 9), and 1.2±4.7 (range, 0 to 18.2) in Groups A, B, and C, respectively. All the patients were able to resume previous activities.

Conclusion: Surgery is not contraindicated in children with displaced humeral shaft fractures. EF and ESIN provide a better radiologic outcome, less post treatment pain and faster mobilization than DB. However, numerical differences, although statistically significant, were not clinically relevant for all variables but immobilization time. Nonoperative treatment was as efficacious as surgical treatment apart from the length of time for immobilization.

Significance: ESIN and EF are 2 safe and effective methods for humeral shaft fracture treatment in children. Each technique has its own advantages and disadvantages. EF allows earlier mobilization, but it can lead to unsightly scars. ESIN required postsurgical immobilization; however, it is characterized by a better esthetic appearance of scarring. If nonoperative treatment is chosen, close clinical and radiologic follow-up is mandatory due to the tendency of such injuries to displace. Nonoperative treatment was as efficacious as surgical treatment apart from the length of time for immobilization.

Trends in the Treatment of Femoral Fractures in Children and Adolescents

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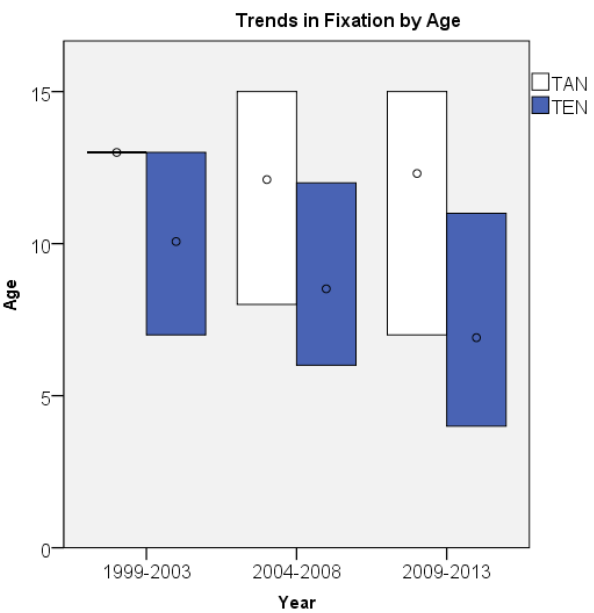
Purpose: Debate still exists regarding the safety of Trochanteric Anterograde Nails (TAN) fixation in femoral shaft fractures in children and adolescents. Increased deformity has also been noted with the use of Titanium Elastic Nails (TENs) in children over 50kg. At our institution there has been increasing surgeon preference for TAN fixation. The objectives of this study were to note evolving trends in our practice and evaluate the outcomes comparing each method of intramedullary fixation.

Methods: A retrospective review was performed of all femoral fractures treated at our referral Children's Hospital from November 1998 to June 2013. Pathological fractures were excluded. Results were analysed using SPSS 21. The study was approved by the local ethics committee.

Results: The study population consisted of 148 patients with 150 femoral shaft fractures, 95 of which underwent TENs fixation, and 55 of which underwent TAN fixation. Patients were predominantly male (77%) with a mean age was 12.2 (7-15) years for TAN and 8.4 (4-13) years for TENs fixation. The vast majority were closed (97.4%) and resulted from high energy injuries (57.3%). There has been a trend towards using both methods of fixation in younger age groups over the last 15 years.
Length of stay was affected by factors other than the femoral fracture in some cases, but was shorter in the TAN group. Malunion (defined as more than 10 degrees of angulation in the coronal or sagittal plane) was not different between the two groups. Zero% of TAN and 4.4% of TENs had coronal plane; and 7.3% of TAN and 14.7% of TENs resulting in sagittal plane deformity (p = 0.29 and p=0.20 respectively). Rotational deformity was found in 3.6% and 3.2% of TAN and TENs fixation respectively.
A clinically significant limb length discrepancy (≥2cm) occurred only following of TENs fixation in 3.2% of cases. All required epiphyseodesis. Hardware prominence requiring return to the operating theatre was equal in the two groups. There were no cases of avascular necrosis of the femoral head.



Conclusion: There has been a trend at our institution to use trochanteric entry nails in the second half of the study period without an increase in complications. Early mobilisation of these patients is possible and more secure fixation might be important in nursing multiply injured patients.

Significance: Modern trochanteric entry locking nails are safe and ef-

fective even in young patients. Future studies need to examine any possible negative effects on the growth of the greater trochanter.

Arthroscopically Assisted Reduction and Fixation with Cannulated Screws for Tibial Eminence Fracture in Skeletally Immature Patients

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Purpose: To evaluate efficacy and complications of arthroscopically assisted reduction and fixation with cannulated screws for tibial eminence fracture in skeletally immature patients.

Methods: The study design was a retrospective case series and the IRB was approved. Forty-eight patients who were skeletally immature at the time of tibial eminence fracture were treated in a tertiary children's hospital between May 2003 and Aug 2015. Twenty-one patients were excluded because of non-operative treatment (n=10), other surgical treatments (n=9), multiple fracture (n=1), and follow-up less than 1 year (n=1). Twenty-seven knees of 27 patients (19 boys and 8 girls) were the subjects of this study. Avulsed fragment was reduced arthroscopically and 2 to 3 cannulated screws (4mm or 5mm of diameter) were used for fixation. C-arm fluoroscopy was used to avoid iatrogenic physeal penetration. A long leg splint was applied for 3-4 weeks and then passive motion was started. Weight bearing was permitted 6 weeks after surgery. Clinical outcomes were evaluated with Lysholm score, instability of the knee based on physical examinations and KT-1000 arthrometer, and complications. Radiological outcomes were evaluated with leg length discrepancy, nonunion and malunion of the avulsed fragment.

Results: The mean age at the time of surgery was 10.1 years (6.2 to 13.8). Patients were followed for mean 3.9 years (1.0 to 7.6). Fracture type was type III (n=13), type II (n=12), and type IV (n=2) according to Zaricznyj modification of Meyers and McKeever classification. Meniscus was entrapped in 5 patients. Six patients showed concomitant meniscal tear. The mean Lysholm score at the final follow-up was 95 (78 to 100). Joint instability was not observed in all patients except one who showed a 5-10mm instability. All patients showed full range of knee motion except one who showed a 10 degree of flexion contracture. Screw head impingement against the femoral notch was observed in two patients during screw removal procedure that was performed routinely in all patients. The injured lower limb was longer than the contralateral normal side by mean 6.6 mm (-4 to 18). Five knees showed prominent tibial eminence without symptoms.

Conclusion: Arthroscopically assisted reduction and fixation with cannulated screw is a reliable surgical option with few complication in the treatment of tibial eminence fracture.

Significance: Two or three cannulated screw fixation provides sufficient immediate stability that enables early knee motion and thus rare development of arthrofibrosis in skeletally immature patients.

Comparing Treatment Recommendations based on the Anterior Humeral Line and Shaft-Condylar Angle for Posteriorly Hinged Supracondylar Humerus Fractures

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Purpose: The anterior humeral line (AHL) is a valid radiographic tool in assessing sagittal plane deformity in pediatric elbow injury, passing through the middle 1/3rd of the capitellum in 85% of normal pediatric elbows. We have found the AHL to be more reliable than the Gartland classification in assessing posteriorly hinged (non-Gartland Type 3) supracondylar humerus (SCH) fractures. The lateral humeral shaft condylar angle (SCA) has been used to assess SCH fracture extension. This study compares recommendations of an AHL-based protocol to those of the SCA-based protocol outlined by Spencer et al. (JPO 2012;32:675-681) for a retrospective group of posteriorly hinged SCH fractures, hypothesizing that the protocols would largely agree.

Methods: With IRB approval, 376 pediatric patients (<16yo) from 2012 with posteriorly hinged SCH fractures were identified. Elbow radiographs and records were reviewed for: 1) AHL index (on lateral radiograph, AHL0=passes anterior to the capitellum, AHL1=passes through anterior 1/3rd of the capitellum, AHL2=passes through middle 1/3rd of the capitellum), 2) SCA (on lateral radiograph, the angle between the humeral shaft and distal humeral condyle, nl=40), 3) Bauman's angle and 4) patient age. In both protocols, fractures with significant rotation or coronal deformity are treated operatively, but those factors were not evaluated here. In the AHL protocol, AHL0 fractures are treated with CRPP. In the SCA protocol, fractures with SCA<15° are treated with CRPP.

Results:

Anterior Humeral Line Index (AHL)		**Average Shaft Condylar Angle (SCA)**	**Recommended treatment**	**Agreement between protocols**
AHL 0	N=141	13.81° (SD=12)	CRPP	57%
AHL 1	N=133	25.80°(SD=7)	Non-operative	94%
AHL 2	N=102	33.24°(SD=7.5)	Non-operative	99%

The protocols agreed on average. However, in 43% of AHL0 (AHL anterior to capitellum), SCA was >15° and therefore the SCA protocol would **not** recommend CRPP. 70% of chidren <2yo with AHL0 had SCA >15°. If CRPP was recommended when the SCA<30° (10° extension), the recommendations for AHL0 would only differ 8% between protocols. In 6% of AHL1 and 1% of AHL2, the SCA <15° (SCA protocol would recommend CRPP). No significant differences in Bauman's angle between AHL groups.

Conclusion: The AHL and SCA protocols agree well on non-operative treatment in fractures where the AHL passes through the anterior or middle 1/3rd of the capitellum, but the AHL protocol is more likely to recommend CRPP for fractures where the AHL passes anterior to the capitellum.

Significance: These protocols should help with standardizing treatment for posteriorly hinged SCH fractures, but how much extension is acceptable needs further clarification.

Factors Associated with Patients Transferred to a Level 1 Pediatric Trauma Center with Orthopaedic Injuries

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Purpose: Pediatric patients account for one-fourth of emergency department (ED) visits in the United States, with two percent (510,353) being transferred to another ED. It has been shown that adult transfers are associated with insurance status. The primary aim of this study was to assess if transfer to a Level 1 pediatric ED was warranted based on injury complexity. The secondary aim was to elucidate which factors were associated with transfer.

Methods: After IRB-approval, the charts of patients aged 0-17 with orthopaedic injuries transferred to a Level 1 pediatric ED between July 2012 and April 2014 were reviewed for demographics, clinical factors, and service delivery factors. Transfers were compared to primary presenters (PPs) who required an orthopaedic consult in the pediatric ED during the same time period. The main outcome measure was rationale for transfer, categorized as high or low complexity. High complexity injuries were those requiring operative management, sedation, or closed reduction with casting, while low complexity were those treated with non-operative management without reduction or sedation.

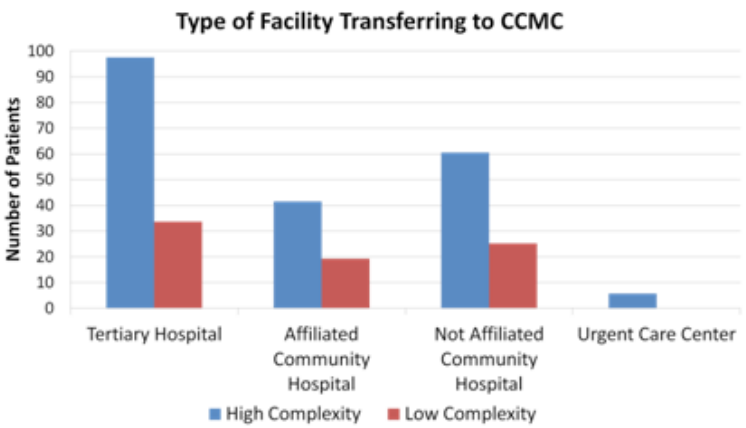
Results: Data for 1436 patients, 286 transfers and 1150 PPs, were analyzed. 205 (72%) transfers had high complexity injuries. Transfers experienced higher admission rates (n=194; 68%) than PPs (n= 288; 25%, p=0.0001). Compared to PPs, transfers were more likely to have a longer LOS (66.1% vs. 24.2% had LOS >12 hrs, p=0.0001), arrive in the evening (57.3% vs. 39.9%) or overnight (21.3% vs. 4.1% p=0.0001), and be admitted (67.8% vs. 24.7%, p=0.0001). Transfers and PPs had similar rates of private insurance (61.5% and 58.5%, respectively). There were also no significant differences in age, gender, or presentation day. The transfers all came from facilities that had an on-call attending orthopaedic surgeon, but only 37% had an in-house resident. 46% of transfers came from tertiary hospitals, while the remaining 54% were from community hospitals.

Conclusion: 81 (28%) transfers presented with low complexity injuries that could have been managed in the original facility and sent for follow-up as an outpatient, which may be attributable to the discomfort adult orthopaedic surgeons have with treating pediatric trauma. Approximately half of transfers came from tertiary referral centers. In contrast to findings in the adult literature, insurance status was similar in both groups.

Significance: Most pediatric orthopaedic trauma transfers have high complexity injuries requiring pediatric expertise. However, a substantial amount do not warrant transfer and represent a societal cost that could be avoided with better communication between transferring and receiving facilities and physicians.

Characteristics	Transfers (n = 286)	Primary Presenters (n = 1,150)	P-value
Age (years) mean ± SD	8.1 ± 4.6	8.7 ± 4.8	0.107
Gender			0.0732
Male	66.8%	61.0%	
Insurance Type			0.353
Private	61.5%	58.5%	
Not private	38.5%	41.5%	
LOS			**0.0001**
<12 hours	33.9%	75.8%	
12-24 hours	30.8%	8.2%	
25-48 hours	16.1%	6.6%	
>48 hours	19.2%	9.4%	
Day of the week			0.9699
Weekday	57.0%	56.9%	
Weekend	43.0%	43.1%	
Time of Day			**0.0001**
Morning (6a-12p)	2.8%	13.1%	
Afternoon (12p-6p)	18.5%	42.8%	
Evening (6p-12a)	57.3%	39.9%	
Overnight (12a-6a)	21.3%	4.2%	
Injury Type			**0.0001**
Infection	4.6%	5.9%	
Tumor	0.7%	0.5%	
Pain in limb/sprain	3.9%	12.5%	
Upper extremity fracture/dislocation	50.9%	56.0%	
Lower extremity fracture/dislocation	37.5%	23.1%	
Head, neck, pelvis fracture/injury	2.5%	2.0%	
Admitted			**0.0001**
Yes	67.8%	24.7%	
Complexity			**0.0001**
Low	27.6	51.3	
High	72.4	48.7	

Characteristics of patients and health service delivery factors for high and low complexity procedures for inter-facility pediatric orthopaedic trauma transfers



Distribution of Facility Transfers to CCMC

Flexible Intramedullary Nailing of Pediatric Femur Fractures Results in Less Pain than Submuscular Plating

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Purpose: AAOS clinical practice guidelines indicate flexible intramedullary nailing (FIN) to treat pediatric femur fractures, although open plating (OP) or submuscular plating (SMP) are viable options. The purpose of this study was to compare both subjective and objective pain measurements in pediatric femur fractures treated with FIN, OP, or SMP both after initial fixation and elective removal of hardware (ROH). We hypothesized that lower pain measurements would be demonstrated in the SMP group due to its minimal incision and initial stability.

Methods: An IRB-approved, retrospective review of pediatric femur fractures treated with FIN, OP, or SMP between 2004 and 2014 was performed. Data included demographics, injury, surgical, pre-operative visual analog scale (VAS), post-operative VAS, as-needed inpatient narcotic use, and whether additional narcotics were required at follow-up. Additionally surgical data, inpatient narcotic use, and need for follow up narcotics were recorded for the elective ROH. Variables were compared between the fixation techniques using chi-squared, paired t-tests, Fisher's exact test, or ANOVA as appropriate.

Results: 145 fractures in 140 patients were included. FIN was utilized most frequently (89/145=61%) followed by SMP (37/145=26%) and OP (19/145=13%). Elective ROH occurred in 76/89 FIN, 29/37 SMP, and 17/19 OP. No statistical difference existed between demographics or injury data. EBL was greater for OP v. FIN (115.2 v. 36.2 mL, $p<0.01$) and SMP v. FIN (76.4 v. 36.2mL, $p=0.03$). Operative time was less in FIN v. OP (95 v. 147.2min, $p=0.01$) and FIN v. SMP (95 v. 138.5min, $p<0.01$). VAS was not significant between FIN v. OP, FIN v. SMP, or OP v. SMP. However, the FIN group used significantly less narcotics than the SMP group ($p = 0.011$). At elective ROH, EBL was greater for OP v. FIN (40.5 v. 11mL, $p < 0.001$) and SMP (47.1 v. 11mL, $p < 0.001$). Operative time for FIN was lower than OP (43.9 vs 70.2min, $p < 0.001$) or SMP (43.9 vs 76.9min, $p < 0.001$). Narcotic use and need for further analgesics at follow up was not significant.

Conclusion: Pediatric FIN fixation is a less painful procedure indicated by a decreased consumption of narcotics compared to SMP fixation. EBL and operative time were also less with FIN at the index and ROH surgeries.

Significance: To our knowledge, this is the first study to address the differences in pain in pediatric femur fractures between FIN and plating techniques, with FIN requiring less pain medication.

Nonoperative Management of Pediatric Grade 1 Open Fractures

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Purpose: The purpose of this study was to evaluate the results of nonoperative management of pediatric grade 1 open fractures treated either in the emergency room only or as an inpatient with a less than 24-hour admission.

Methods: A retrospective chart review was performed on all patients from 2000-2015 at our institution. Inclusion in our study required patients identified to have Gustilo and Anderson grade I open fractures who were treated with antibiotics and closed reduction and casting in the emergency room or were admitted for no more than 24 hours for administration of intravenously administered antibiotics. Our population included 83 patients who were followed up until healing was confirmed clinically and radiographically.

Results: One patient with persistent serosanguineous drainage from the wound site and fever was admitted for 48 hours of intravenously administered antibiotics for presumed infection. That patient went on to heal both clinically and radiographically without further complication. 6 patients underwent open reduction and internal fixation for loss of reduction. Of these 6 patients none had clinical signs of infection prior to surgery. One of these 6 operative patients developed persistent drainage from their incision and was placed on a course of oral antibiotics without further complication. Our overall infection rate was 2.4%.

Conclusion: This study demonstrates the safe non-operative treatment of grade 1 open fractures in our pediatric population. This eliminates possible risks of anesthesia as well as significantly decreases the cost of caring for these patients as inpatients without increasing risk to patients.

Significance: Our treatments protocol greatly decreases the hospital and social costs associated with treating these fractures operatively. Furthermore it eliminates anesthesia and operative risks. We feel that the vast majority of pediatric grade 1 open fractures can be treated this way. We have done this for years at our institution with excellent results.

Occult Pelvic Fractures in CT Scans of Injured Children Attending a Major Trauma Centre in the United Kingdom

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Purpose: It is becoming routine for children with serious injuries to receive a CT scan as part of initial assessment. We have noticed that CT scans are also revealing minor pelvic injuries that have unknown clinical significance.

Methods: All children (<16yr) presenting to the Cambridge Major Trauma Centre from January 2012 to December 2014, Injury Severity Scores (ISS) >4 were assessed.
150 children were identified, 96 boys and 54 girls, mean age 7.8yr (range0-16yr); of these 62 (41%) children had CT scans of their pelvis. 24 children had standard AP pelvis radiographs. 62 children had no pelvic imaging.
Two consultant orthopaedic surgeons examined the CT scans using a standardised protocol. A consultant radiologist then verified findings.

Results: Nine children had known, obvious, pelvic fractures, 8 girls and 1 boy, mean age 8.9yr (range2-14yr), mean ISS-23.9 (range8-50), 2 children died. Only one child had an isolated pelvic fracture – this was the only child not involved in a motor vehicle accident.
14 children with 'occult' fractures were identified, 6 girls and 8 boys, mean age 14.3yr (range6-15yr), mean ISS-20.4 (range9-50). Only one child had an isolated pelvic fracture, 12 children were involved in motor vehicle accidents and two had falls <2m. 9 children had asymmetrical sacroiliac joint widening, 2 children had unicortical pubic ramus fractures, 2 children had undisplaced sacral unicortical fractures and 1 child had an undisplaced acetabular fracture. 12/14 children in the occult fracture group (SI joint asymmetry) were wearing pelvic binders at time of CT scan.

Conclusion: The incidence of known pelvic fractures is 6% of major paediatric trauma, this reflects published findings elsewhere. We have found a higher incidence in girls.
Known pelvic fractures are associated with significant accompanying injuries.
The discovery of occult fractures brings the incidence of pelvic fractures higher – 15%.
The occult fracture group are a little older than the known pelvic fracture group but the Injury Severity Scores are similar.
Retrospective examination of the medical notes reveals no pelvic morbidity in the occult group but this was not directly assessed at time of injury.

Significance: Most 'occult' injuries involve asymmetric sacroiliac joint widening which is uncommon in the general uninjured population. However the contribution of the pelvic binder is unknown.
Mechanism of trauma and associated injuries are similar in the 'known' and 'occult' groups.
We recommend careful pelvic examination in children with ISS>15.
The clinical significance of occult pelvic injury is unknown and merits further study.

Risk Factors of Fractures in Children with Multiple Disabilities

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Purpose: Fractures are a common problem among children with multiple disabilities. The mechanism of these fractures is substantially non-traumatic. In the literature, several studies tried to evaluate risk factors of fractures in children with cerebral palsy and other disabilities, but no projects on those with multiple disabilities. And so far, these risk factors are still not well defined even in the above populations. The aim of this study is to assess the fractures' risk factors, to evaluate the severity of each risk, and to propose guidelines for adequate preventive treatment in this population.

Methods: It is an epidemiological, cross-sectional, observational, analytical study realized in two center care facilities, based on a sample of 75 children with multiple disabilities aged between 3 and 18 year old. Data collection focused on gender, age, weight, height, Body Mass Index, diagnosis, type of the disability, gastrostomy, antiepileptic drugs, stunted growth, previous fractures, and socio-economic status.

Results: The bivariate analysis showed an association between non-traumatic fractures and the following variables: the administration of valproic acid (p=0.026), the combination of three or more antiepileptic drugs (p=0.033), the presence of a gastrostomy tube (p=0.010), stunted growth (p=0.0001), previous fractures (p=0.0001), and advanced age (p=0.033). Multivariate analysis showed that the presence of a gastrostomy catheter increases 5.3 times the risk of sustaining non-traumatic fractures (Exp B=5.37) (P=0.036). While stunted growth, increases 7.4 times this risk (Exp B=7.48) (P=0.001).

Conclusion: Valproic acid and/or three or more antiepileptic drugs, increases the risk of fracture, because of their negative impact on the metabolism of vitamin D and bone mineralization. The presence of a gastrostomy tube, and/or stunted growth, represents a state of malnutrition and chronic hormonal disorder. Patients with a history of fracture are victims of post therapeutic immobility, and of osteoporosis due to a reduced mobility, on top of low mobility status at baseline. Older children are also at an increased risk, due to inadequate bone mineralization, mostly needed during adolescence.

Significance: The prevention of fractures in these patients is imperative. This must be based on, a more aggressive indications of gastrostomy; a treatment with vitamin D and Calcium for all patients treated with valproic acid, or with 3 or more antiepileptic drugs, or with stunted growth; and a close monitoring of patients that have previous fractures or aged between 12 and 14 year-old.

The Effect of Canal Fill on Pediatric Femur Fractures Treated with Titanium Elastic Nails

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Purpose: In treatment of pediatric femur fractures, traditional teaching recommends 80% canal fill for successful maintenance of reduction. Prior studies have investigated this with stainless steel Enders nails. However, this has not been studied in the use of flexible titanium elastic nails (TEN). Our purpose was to assess the impact of canal fill on maintenance of reduction and rate of malunion in pediatric femur fractures treated with TEN.

Methods: Retrospective data was collected on all pediatric patients treated with TEN for diaphyseal femur fractures at a single tertiary care institution over a ten year period. Patients with co-morbidities such as osteogenesis imperfecta, mucopolysaccaridoses, and dwarfism were excluded. Patients were subdivided into groups based on percent canal fill. Fractures were considered malunited if limb length discrepancy was >2 cm, angulation in the sagittal plane (anterior/posterior) was >15°, or coronal angulation (varus/valgus) was >10°.

Results: There were 66 patients who met the inclusion criteria; mean age at time of injury was 6.6 years old (range 1.8 to 17.7). Of these 66 patients, 2 patients had less than 40% canal fill (group A); 4 patients had 40-60% canal fill (group B); 25 patients had 60-80% canal fill (group C) and 35 patients had 80-100% canal fill (group D). The shortening was as follows in the groups: A= 5.5 mm; B= 6.5 mm; C= 7.7 mm; D= 4.6 mm. There was no correlation between percent canal fill and shortening (p=0.32). The angulation in the sagittal plane was as follows in the groups: A= 0 degrees; B= 0 degrees; C= 3.9 degrees; D= 4.6 degrees. There was no correlation between percent canal fill and angulation in the sagittal plane (p= 0.26). The coronal angulation was as follows in the groups: A= 4 degrees; B= -1.5 degrees; C= -1.7 degrees; D= -0.4 degrees. There was no correlation between percent canal fill and coronal angulation (p= 0.28) amongst the subjects, three patients fit malunion criteria. Percent canal fill for these patients were 40%, 67%, and 79%.

Conclusion: There was no correlation between percentage canal fill and shortening or malangulation. The majority of patients in this series with less than 80% fill with TEN healed within acceptable parameters.

Significance: Increased canal fill did not significantly correlate with maintenance of optimal reductions when using TEN for pediatric femur fractures.

Pediatric and Adolescent Clavicle Nonunions: Potential Risk Factors and Surgical Management

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Purpose: Clavicle nonunions in pediatric patients are exceedingly rare, with less than 10 cases having been reported in the literature. The purpose of this study was to evaluate a series of clavicle nonunions from a pediatric multicenter clavicle study group to assess potential risk factors and treatment options.

Methods: A retrospective review of pediatric clavicle nonunions was performed from 9 high volume pediatric hospitals. Demographic and injury data was documented, including patient age, gender, skeletal maturity, mechanism of injury, sports participation, and initial management. Radiographs were evaluated for initial fracture classification, displacement, shortening, and angulation as well as nonunion type. Surgical data was recorded including stabilization technique, utilization of bone graft, plate placement, and screw configuration. Patient outcomes were evaluated including healing, time to union, return to sports, and complications.

Results: A total of 26 nonunions were identified with a mean age of 15.2 years (range 10 to 18 years). The majority of nonunions occurred in male patients (75%) with open growth plates (70%), and were sustained while playing sports (79%). The mean end-to-end shortening of the original fractures was 20 mm and 82% were completely displaced. 35% of the nonunions occurred after a clavicle refracture and 15% had undergone previous surgical stabilization. All patients subsequently underwent surgery with 92% being managed with plate fixation and 8% with an intramedullary device. Local bone graft was utilized in 60% of cases, iliac crest in 20%, and allograft in 15%. Complete radiographic healing was achieved in 92% of cases at a mean time of 12.9 weeks after surgery for the non-union. No significant ROM deficits were identified and no intra-operative or post-operative complications were documented.

Conclusion: 26 pediatric clavicle nonunions were identified from 9 different hospitals essentially tripling the reported cases in the literature. Healing of the non-union can be reproducibly achieved with plate fixation and the utilization of either local or iliac crest bone graft.

Significance: While uncommon, clavicle nonunions do occur in the pediatric and adolescent population. Whereas, the majority of nonunions occur in older adolescent boys with with completely displaced fractures, it is important to note that a fifth of the nonunions occurred in fractures that were not completely displaced. Surgical fixation is not a fail-safe to guard against nonunion, as a sixth of the children with nonunions were initially treated with surgery. Regardless of initial treatment, children with clavicle fractures should be followed until radiographic union is achieved.

Severity of Lateral Spurring Predictive of Cubitus Varus Deformity after Pediatric Humerus Lateral Condyle Fractures

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Purpose: Numerous studies have suggested that lateral spurring may contribute to decreased carrying angle or cubitus varus after pediatric lateral humeral condyle fractures (PLHCF). However, the correlation between these two deformities is unknown, and no standard method for evaluating the severity of lateral spurring has been established. We developed a modified method for evaluating the severity of lateral spurring and analyzed the cause and clinical implications of this phenomenon.

Methods: We retrospectively evaluated the elbows of 42 patients who received open reduction and internal fixation for PLHCF at our institution between 2004 and 2012. Lateral spurring severity after operation was evaluated by determining the delta lateral spurring ratio (DLSR), which represents the difference between the initial and follow-up ratios of the maximal interepicondylar width to the minimal humerus diaphysis width of the anteroposterior aspect of the elbow. We used the receiver operating characteristic (ROC) curve to assess the predictive discrimination of the DLSR at different time point for final cubital varus. Descriptive and parametric statistical analyses were used to evaluate the data.

Results: The optimal cut-off point for predicting final cubitus varus was DLSR at four months after surgery more than 0.351, exhibited 77.8% sensitivity, 80.0% specificity, and 78.6% accuracy. According to this cut-off point, 24 patients were assigned to a high-spurring group(DLSR > 0.351), and 18 patients were assigned to a low-spurring group(DLSR ≤ 0.351). A higher percentage of patients exhibited good to excellent results (according to the Dhillon scoring system) in the low-spurring group (83.3%) than in the high-spurring group (54.2%); however, this difference was not significant (p= .057). The age (p = .176), sex (p = .073), Jakob-Skaggs classification (p = 1.000), time to fixation (within two week or not) (p = .4), initial displacement (p= .086), and use of screws (p = .086) did not differ significantly between the two groups.

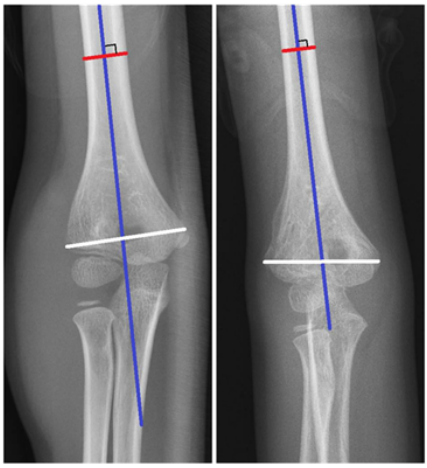
Conclusion: We proposed a new method for evaluating lateral spurring after PLHCF; this method can minimize the effect of elbow rotation and normal bone growth. Although lateral spurring does not affect the functional outcome for most patients, it may increase the risk of developing cubitus varus after PLHCF.

Significance: Patients with the DLSR four months after surgery more than 0.351 should be aware of further development of significant cubitus varus appearance.

Table 1. Comparison of differences and correlations between 2 groups

	Low-spurring group (*n* = 18)(%)	High-spurring group (*n* = 24)(%)	*p*
Male: Female	12 (66.7): 6 (33.3)	11 (45.8): 13(54.2)	.179
Age (years/old)	6.44	4.79	.073
Initial displacement (mm)	7.0	5.1	.086
Jakob classification II:III	1 (5.6): 17 (94.44)	2 (8.3): 22 (91.7)	1#
Time to fixation			
＜2 wk	14 (77.8)	14 (58.3)	.321#
≧2 wk	4 (22.2)	10 (41.7)	
Screw			
Yes	4 (22.2)	5 (20.8)	1#
No	14 (77.8)	19 (79.2)	
Union rate (%)	100	100	
HUA(°)	6.37	-1.03	.001
ROM(°)	135	133	.59
Dhillon score			
Pain	3	3	1
ROM	2.3	2.3	1
Carrying angle	2.06	1.42	.007
Total score	7.39	6.75	.022
Result (n)			
Good–Excellent	15	13	
Fair	3	11	.057#
Poor	0	0	
Complication	0	0	

Fisher exact test



A B

The white line is the interepicondylar width (IEW), which was defined as the maximal distance between the medial epicondyle and lateral epicondyle of the humerus. The red line is the humerus width (HW), which was defined as the smallest width of the humerus diaphysis perpendicular to the axis of the humerus as observed through an AP view of the elbow. The difference between the preoperative (a) and follow-up (b) IEW-to-HW ratios was defined as the delta lateral spurring ratio(DLSR).

Biomechanical Assessment of Torsional Stiffness after Pinning of Pediatric Supracondylar Humerus Fractures

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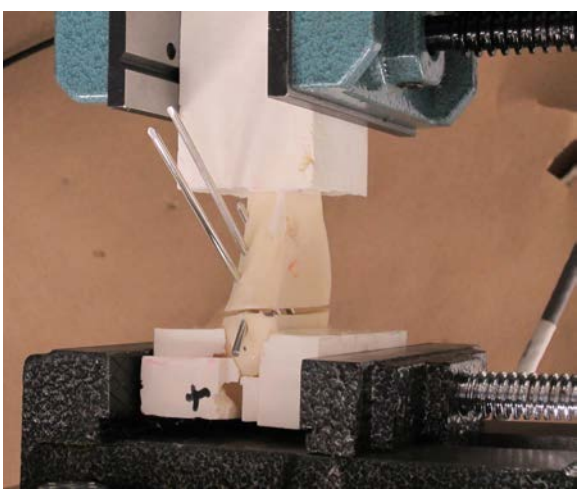
Purpose: We sought to assess torsional stability of various pin diameters and pin configurations in a biomechanical supracondylar humerus fracture model.

Methods: Using a novel design of standardized, 3-D printed models of the distal humerus in 5 different pin configurations, we measured the force needed to deflect the fracture by 10 degrees in internal and 10 degrees in external rotation. After an osteotomy of the model and pin placement, the proximal segments were potted into a resin, the distal segments were clamped, and testing was performed on a MTS machine. Three models had anterior-to-posterior sagittal pins but differed in the lateral pin coronal plane to be 3 divergent, 3 parallel, or 3 convergent. Two other models were divergent in the coronal plane, but either neutral or posterior –to-anterior in the sagittal plane. Each model had a medial to lateral pin, thus each model had 4 pins placed. We tested these same configurations with 1.6, 2.0, and 2.4 diameter pins to assess the contribution of pin diameter to stability. We then sequentially removed pins and retested the specimens to determine the loss of stability by fewer pins. We created and tested 3 models for each configuration and pin diameter.

Results: In all models and configurations, the 2.4 pin diameter was statistically stiffer than the 1.6 diameter pins; however, this lost statistical significance in certain patterns when comparing 2.0 and 2.4 wires. When comparing a divergent to a parallel configuration in the coronal plane, there was no difference in stability when pin diameter or pin number was controlled; however, the convergent pin configuration was in general the least stable. The use of a medial pin conferred statistically significant stiffness throughout most models as demonstrated with pin deletion. The use of 2 pins was significantly less stiff than most of the 3 pin models.

Conclusion: Larger pin diameters confer greater stiffness among all pin patterns. The use of 3 lateral and 1 medial pin was not statistically different than 2 lateral and 1 medial pin in our models; however, both patterns were stiffer than 3 lateral pins only or other fewer pin constructs.



Significance: With reproducible biomechanical models, the use of 2 lateral and 1 medial pin creates a stiff construct. Larger diameter pins can increase this stiffness; however, the clinical utility might be limited once pins greater than 2.0 in diameter are used.

Evaluation of Intramedullary Fixation for Pediatric Femoral Shaft Fractures in Developing Countries

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Purpose: The Surgical Implant Generation Network (SIGN) intramedullary nails have been shown to be a safe and cost-effective method to treat adult long bone fractures in resource-poor settings. The purpose of this study is to report the clinical results and complications following treatment of pediatric femoral shaft fractures with both the SIGN pediatric and standard fin nails.

Methods: The SIGN online surgical database (SOSD) was used to identify all patients 18 years or younger who sustained an isolated femoral shaft fracture treated with an antegrade intramedullary device. One hundred and twelve patients were retrospectively evaluated from sixteen countries with a minimum follow-up of two months. Fifty-seven patients were treated with the pediatric fin nail and 55 patients with the standard fin nail. Patient demographics, injury characteristics, surgical details, and complications were collected. Radiographs were used for classification, evidence of healing, and callus index. Isthmus to nail ratio and fracture bypass distance were measured to evaluate for appropriate fit. Presence of painless weight bearing and infections were collected.

Results: The mean age of the pediatric fin patients was 9.4 (4 to 15) versus 11.2 years (4 to 18) for the standard fin patients. Fractures were typically mid-shaft (59.7%, 54.5%). All were closed except for one Gustilo I fracture in the pediatric fin group. The majority required an open reduction (79.0%, 67.3%). The mean follow-up was 286.3 (60-1070) and 214.8 days (60-1567). There were no post-operative infections. Overall, 95% of patients achieved painless weight bearing at the last follow-up. In total, 23 patients had repeat surgery for removal of hardware. Failure of hardware with bending of the nail and/or a valgus or varus deformity (>10 degrees) was noted in 3.2% (1) of the pediatric

9 year old female (Philippines) treated with Pediatric Fin Nail

10 year old female (Mongolia) treated with Standard Fin Nail

fin patients <10 years of age and 23% (6) of patients 10 years or older. Five of these seven patients were classified as technical errors attributed to inadequate nail diameter, length, or initial mal-reduction. No complications were noted in the standard fin nail group.

Conclusion: In resource-poor settings that lack intra-operative fluoroscopic imaging and power reaming, rigid nailing with the SIGN pediatric fin and standard fin nails appear to be an effective treatment option for femoral shaft fractures. In patients older than 10 years, the surgeon should consider using the standard fin nail for improved stability and to minimize potential complications.

Significance: Both the SIGN pediatric and standard fin nails appear to be an effective treatment option for pediatric femoral shaft fractures.

Fracture Displacement and Neurological Injury in Pediatric Supracondylar Humerus Fractures

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Purpose: Supracondylar humerus fractures (SCH) are a common injury in children and resultant neuropraxia is a well-described complication. Increased age and obesity have been associated with higher rates of neuropraxia. This retrospective study examines both the relationship between patient factors (age and weight), as well as injury-specific factors and neuropraxia after fracture.

Methods: Retrospective data was collected on 400 patients who were treated operatively for SCH fractures. Age, gender, weight, mechanism of injury, pre- and post-operative neurologic and vascular status, and time to neuropraxia resolution were extracted from the medical records.

Results: 11% of patients had a documented pre-operative neuropraxia. There were no significant differences between patients with or without preoperative nerve palsy with respect to age, gender or weight for age percentile. In patients with neuropraxia, the anterior interosseous nerve (AIN) was injured in 67% of cases and was associated with displacement in the posterolateral direction. Second most common neuropraxia was of the posterior interosseous nerve (PIN) injury which was associated with posteromedial fracture displacement. The ulnar nerve was least likely injured and all these fractures were displaced anteriomedially. At last follow-up, 86% of patients demonstrated neurologic improvement.

Conclusion: The incidence of neuropraxia was not associated with age, gender or weight for age percentile. In patients sustaining a neuropraxia, the AIN was most commonly injured due to posterolateral displacement, the PIN with posteromedial displacement, and the ulnar nerve was injured more with anteriomedially displaced fractures. The majority of

Comparison of demographic and injury characteristics by presence of Pre-Op Nerve Palsy

Characteristic	Pre-Op Nerve Palsy	No Pre-Op Nerve Palsy	p-value
N	43	357	
Mean Age (SD)	5.9 (1.85)	5.6 (2.65)	0.3439
Male (%)	23 (53.5)	194 (54.3)	0.9155
Mean Weight Kg (SD)	25.0 (7.89)	23.9 (9.62)	0.4987
Injury			
Gartland score (%)			<0.0001[FX]
2	0 -	106 (29.6)	
3	43 (100)	251 (70.3)	
Direction of displacement			0.0012[FX]
Anterior lateral	0 (-)	8 (2.2)	
Anterior medial	1 (2.4)	4 (1.2)	
Anterior	0 (-)	3 (0.8)	
Lateral	0 (-)	1 (0.3)	
Medial	0 (-)	5 (1.4)	
Posterior lateral	20 (46.5)	100 (28.0)	
Posterior medial	16 (37.2)	72 (20.2)	
Posterior	6 (14.0)	164 (45.9)	
Perfect fixation vs imperfect reduction (%)			0.0048
Perfect	27 (62.8)	290 (81.2)	
Imperfect	16 (37.2)	67 (37.2)	

patients recovered nerve function.

Significance: This paper found no patient risk factors that affected neuropraxia rate which is contrast to prior, smaller, studies. This opens avenues to continued research. Additionally, it details fracture displacement and correlates it to nerve injury in a way that has not been done prior

Improved Outcomes after Surgical Treatment of Displaced Salter-Harris II Physeal Fractures of the Distal Tibia

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Purpose: The purpose of this study was to compare the outcomes of operative and nonoperative treatment of Salter-Harris (SH) II distal tibial fractures with residual gap of >3 mm. The factors that may be associated with the incidence of premature physeal closure (PPC) were analyzed.

Methods: We retrospectively reviewed 96 patients who were treated for SH II distal tibial fractures with residual gap of >3 mm. Patients were assigned to one of two groups: Group 1 (*n*=26) included patients with operative treatment, Group 2 (*n*=70) included patients with nonoperative treatment. Additioanlly, we created Group 2A to control for the amount of residual displacement in Group 2 patients due to potential bias arising from the surgeon's preference for fixation procedure. All patients were followed for >12 months after surgery, with a mean follow-up time of 20.4 months. Comparisons were performed to determine if the incidence of PPC differed significantly among the three groups (Groups 1, 2, and 2A). Several demographic and surgical variables were considered as possible factors that could be related to the occurrence of PPC. These factors included (1) age, (2) gender, (3) mechanism of injury, (4) presence of fibula fracture, (5) amount of initial displacement, (6) amount of residual displacement, (7) method of treatment, and (8) type of implant type. Correlation analyses were performed to determine if the occurrence of PPC was significantly correlated with these demographic factors and surgical variables.

Results: The incidence of PPC in patients who received nonoperative treatment was 61.5%, whereas PPC incidence in patients who received operative treatment was 35.7%. Multivariate logistic regression analysis determined that significant risk factors for the occurrence of PPC were nonoperative treatment (odds ratio, 2.820; *p*=0.049) and pronation-external rotation injury (odds ratio, 8.862; *p*=0.019). Age at injury, gender, presence of fibula fracture, initial and residual displacements, and implant type were not predictive factors for the occurrence of PPC.

Conclusion: Although operative treatment for displaced SH II distal tibial fractures leads to relatively higher incidence of PPC, it is more effective than nonoperative treatment. We recommend anatomical reduction and removal of interposed tissue to reduce the risk of PPC in patients with SH II distal tibial fractures with residual gap of >3 mm.

Significance: we recommend surgical treatment for displaced SH II distal tibial physeal fractures with residual gap of >3 mm in relatively young patients who are still undergoing significant growth.

Operative Methods of Pediatric Femoral Fractures in Five to Ten Years Olds: Case Matched Comparison between Flexible Intramedullary Nailing and Submuscular Plating

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Purpose: Although flexible intramedualllry nails (FIN) are currently the standard operative option for femoral shaft fractures in school age, fractures in the proximal and distal third of the femur, and length-unstable fractures, are known to have higher risk of complications with FIN. With a help of locking plates, submuscular plating (SP) has been a minimal invasive alternative. However, there have been no studies comparing FIN and SP of pediatric femur fractures. The purpose of the current study was to retrospectively compare the outcomes and complications of FIN and SP of femur fractures in children from age 5 to 10.

Methods: In a retrospective case-matched series assembled from 99 patients of age from 5 to 10 years, treated with FIN or SP, we matched 38 patients (19 pairs) according to the following criteria: 1) length-stability according to the fracture pattern (14 length-stable, and 5 length-unstable pairs); 2) fracture location (8 location-stable and 11 location-unstable pairs); 3) weight and/or body mass index; 4) patient's age at the operation. The outcome was evaluated using the union, alignment, postoperative complications and outcome scores. A major complication was defined as any complication that remained after treatment. Minor complications were defined as complications that resolved with nonoperative treatment or did not require any treatment.

Results: The mean age was 7 years. All (except one nonunion in SP) achieved the union at mean 11.9 weeks in FIN and 12.6 weeks in SP ($P > 0.05$). There were 3 malunions (2 length-stable and 1 length-unstable) in FIN and none in SP. The FIN showed 5 postoperative complications (4 distal migration of nail, 1 infection) which were all length or location-unstable, but the SP showed none. Outcome scores were significantly better in SP group ($P < 0.05$). The excellent or satisfactory was 11 (57.9%) in FIN and 18 (94.8%) in SP.

Conclusion: Although both FIN and SP showed a satisfactory bony healing as well as functional results, complication rate was higher in FIN. In length-unstable or location-unstable fractures, SP may have a better result in terms of alignment and implant related issues.

Significance: This study retrospectively compare the outcomes and complications of FIN and SP of femur fractures in children from age 5 to 10.

Hoverboards: How the Grinch Stole Christmas

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Purpose: The "hoverboard" is a battery-powered, hands-free, horizontal, two-wheeled device. Currently, there is no public information regarding the orthopaedic injuries associated with these boards. Our study aim is to present an account of hoverboard-related injuries based on patients seen at one high-volume pediatric hospital.

Methods: A retrospective review of fractures that occurred due to hoverboard falls from 4 months before to 4 months after Christmas were identified. Data regarding demographics and the nature of the fractures was collected and analyzed for trends.

Results: 44 children met inclusion criteria. Mean age was 11 years (range 7-17), 68% were male. 82% of fractures involved the upper extremity. 32% of fractures required reduction and 7% required surgical fixation. Distal both bone fractures (32%) and distal radius fractures (27%) were the most common fracture pattern (table 1). 41% of fractures presented in the 3 weeks surrounding Christmas (December 18-January 7), and these numbers steadily decreased in the weeks following Christmas. 7% of fractures occurred in the 3 weeks prior to December 18 and none occurred before this time point.

Conclusion: Patients with hoverboard-related orthopedic injuries have become commonplace within our high-volume pediatric emergency department and orthopedic clinic, and we would like to place an emphasis on the needs for increased awareness and better utilization of safety precautions with hoverboards. Our data shows a high number of hoverboard injuries with a male predominance with wrist injuries. A correlation to Christmas based on timing of injuries appeared to be present. We recommend safety gear including wrist guards, helmets, elbow and kneepads for hoverboard-riders due to the high volume of orthopaedic injuries.

Significance: With the safety of the hoverboard in question, this is the first review of orthopaedic injuries. This is also the first study that has linked fracture rate to Christmas. We have shown the hoverboard to be associated with many fractures, especially of the wrist, and for these injuries to be associated with winter holiday season. This emphasizes the need of safety equipment when using these devices.

Fractures (N=44)	Number (%)
Upper Extremity	36 (82%)
Distal Forearm Both Bone	14 (32%)
Distal Radius	12 (27%)
Phalangeal	3 (7%)
Proximal Humerus	2 (5%)
Supracondylar Humerus	2 (2%)
Carpal	1 (2%)
Radial Neck	1 (2%)
Clavicle	1 (2%)
Lower Extremity	8 (18%)
Metatarsal	2 (5%)
Tibial Shaft	2 (5%)
Ankle	2 (5%)
Tibial Tubercle Avulsion	1 (2%)
Phalangeal	1 (2%)

Table 1. A summary of the Hoverboard fracture distribution.

Accidental versus Non-Accidental Trauma in a Child with a Fracture: Associated Risk Factors Using a National Inpatient Database

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Purpose: Despite heightened awareness and the multidisciplinary efforts of the child protection services in the United States, non-accidental trauma as a cause of physical abuse remains a persistent problem in orthopaedic practice and in society at large. The purpose of this study is to identify objective clinical and demographic factors that are associated with non-accidental trauma in a child presenting to the hospital with a fracture.

Methods: Utilizing the weighted Kids' Inpatient Database (KID) containing data from over seven million inpatient admissions, we identified 57,183 children admitted to hospitals in the United States with a diagnosed fracture. We separated these children into study groups containing a diagnosis code for child abuse (n=881) and those without a child abuse code (n=56,302). Each group was then sub-divided based on fracture location. Univariate analysis was used to assess significant associations between each sub-group and various demographic and clinical data available in the database. We then performed multivariate analysis using logistic regression method to identify significant factors associated with the diagnosis of child abuse.

Results: The overall prevalence of non-accidental trauma in children presenting to the hospital with a fracture was 1.54%. Of these children, those presenting with multiple fractures had the highest rate of non-accidental trauma (2.80%). Multivariate analysis revealed that African-American race (OR = 1.40, 95% CI 1.14-1.71) and presentation at an urban teaching hospital (OR = 1.65, 1.32-2.06 = 95% CI) were the only demographic data significantly associated with non-accidental trauma. Clinically, concurrent diagnoses of a burn (OR = 5.77, 95% CI 2.56-13.00), intracranial injury (OR = 2.48, 95% CI 1.94-3.16), anemia (OR = 2.12, 95% CI 1.50-3.00), pre-existing neurological disorder (OR = 2.40, 95% CI 1.64-3.50), and weight loss (OR = 4.88, 95% CI 2.31-10.32) were all significantly associated with non-accidental trauma in children diagnosed with a fracture.

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
AGE	0.526	0.501	0.552
FEMALE	1.082	0.915	1.280
race2	1.398	1.140	1.714
NCHRONIC	1.003	0.936	1.075
ZIPINC_QRTL	0.796	0.734	0.863
HOSP_LOCTEACH	1.704	1.364	2.130
dxFxclrib	6.825	5.319	8.756
dxInt	2.639	2.054	3.389
dxBurn	6.526	2.847	14.956
CM_ANEMDEF	2.365	1.664	3.360
CM_LYTES	0.903	0.617	1.320
CM_NEURO	2.380	1.613	3.513
CM_WGHTLOSS	4.739	2.244	10.008

Conclusion: Utilizing a large, national inpatient database, the overall prevalence of non-accidental trauma in children presenting to the hospital with a diagnosed fracture was 1.54%. Risk factors associated with non-accidental trauma in this population include African-American race, presentation at an urban teaching hospital, and concurrent diagnoses of burns, intracranial injury, anemia, pre-existing neurological disorder or weight loss, . When combined, these data can heighten clinical acumen to-

ward detecting child abuse and potentially improve the treatment and protection of pediatric patients with fractures.

Significance: We identify specific clinical and demographic risk factors indicating non-accidental trauma for children presenting with a fracture using a national inpatient database.

Concomitant Nerve Injury in Supracondylar Fracture of the Humerus in Children

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Purpose: The purpose of this study is to investigate over all incidence, prevalence of injured nerves, direction of displacement of distal fragment, and recovery of nerve injuries in supracondylar fracture of the humerus in children.

Methods: We analyzed retrospectively 764 patients with supracondylar fracture of the humerus in children from May 1990 to May 2014. They had been treated at single institution and had adequate follow up and documentation .50 patients with a 58 concomitant nerve injuries were included for this study.

Results: Among total 764 supracondylar fracture of the humerus in children, 55 nerves in 50 patients (6.5 %) had concomitant nerve injury after initial trauma. The radial nerve was injured in 27 cases, median nerve in 20 cases, ulnar nerve in 5 cases and anterior interosseous nerve in 3 cases and. 5 cases(10%) had multiple nerves injuries. In 24 (89%) of 27 patients with radial nerve injuries, distal fragment was displaced posteromedially. In the median nerve injuries, 11 (55 %) of 20 cases were associated with posterolateral displacement of distal fragment, posterior displacement in 5 (21.1%) and posteromedial displacement in 4 (26.3%). Ulnar nerve were involved in four cases. Repair of the radial nerve and internal fixation were performed in one open fracture. All nerves were recovered without additional procedure, radial nerve was recovered at 47 days in average (ranged 1 day to 3), median nerve at 32 days (ranged 1 day 6 to 97days) , ulnar nerve in 50 days (ranged 1-97days) and anterior interosseous nerve in 62 days (36-73 days) after trauma in each.

Conclusion: The radial nerve was most commonly involved, and revealed close relation to the posteromedial displacement of the distal fragment. The median nerve had less close relation with postrolateral or pure posterior displacement. All injured nerves were recovered within 97 days after initial trauma without any surgical procedures for nerve.

Significance: Supracondylar humeral fractures are the most common elbow fracture in childhood. The nerve injury as complication of supracondylar humeral fracture is the highest, accounting for 5% to 19% of supracondylar humeral fractures. The most common nerve involved in related to supracondylar humeral fracture is anterior interosseous nerve, follow by the radial, median and ulnar nerves. In extension type, radial nerve injury is associated with posteromedial displacement, and median nerve injury is associated with posterolateral displacement. Whearas ulnar nerve injury is more common in flexion type.

Open Reduction for the Irreducible Supracondylar Humerus Fracture Varies by Surgeon, Not Years of Experience

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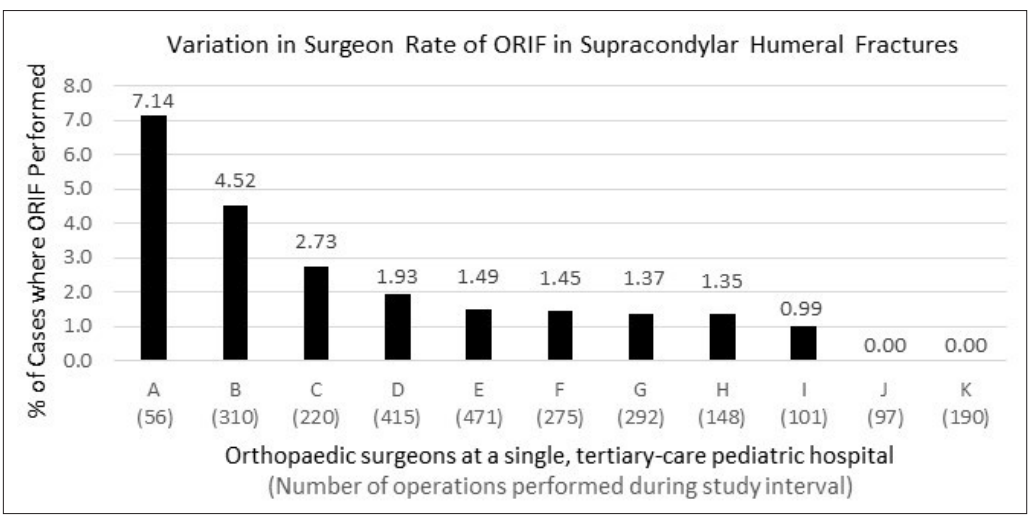
Purpose: The majority of pediatric supracondylar humerus (SCH) fractures that require surgical treatment can be effectively managed with closed reduction and percutaneous pinning. Open reduction may be required for irreducible fractures and in cases of concomitant neurovascular injury. This study aimed to determine the rate of open reduction in the operative management of SCH fractures and to identify surgeon-dependent variability in failure to achieve satisfactory closed reduction.

Methods: We performed a retrospective, descriptive cohort study of consecutive patients treated operatively for closed, extension-type SCH fractures at a level I pediatric trauma center over a 16-year period. A one-way analysis of variance (ANOVA) was performed to compare the effect of surgeon on the rate of inability to achieve satisfactory closed reduction. A univariate logistic regression model was used to determine if surgeon experience, as measured by years in practice at the time of surgery, correlated with rate of open reduction performed specifically for the inability to achieve closed reduction.

Results: Of 2,647 patients (47.9% female, mean age 5.8 ± 2.5 years) who underwent surgical management for a closed, extension-type SCH fracture, open reduction was performed in 1.9% (50) of cases. Eighty-two percent (41/50) of these open reductions were performed after failure of closed reduction techniques. Operations were performed by 12 different fellowship-trained pediatric orthopaedic surgeons with practice experience ranging from two weeks to 32.8 years. A one-way ANOVA revealed significant variability in individual surgeon's rate of open reduction performed for "irreducible" fractures, [F(11, 2604)=2.61, p=0.003] (Figure 1). Mean surgeon rate of open reduction was 2.1% (SD ± 2.1, Range, 0-7.1). Regression analysis did not demonstrate an association between surgeon experience and the rate of open reduction (p=0.27).



Conclusion: In our large cohort of supracondylar humerus fractures, open reduction for failed closed reduction was rarely needed, but the individual surgeon rate of converting to open reduction varied significantly. Failure to achieve closed reduction did not correlate with surgeon experience.

Significance: A retrospective study of supracondylar humerus fractures revealed that individual surgeon rate of converting to open reduction varied significantly, yet did not correlate with surgeon experience.

Blood Pressure Cuffs are Safe in Osteogenesis Imperfecta

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Purpose: Patients with Osteogenesis Imperfecta (OI) are highly susceptible to skeletal fractures. Some experts have advocated against the use of blood pressure (BP) cuffs in the operating room. We sought to investigate and compare the intraoperative use of BP cuffs, intra-arterial lines, and tourniquets in the surgical management of OI patients.

Methods: We retrospectively reviewed OI patients less than 21 years who underwent operations with general anesthesia from 2010 to 2016 at a single center. The primary outcome was the risk for an iatrogenic humerus fracture from BP cuff use. Secondary outcomes included: complications associated with tourniquets, intra-arterial lines, and intraoperative body positioning. The complication risks were evaluated with the Fisher's exact test. P-values of < 0.05 were considered statistically significant.

Results: Thirty-seven OI patients underwent 96 orthopaedic (lower- and upper-extremity, spine) and two non-orthopaedic (myringotomy, dental caries) procedures. The mean age at the time of surgery was 10 ± 4.8 years. Noninvasive blood pressure (NIBP) monitoring was used in 79 (81%) of the operations, while 17 (17%) had an intra-arterial line (Table 1). Tourniquets were used in 30 (31%) surgeries to minimize bleeding in the limb. No iatrogenic humerus fractures occurred in the NIBP or intra-arterial line groups (P = 1). No iatrogenic femur fractures occurred from tourniquet use. Two patients presented with humerus fractures at four-week postoperative clinic visits but these were unrelated to blood pressure monitoring. One patient was identified with a left humerus fracture following posterior spinal fusion with an intra-arterial line due to perioperative positioning. No complications were reported from intra-arterial lines.

Table 1. Osteogenesis Imperfecta Subtype Analysis with Accompanying Arterial Line Placement and Tourniquet Count for 98 Procedures in OI Patients from 2010 to 2016

OI type	Count (n, %)	Intra-arterial line (n)	Tourniquet (n)
I	25, 26	0	9
III	40, 41	7	11
IV	12, 12	3	5
V	1, 1	1	0
VII	1,1	1	0
Unreported	19, 19	5	5

Abbreviations: OI = Osteogenesis Imperfecta, n = number, % = Percent

Conclusion: Blood pressure cuffs were not associated with an increased risk for an iatrogenic fracture. Therefore, we conclude patients with OI can undergo NIBP mon-

itoring with a low risk for intraoperative fracture. Furthermore, lower extremity tourniquet use was not associated with complications in our OI patient series. Care must be used during the perioperative period to prevent additional fractures from body positioning.

Significance: Greater use of NIBP monitoring in OI patients will decrease the need for intra-arterial lines for blood pressure measurement intraoperatively.

Characterizing Ligamentous Laxity Norms in a US Pediatric Orthopedic Population

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Purpose: Generalized ligamentous laxity (GLL) in children has been associated with various health problems, including increased rates of musculoskeletal injury, anxiety disorders, and amplified pain syndromes. However, the prevalence of GLL has been ill-defined, with reported rates in children ranging from 2.3% to 64%. Previous studies have examined populations of various ages using non-standardized evaluation criteria. This study seeks to establish epidemiologic norms of GLL in a US population of patients evaluated in the ambulatory pediatric orthopedic setting.

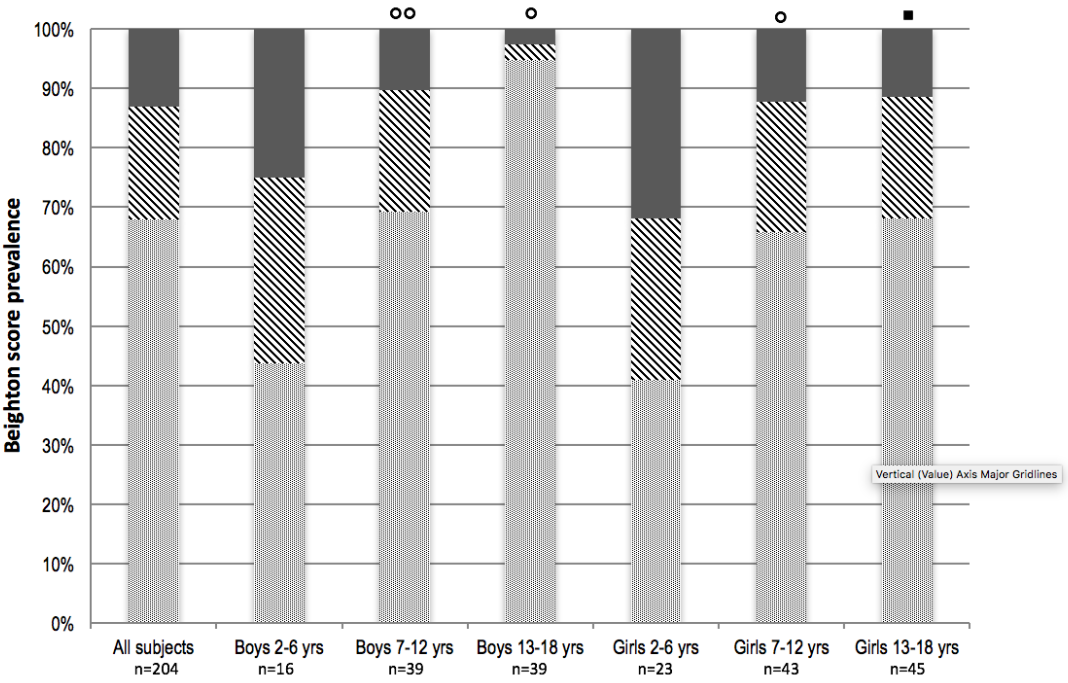
Methods: With IRB approval and informed parental consent, children aged 2-18 years presenting to a tertiary care pediatric orthopedic clinic in the US were enrolled. Exclusion criteria included systemic illness, connective tissue disorders, neuromuscular disease, scoliosis, and inability to complete the examination. Subjects were assessed for GLL using the widely accepted Beighton criteria. Scores of 5 or greater were used to define GLL. Independent samples t-tests were used to compare mean Beighton scores (MBS) amongst patients grouped by age and gender. Fisher's exact test was used to compare laxity prevalence amongst groups.

Results: 204 patients participated (94 boys, 110 girls). Average age=10.7 years. 100 patients were white, 32 black, 30 Hispanic, 11 Asian, and 31 were of mixed or other race. Overall prevalence of GLL was 13%; 10% among boys and 15% among girls. Overall mean MBS was 2.05(SD=2.07). For additional analysis, the study population was divided into three cohorts by age: 2-6 years, 7-12 years and 13-18 years. In boys, the MBS was significantly different between each group ($p<0.005$). In girls, the MBS decreased significantly between the youngest and middle cohorts ($p<0.05$), but was similar for girls in the 7-12 and 13-18 cohorts. Gender-based differences in MBS were only significant for children in the oldest cohort (higher MBS for girls, $p<0.0003$). GLL prevalence followed similar age- and gender-based patterns ($p<0.05$, **Figure**).

Conclusion: This study establishes normative values for GLL prevalence amongst US children, with an overall prevalence of 13%. It supports previous studies demonstrating age- and gender-related differences in GLL prevalence and characterizes them further, demonstrating that (1)the predominance of GLL in girls becomes significant only in middle-to-late adolescence and, (2)this coincides with additional decreases in laxity seen in boys from late childhood into adolescence, while girls of the same age experience no additional change in laxity.

Significance: Normative epidemiologic values for the prevalence of GLL amongst patients of different ages and genders have now been established in a diverse population of US pediatric orthopaedic patients.

Figure 1. Generalized joint laxity by Beighton score prevalence



Mean Beighton score comparison by age (between groups of same gender):
2-6 vs 7-12 years; 2-6 vs 13-18 years : oop<0.01, op<0.05
Mean Beighton score comparison by gender (between groups of same age):
girls v. boys, ■p<0.05

Complication Rates of Pediatric Spinal Deformity Surgery: Report of 4481 Cases Prospectively Collected Across Children's Hospitals

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Purpose: Variation in complication rates exists among patient populations undergoing spinal deformity procedures. The purpose of the study was to examine the complication rates associated with with treatment of spinal deformity at hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program-Pediatric (NSQIP-Pediatric).

Methods: Procedure-targeted variables were developed within NSQIP-Pediatric. In addition to the traditional program variables, data was collected specifically related to spinal fusion procedures including etiology of spinal deformity, neurologic injuries, reoperation at 30 days and 30 and 90-day surgical site infection (SSI). The classification of the spinal deformity and related complications were assessed from prospectively collected data entered in 2014 and 2015.

Results: 43 participating hospitals contributed 4481 cases to the NSQIP-Pediatric spinal fusion procedure targeted pilot. The majority of cases were posterior spinal fusions (98.2%) versus anterior (1.8%). Overall SSI rates at 30 days were 1.65% (range 0.68% in idiopathic scoliosis to 5.06% neuromuscular scoliosis) and at 90 days were 2.43% (range 1.59% in idiopathic scoliosis and 7.11% neuromuscular scoliosis). The incidence of new neurological deficits was 1.72% with a 0.47% incidence of spinal cord injury. Six deaths were reported: 3 in the neuromuscular cohort and 1 each in the syndromic, congenital and kyphosis groups. Bleeding events (defined as transfusions >25mL/kg), 30 day readmission rates and unplanned returns to the operating room were also reported for each etiology of spinal deformity (see Table).

2014-2015 NSQIP-Pediatric Spinal Fusion Procedure-Targeted Variable Complication Rates

	Idiopathic (2927)	Neuromuscular (731)	Congenital/ Structural (339)	Kyphosis (224)	Syndromic (178)	Unclassified (82)	TOTAL (4481)
SSI 30 Days	0.68% (20)	5.06% (37)	0.59% (2)	2.23% (5)	4.49% (8)	3.45% (2)	1.65% (74)
Superficial SSI 30 Days	0.38% (11)	2.87% (21)	0.29% (1)	0.45% (1)	1.69% (3)	0.00% (0)	0.83% (37)
Deep SSI 30 Days	0.31% (9)	2.19% (16)	0.29% (1)	1.79% (4)	2.81% (5)	3.45% (2)	0.83% (37)
SSI 90 Days*	1.59%	7.11%	1.18%	3.13%	5.06%	3.45%	2.43%
New Neurological Deficit	1.47% (43)	1.09% (8)	4.42% (15)	3.13% (7)	2.24% (4)	0.00% (0)	1.72% (77)
Spinal Cord Injury	0.34% (10)	0.55% (4)	0.59% (2)	1.34% (3)	1.12% (2)	0.00% (0)	0.47% (21)
Bleeding Event	3.04% (89)	24.49% (179)	10.03% (34)	5.80% (13)	12.92% (23)	4.88% (4)	7.63% (342)
Readmission 30 days	2.63% (77)	9.99% (73)	1.47% (5)	3.57% (8)	4.49% (8)	2.44% (2)	3.88% (174)
Unplanned reoperation 30 Days	1.71% (50)	6.70% (49)	1.77% (6)	5.80% (13)	8.99% (16)	0.00% (0)	3.04% (136)

Conclusion: Inherent complications exist in the treatment of pediatric spinal deformity, but variability was identified in this large, prospectively collected sample. Compli-

cations such as SSI, readmission and reoperation were highest in the neuromuscular scoliosis group, and neurologic deficit after surgery was highest in the congenital scoliosis group. Quality improvement efforts should be targeted towards reducing specific complications in identified at-risk populations.

Significance: Analysis of complication rates for spinal fusion procedures for specific patient populations allows surgeons and families to have informed discussions around risks when deciding upon surgery. In addition, the collection of procedure-targeted variables allows for improved measures of risk stratification, risk adjustment and improved outcomes in spinal deformity surgery.

How Do We Best Estimate Surgical Blood Loss during AIS? A Proposed Mathematical Calculation

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Purpose: In previous studies, We found the documented estimated blood loss (EBL) is poorly reproducible and typically underestimates the true total. Therefore, comparison of surgical outcomes such as blood loss and amount of blood transfused across institutions and surgeons is insensitive. Currently, the arthroplasty literature reports on validated mathematical calculations, and not measured EBL, as they are more reproducible and an improved metric for blood loss. The purpose of this study is to evaluate a proposed mathematical calculation for the reproducible assessment of blood loss after deformity surgery.

Methods: A review of patients (2012-2014) who had a single stage posterior spinal fusion for AIS (n=378) was reviewed. The total blood loss (TBL) calculation, derived from the arthroplasty literature (modified for use in the registry), was correlated with the documented EBL, cell salvage returns, and total transfusion volumes.

Results: 91.4% of transfusions were given in the intra-operative or immediate post-operative setting. No patients required transfusion after the second postoperative day. Transfusion rates varied across hospitals (17% to 77%, $p<0.01$). The mean TBL was higher than EBL (TBL: 1197±369cc vs. EBL: 591±337cc; $p<0.01$). %TBVL (TBL as a percentage of blood volume) showed a moderate positive linear correlation with transfusion volumes (red blood cells transfused in mL plus cell saver return in mL) ($r=0.6428$, $p<0.05$). The correlation was significantly ($p<0.01$) stronger than %EBVL ($r=0.3998$, $p<0.05$). Intra-surgeon comparisons of %TBVL and %EBVL showed that %TBVL had significantly stronger correlation than %EBVL with respect to transfusion volumes. A high %TBVL was associated with an increased rate (39% vs. 14%, $p<0.01$) of prolonged hospital stay.

Conclusion: A mathematical calculation with an objective measurement has improved linear correlation with transfusion and Cell Saver volumes across multiple institutions. This significantly increases the ability to reproducibly calculate blood loss during AIS surgery.

Significance: Currently, the arthroplasty literature reports on validated mathematical calculations, and not EBL, as they are more reproducible and an improved metric for blood loss. This study validates a proposed mathematical calculation for the reproducible assessment of blood loss after deformity surgery. This significantly increases our ability to reproducibly calculate blood loss during AIS surgery.

Impact of an Accelerated Discharge Pathway on Early Outcomes and Recovery Following Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis: A Prospective Comparative Study

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Purpose: Accelerated discharge (AD) pathways following posterior spinal fusion (PSF) for AIS offer earlier discharge home with a modest cost savings and similar complication rates when compared to a traditional discharge (TD) pathway. The impact on post operative pain scores and recovery have not been well defined.

Methods: A prospective evaluation of patients undergoing PSF for AIS at two high volume spine centers was performed with focus on early post operative recovery. One center used the AD pathway while the other used a TD pathway. Post operative quality of recovery as determined using the validated QOR9 instrument, last inpatient VAS score, and return to school when applicable were collected. Patients were matched for curve magnitude and estimated blood loss (EBL).

Results: 30 patients treated using the AD pathway were compared to 33 patients treated with the TD pathway. Length of stay was 2.7 days shorter in the AD group (2.48 ±1.22 days AD vs 5.0±0.83 days TD, p<0.0001). Preoperative demographics including age at surgery, major curve magnitude (59.2°±10.6° AD vs 58.6°±10.8° TD, p=0.83), percent major curve correction (71.8±15.6% AD vs 72.3±8.3% TD, p=0.64), number of levels fused (11.4±2.5AD vs 11.2±2.1 TD, p=0.62) and EBL (616±193cc AD vs 669±264cc TD, p=0.38) were similar between the groups. Patients treated at the TD center had 30 minutes longer total operating room time (332±54 min TD vs 302±55min, p=0.03), likely due to a greater number of posterior osteotomies (50%AD vs 100%TD, p<0.001). Pain based on the VAS score at discharge was lower in the AD group (2.6 vs 4.5, p=0.001) and patient based quality of recovery scores were similar at 6 weeks follow up (15.6±2.3 AD vs 15.4±2.4 TD, p=0.80).

	Accelerated Discharge (AD)	Traditional Discharge (TD)	P value
Major Cobb Angle	59.2°±10.6	58.6°±10.8°	0.83
Major Cobb Correction	71.8±15.6% AD	72.3±8.3%	0.64
Number of Levels Fused	11.4±2.5	11.2±2.1	0.62
EBL	616±193cc	669±264cc	0.38
Operating room time	302±55min	332±54 min	**0.03**
Posterior Column Osteotomies	50%	100%	**<0.001**
Length of Stay	2.48 ±1.22 days	5.0±0.83 days	**<0.001**
VAS at discharge	2.6±2.1	4.5±2.15	**0.001**
QOR9 at 6 weeks	15.6±2.3	15.4±2.4	0.80
Days until return to school	21.4±9.0 days	18.7±5.7 days	0.28

Days until return to school was similar between groups (21.4±9.0 days AD vs 18.7±5.7 days TD, p =0.28). 1 patient in the TD group and none in the AD group developed a postoperative infection. No patient was readmitted within 90 days of discharge for medical issues.

Conclusion: The use of an accelerated discharge pathway resulted in a shorter length of stay with lower pain scores at discharge. No patient required readmission or sustained a wound infection related to early discharge. Quality of recovery and time off of school are likely multifactorial and not as dependent on length of stay.

Significance: An accelerated discharge pathway for post operative management following PSF for AIS can result in an earlier discharge with no difference in complications and a similar return to school.

Live In-Office Video Recording of Pediatric Cast Care Instructions: Caregiver Satisfaction and Lessons Learned

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Purpose: Describe the caregiver and provider experiences with the use of live in-office video recordings of cast care instructions. We hypothesize that our patients' caregivers would be comfortable with and find utility in this process.

Methods: Between 2015-2016, all patients undergoing cast immobilization were offered the opportunity for their caregivers to our record cast care instructions with a personal electronic device (PED). Upon follow-up, a survey was administered to assess the caregivers' comfort in and utility of the recording using a 10-point Likert scale. We also examined their usage and sharing of the recording and whether they preferred a paper handout or the recording as their information reference. Statistical analysis was performed with R v3.2.4.

Results: 308 surveys were completed. Of the respondents, 87% of caregivers reviewed the video following the visit and 37% shared the clip with at least 1 family member (avg 2; range 1-6). Average rating of video usefulness was 9.5/10 and comfort was 9.8/10. Caregivers with an education level of high school or lower rated the recording as more useful than those with an education beyond high school ($p < 0.001$); age had no impact on perceived usefulness. Age and education level also had no statistically significant impact on comfort level. Most caregivers (97.1%) felt the video improved their confidence caring for their child. 91.4% of those expressing a definitive preference chose the recording over the handout. No caregiver had been invited to record a medical visit before, and 91.8% indicated that they would like other doctors to also allow recordings of their visit.

Conclusion: Caregivers regard live in-office recordings in a very positive light with high ratings for comfort, utility, confidence and desire for others to do the same. Our experience indicates that physicians should consider encouraging patients and their caregivers to record discussions related to key portions of the office visit on their PED.

Significance: To our knowledge, this is the largest study of the use of live in-office recordings in the orthopedic field. PED's are nearly ubiquitous and with the recording of outpatient visits likely to become more commonplace in the future, it behooves all healthcare providers to become familiar with this process now.

MRSA Swab Results Did Not Change Treatment or Outcome in Spinal Fusion Patients

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Purpose: Previous studies have reported that nasal colonization with *S. aureus* is an important predictor for subsequent SSI with *S. aureus*. Hospital protocols vary, with some institutions obtaining MRSA nasal swabs the week prior to surgery, while other institutions, like ours, obtain them the morning of surgery. Our purpose was to investigate if the MRSA swab results were predictive of surgical site infections in these patients.

Methods: A retrospective chart review of all patients who underwent posterior spinal fusion surgery between 2004-2014 was conducted to determine preoperative MRSA colonization status and SSI infection rates and organisms. Lengthening procedures for guided growth systems were excluded. Patients who did not receive a MRSA swab, who had less than 1 year of follow-up, or who underwent fusion for trauma, tumor, or infection were also excluded. Prior to 10/1/2012 patients were given vancomycin for infection prophylaxis; beginning 10/1/2012 patients received ceftazidime and ancef for prophylaxis. Powdered vancomycin was added to all bone grafts.

Results: 986 patients met inclusion criteria. 2.3% (*n*= 23/986) of patients were positive for MRSA. 3.2% (32/986) of patients developed an SSI. There was no significant difference in infection rates between patients whose MRSA swab was positive or negative (positive swab= 0 SSIs, negative swab= 32 SSIs, *p*= 0.38). 2 of the SSIs were caused by MRSA. Patients treated prior to 10/1/2012 had a positive MRSA swab rate of 2.6% (*n*= 16/615) vs 1.9% (*n*= 7/371) for patients treated after 10/1/2012. This difference was not significant (*p*= 0.46). The rate of SSI differed significantly between the two groups (*p*= 0.009), with those prior to 10/1/2012 having a higher rate of postoperative infection (4.4%, *n*=27/615) than those after 10/1/2012 (1.3%, *n*= 5/371). Chart review revealed that the antibiotic regimen was not altered for any patients due to a positive MRSA swab. The cash price for the nasal swab at our institution was $60 per patient.

Conclusion: The results of a preoperative MRSA nasal swab had no relationship to SSI rates or organisms and had no effect on patient care. The total cost of the nasal swabs was $59,160.

Significance: As the MRSA swab test results did not change patient outcome or management, this may provide an opportunity for cost savings.

Postoperative Magnetic Resonance Imaging Safety in Pediatric Patients after Open Hip Reduction and Hardware Implantation

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Purpose: Magnetic resonance imaging (MRI) is considered a valuable diagnostic tool in musculoskeletal imaging. However, there are concerns regarding the use of MRI when metallic implants are present, which include loosening, migration, and heating of the hardware and magnetic field interactions. Few clinical studies have evaluated the safety of MRI use with orthopedic implants, especially in the immediate post-operative period. The objectives of this study were to first assess the safety of obtaining a MRI within six weeks of an open hip reduction and femoral osteotomy in pediatric patients with developmental dysplasia of the hip (DDH), and then to determine whether MRI within this timeframe may compromise metal ingrowth of fixation.

Methods: We retrospectively identified patients with DDH who underwent postoperative MRI within six weeks of hardware implantation from January 2011 to October 2015 at a tertiary children's hospital. The implants consisted of 4-hole stainless steel plates and 4 screws in all cases. Study inclusion required a minimum of six months of radiographic and clinical follow-up, with no comorbid fragile bone disease or pre-existing infection. Clinical records and follow-up imaging were reviewed to assess time interval between implantation and postoperative MRI, magnetic field strength, implant type and patient outcomes. Descriptive statistics were calculated.

Results: 32 post-operative MRIs were conducted in 28 pediatric patients with DDH (median age: 2.1 years, range: 8 months – 5.3 years). All MRIs began within 7 hours of exit from the operating room, and the average time to MRI was 2 hours and 11 minutes. No clinical or radiographic complications were observed with regard to implant loosening, nonunion, compromised metal ingrowth, migration of implants, or thermal effects to the soft tissues for a minimum 6 month interval from the time of imaging.

Conclusion: To our knowledge this is the largest cohort studied to assess the safety of postoperative MRIs following hardware insertion, and the only study exclusively in pediatric patients with DDH. There were no clinical or radiographic adverse effects attributable to MRI use for a minimum of six months in this patient population.

Significance: Well-fixed orthopedic implants in the pediatric population can be safely imaged in the immediate postoperative period.

Can a Novel, Low-Cost Simulation Model be Used to Teach Anterior Cruciate Ligament Graft Preparation?

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Purpose: Surgical simulation offers a low-risk means of providing surgical residents with necessary training while pushing the learning curve away from direct patient care. However, prohibitive costs have impeded widespread implementation of simulation tools. In this study, we developed and evaluated a low-cost simulation intervention for teaching anterior cruciate ligament (ACL) graft preparation.

Methods: A simulation model for ACL graft preparation was constructed using shoelace as graft material and a wooden graft preparation board that matched the dimensions of existing products (Figure 1). Each simulation model cost less than $20 (2016 fiscal year dollars). A 12-minute instructional video targeted at novice learners was created to accompany the simulation model. A prospective trial was conducted on orthopaedic surgery residents divided into two groups with equal distributions of postgraduate year (PGY) status. The control group viewed an instructional video on ACL graft preparation. The intervention group completed the Shoe-Lace ACL teaching module. All participants then prepared an ACL graft using allograft materials. An expert blinded to group allocation evaluated each participant via a 20-point checklist of critical steps and a 12-point global assessment rating for a maximum score of 32 points. Secondary outcomes included participants' pre- and post-intervention self-assessment scores.

Results: Ten orthopaedic surgery residents from a single institution participated in the study, with even distributions across study groups of PGY-1, PGY-3, and PGY-4 residents. Pre-intervention self-assessments of knowledge and technical ability were similar between participant groups. The mean overall performance score was significantly greater in the intervention group (22.6 ± 1.5) than in the control group (16.0 ± 5.1) (p=0.043). Participants in the intervention group showed greater improvement in self-confidence in their technical ability than those in the control group (p=0.012). Groups demonstrated similar post-intervention improvements in self-reported knowledge of ACL graft preparation (p=0.128). All participants who learned via the Shoelace ACL module strongly agreed that

Figure 1A. Shoelace ACL Teaching Guide

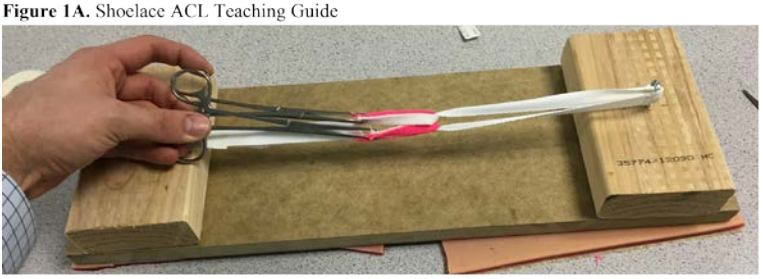

Figure 1B. Graft Preparation Board Used in the Operating Room

they would use the learning tool to prepare for ACL reconstruction surgery.

Conclusion: A low-cost simulation model for ACL graft preparation resulted in improved objective surgical trainee performance compared to standard video instruction. The teaching model may be incorporated easily and inexpensively into simulation curricula at other training programs.

Significance: Given the need for improved educational efficiency in today's surgical environment, this study presents a promising low-fidelity simulation model for teaching ACL graft preparation that offers training programs a viable tool to prepare trainees for pediatric ACL reconstruction procedures at minimal expense and faculty time commitment.

Disproportionate Abstract Submission Rates for Men and Women in Academic Pediatric Orthopaedic Surgery: An Analysis of POSNA Annual Meeting Abstract Submissions 2012-2015

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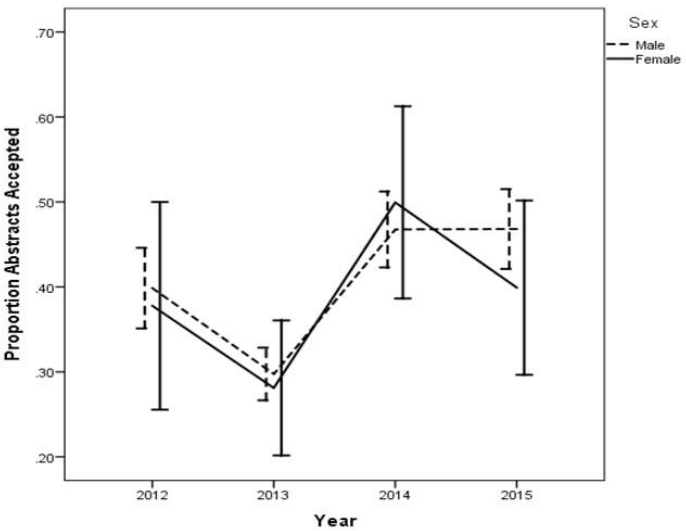
Purpose: It has recently been demonstrated that female members of POSNA participate at the Annual Meeting at disproportionately lower rates than male members, as defined by accepted abstract authorship. We hypothesize that this discrepancy is associated with lower abstract submission rates by female members.

Methods: POSNA membership directories for the years 2012-2015 were used to record the name, gender, membership category, and years of membership for each member. Final programs for Annual Meetings and abstract submission records for the same time period were used to record the number of accepted/presented and rejected abstracts for each member. General estimating equations with a binomial model and logit link were used to compare the proportion of abstract acceptances between genders across years.

Results: During the period 2012-2015, there were 1075 (81.4%) unique male members of POSNA and 246 (18.6%) unique female members. Active members included 534 men (83.8%) and 103 women (16.2%) while candidate members included 207 men (64.7%) and 113 women (35.3%). When active and candidate members were considered collectively, men were significantly more likely to have a presented abstract ($p=0.009$) and this significant difference did not change over the 4-year period ($p=0.627$). However, men submitted significantly more abstracts per member per year than women (means: men=1.5, women=0.8, $p< 0.001$). This held true for both candidate members (early career) ($p=0.001$) as well as active members (mid-career) ($p<0.001$). When the total number of abstract submissions per year per member was taken into account, the percentage of abstract acceptances was similar for men and women (men=42%, women=40%, $p=0.847$).



Conclusion: Abstract acceptance rates were similar for female and male members of POSNA for the 2012-2015 Annual Meetings. However, men had a significantly greater number of abstract submissions per member than women, and consequently, men presented a higher proportion of abstracts relative to their membership numbers. This supports our hypothesis that the disproportionately lower rate of

active participation amongst female members at POSNA Annual Meetings is due to lower rates of abstract submissions, rather than to lower rates of acceptances.

Significance: Even as women comprise an increasing percentage of the POSNA membership, they consistently demonstrate lower rates of active participation at Annual Meetings, a discrepancy attributable to lower rates of abstract submissions amongst female POSNA members. Focused efforts to support and encourage women to share innovative research via abstract submissions are needed in order for POSNA to continue to lead in the advancement of our field.

Infection Control in Pediatric Spinal Deformity Surgery: A Critical Analysis of Cause and Prevention Strategies in Adolescent Idiopathic Scoliosis, Neuromuscular Scoliosis, and Early Onset Scoliosis

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Purpose: Surgical site infections (SSIs) significantly impact post-surgical morbidity and cost of care in pediatric spinal deformity surgery. While there have been prior attempts to identify preventative strategies and risks factors, few practice guidelines exist. This review updates the state of the literature, reflecting new evidence since the last systematic review was performed five years ago.

Methods: We performed a systematic review in April 2016, searching Pubmed, EMBASE, and Cochrane databases. Search terms were scoliosis, scolio*, spine, spin*, infection, and infect*. The search returned 4,436 studies from 2012 (when a prior review was performed) to the present. After application of inclusion and exclusion criteria by consensus of three authors, we identified 95 studies investigating risk factors and interventions for pediatric spinal deformity surgery. We also included 72 previously identified studies from the prior review, yielding a total of 167 studies. Grades of recommendation were assigned to potential risk factors or interventions. Recommendations were made for individual subpopulations consisting of adolescent idiopathic scoliosis, neuromuscular scoliosis, and early onset scoliosis.

Results: We identified 20 potential risk factors or preventative interventions. Of these, none received generalized Grade A (good evidence) recommendations. The following risk factors/interventions had Grade B (fair evidence) recommendations:

- Closure methods were not shown to affect SSI rates
- Stainless steel implants carry a higher infection risk than titanium
- Drains were not shown to affect SSI
- Pelvic fixation is a risk factor for SSI
- Hypothermia were not shown to affect SSI
- Increased length of surgery were not shown to increase SSI

Complete findings subcategorized based on subpopulations are summarized in Table 1.

Conclusion: Progress has been made in the past five years in performing better studies with higher levels of evidence, though much remains unclear. Many common interventions have either no evidence or very low-level evidence. Others have conflicting data as to whether or not the intervention has an effect. Increased research funding is needed to enable larger and better-designed studies to further develop a true evidence-based approach to SSIs. Each diagnostic category of scoliosis constitutes its own entity, with its own set of risk factors, and we recommend more individualized lines of investigation with respect to each.

Significance: This systematic review summarizes the current state of the art in preventative strategies and modifiable risk factors for pediatric spinal deformity surgery. This study is the first to specifically identify evidence and recommendations for individual subcategories of spinal deformity.

Intervention/Risk Factor	General Grade of Evidence	AIS Grade of Evidence	NMS Grade of Evidence	EOS Grade of Evidence
Vancomycin Powder	I	I	I	I
Betadine Wash	I	I	I	I
Vac Dressing	I	I	I	I
Other Dressing	I	I	I	I
Incontinence	I	I	C	I
Bowel Prep	I	I	I	I
Malnutrition	C	I	C	I
IV Antibiotics	C	C	C	C
Gentamycin in Bone Graft	I	I	I	I
Hypothermia: No Effect	B	I	B	I
Length of Surgery: No Effect	B	B	B	I
Dual Attending Surgery	I	I	I	I
Implant Type/Prominence	B	B	C	I
Drains: No Effect	B	B	C	I
Antibiotics for Multiple Days	I	I	I	I
Type of Bone Graft	C	C	C	I
Obesity	C	C	C	C
Pelvic Fixation	B	I	B	B
Closure Methods: No Effect	B	B	B	I
Prep and Irrigation	I	I	I	I

Table 1: Grades of recommendation for identified preventative interventions and modifiable risk factors.
AIS: Adolescent idiopathic scoliosis, *NMS*: Neuromuscular scoliosis, *EOS:* Early Onset scoliosis

Grades:
A: Good evidence (consistent Level 1 studies)
B: Fair Evidence (consistent Level 2-3 studies)
C: Poor quality or conflicting evidence
I: Insufficient evidence

Inter-rater Reliability of Physical Abuse Determinations in Young Children with Fractures

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Purpose: As there is no "gold standard" in determining whether a fracture is caused by accident or abuse, agreement among medical providers is paramount. The purpose of this study was to examine the reliability of the likelihood of abuse ratings among three specialties that care for abused children with fractures: pediatric orthopaedic surgeons, child abuse pediatricians (CAPs), and pediatric radiologists.

Methods: After IRB approval, data was abstracted from 551 medical records of children <36 months of age who presented to a single, level 1 pediatric emergency department with at least 1 fracture over a 4 year period. To simulate clinical scenarios, two orthopaedic surgeons and two child abuse pediatricians (CAPs) reviewed the full abstraction and imaging, while two pediatric radiologists reviewed a brief history and imaging. Each physician independently rated each case using a 7-point ordinal scale designed to distinguish accidental from abusive injuries. For any discrepancy in independent ratings, the two specialists discussed the case and came to a joint rating. We analyzed 3 types of agreement: (1) within specialties using independent ratings, (2) between specialties using joint ratings, and (3) between clinicians (orthopaedists and CAPs) with more versus less experience.

Results: Agreement between pairs of raters was assessed using Cohen's weighted kappa. Orthopaedists (κ=.78) and CAPs (κ=.67) had substantial within-specialty agreement, while radiologists (κ=.53) had moderate agreement. Orthopaedists and CAPs had almost perfect between-specialty agreement (κ=.81), while agreement was much lower for orthopaedists and radiologists (κ=.37) and CAPs and radiologists (κ=.42). More-experienced clinicians had substantial between-specialty agreement (κ=.80) versus less-experienced clinicians who had moderate agreement (κ=.60).

Conclusion: We found medium to high levels of agreement among pediatric orthopaedic surgeons, CAPs, and pediatric radiologists evaluating the likelihood of an abusive fracture. Access to a complete history was a contributing factor to the extent of agreement, as was the experience level of the rater.

Significance: This is the first study to examine agreement on the likelihood of abuse among 3 different specialties that evaluate young children with fractures. As fractures are a very common presenting manifestation of physical abuse, ongoing education of orthopaedic surgeons regarding clinical features of abusive fractures is critical.

Analysis of Fragility Index in Pediatric Orthopedic Randomized Controlled Trials: An Additional Metric to Explore the Robustness of Study Conclusions

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Purpose: Randomized controlled trials (RCTs) are the gold standard in evaluating clinical outcomes. Statistical significance (p value) has traditionally been used as the main metric on which study conclusions were based. A new index, called the fragility index, quantifies the number of patients required to have a different outcome in order to reverse the study conclusions. The aim of this study was to determine the fragility index of randomized controlled trials in the pediatric orthopedic literature.

Methods: Pubmed was systematically searched for pediatric orthopedic RCTs published from 2006-2016. Two independent reviewers screened titles, abstracts and manuscripts to identify studies involving two parallel arms, published in English, that allocated patients to treatment and control in a 1:1 ratio. Trials were excluded if they did not contain a dichotomous primary or secondary outcome variable, included patients >18 years old or were not published in English. Data were extracted from each eligible article and the Fragility Index was determined using an online, publicly available calculator (http://clincalc.com/Stats/FragilityIndex.aspx).

Results: Thirty-six randomized pediatric orthopedic clinical trials were identified for inclusion. Seven of these trials (16.2%) involved evaluation of anesthetic regimens, the rest focused on orthopedic treatment or diagnostic efficacy. The median patient sample size per experimental group was 37 and the median overall sample size was 69. Half of the studies reported a p value <0.05. The mean fragility index was 3.6 with a range of 0-18. Twenty-four trials had a Fragility Index of 2 or less. In 18.8% of trials with a p value < 0.05, the number of patients lost to follow-up exceeded the Fragility Index, meaning that results of the patients lost to follow-up could theoretically completely reverse the study conclusions.

Conclusion: The fragility index is a useful metric to analyze the robustness of study conclusions, in addition to the traditionally reported p value. Randomized controlled trials in pediatric orthopedics often have small sample sizes, many with low fragility indices.

Significance: The logistical and ethical challenges involved in running randomized controlled trials with pediatric orthopedic patients results in published trials with small sample size. Our results emphasize the need for future efforts that ease barriers to institutional collaboration and patient recruitment with the ultimate goal of improving randomized controlled study sample sizes, and improving the robustness of RCTs.

Do the ACGME Milestones Adequately Track Resident Performance During Their Pediatric Orthopadic Rotation?

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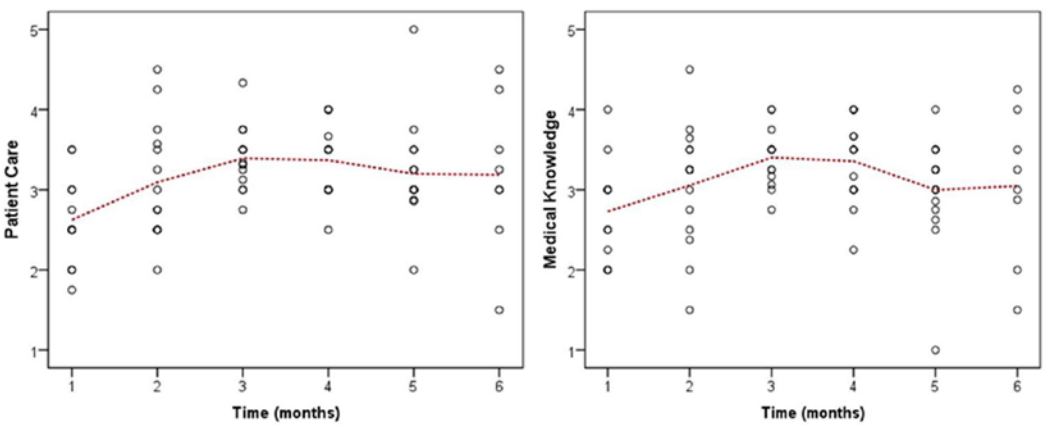
Purpose: In 2013, the Accreditation Council for Graduate Medical Education (ACGME) and American Board of Orthopaedic Surgery released a joint initiative document presenting milestones for descriptors and targets of resident performance. Though universally adopted, the adequacy of this evaluation tool has yet to be determined. The purpose of this study was to determine whether ACGME milestones adequately assess gains in resident competency over the course of a 6-month pediatric orthopaedic rotation.

Methods: Between January 2014 and December 2015, twelve third-year orthopaedic residents were evaluated by 13 pediatric orthopaedic attendings over the course of their 6-month pediatric orthopaedic rotations. Evaluations were conducted monthly via an electronically administered survey containing sub-competency milestones for pediatric supracondylar humerus fracture (SCHFx) patient care and medical knowledge. All attendings received standardized education regarding the scoring and application of the milestones prior to initiation of this study. Paired t-test was used to compare mean milestone scores between each month of the rotation.

Results: SCHFx Patient Care competency improved from a mean of 2.7 (st dev 0.5) at the first rotation month to a mean of 3.2 (st dev 0.8) at the last rotation month (p=0.0062). The SCHFx Medical Knowledge competency improved from a mean of 2.8 (st dev, 0.5) to a mean of 3.2 (st dev 3.2) (p=0.04). Mean scores did not demonstrate consistent monthly improvement throughout the rotation, and there was wide variability in scores amongst residents (Graph 1). In addition, attendings had wide variation in their own mean scores (range 2.4 to 3.8) when evaluating the same cohort of residents.



Graph 1. Scatter plot of residents' ACGME milestone scores at each month. Dotted line represents mean score.

Conclusion: Although resident milestone scores for SCH Fx demonstrated small but statistically significant improvement from the beginning to end of the 6-month rota-

tion, the 6-month mean score was still below the targeted level of achievement (level 4) for graduation. There was wide variation in scores amongst residents at the same time point in their training, and there was wide variability in scores amongst attendings. These findings may represent inadequacy in the design of a single 6-month pediatric orthopaedic rotation in educating residents, flaws in the design of the milestones to adequately track resident performance, or lack of education or understanding of orthopaedic attendings in correctly applying the framework of milestone evaluations.

Significance: It is unclear whether ACGME milestones appropriately demonstrate that orthopaedic resident performance targets in pediatric orthopaedics are achieved.

Increasing Brace Treatment for Distal Radius Buckle Fractures: Using Quality Improvement Methodology to Implement Evidence-Based Medicine

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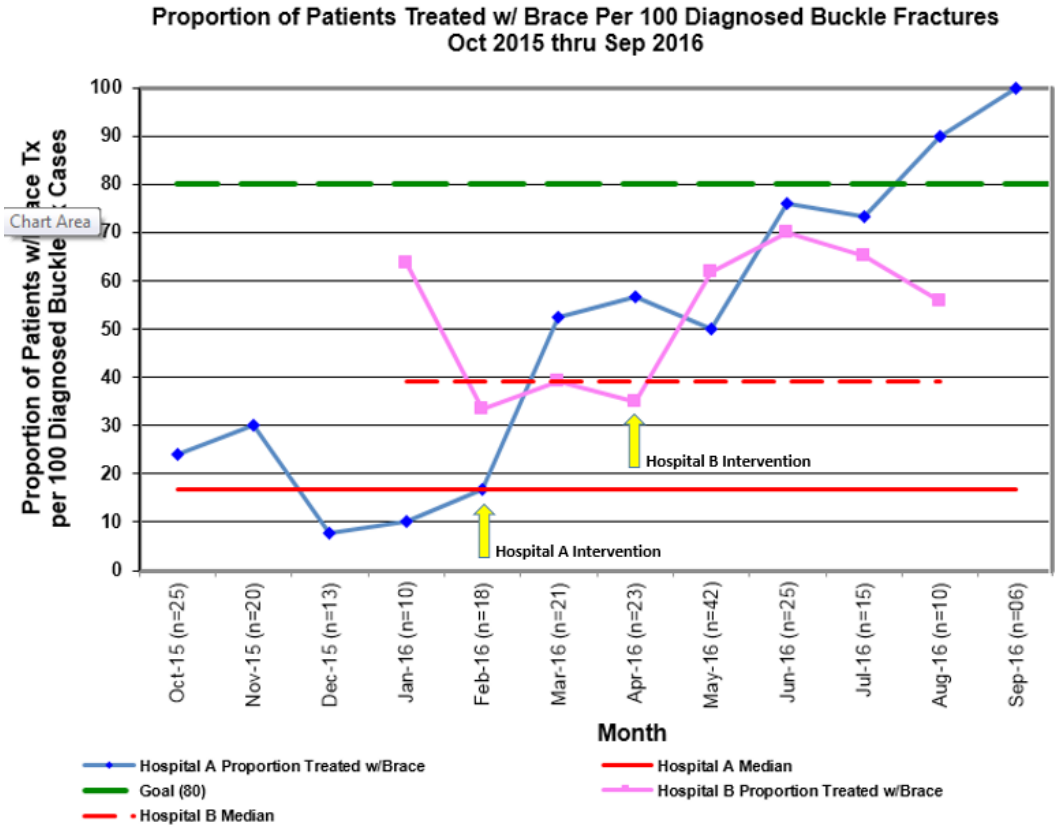
Purpose: Multiple randomized trials have demonstrated equivalent outcomes and improved patient/family satisfaction in the treatment of distal radius buckle fractures (DRBF) with a removable splint or brace when compared to traditional cast immobilization. Brace treatment also obviates the need for routine follow-up and can lead to substantial institutional cost savings. Implementation of brace treatment remains inconsistent, with cast immobilization still widely used for buckle fractures. At two tertiary pediatric hospitals, we used quality improvement (QI) methodology to increase the proportion of patients with distal radius buckle fractures treated in a removable brace in the orthopaedic clinic by orthopaedic providers.

Methods: Clinic billing records were reviewed monthly to determine treatment (brace versus cast) of DRBF and tracked using control charts (p-chart). Additionally, the number of follow up visits, radiographs obtained, and cost data was collected. Baseline date was obtained over a three month period, followed by a 9 month period of interventions using Plan-Do-Study-Act (PDSA) cycles targeting both individuals and groups of providers. Patients/families were given a cost survey to determine non-medical costs associated with follow-up clinic visits.

Results: The proportion of DRBF treated in a brace increased at both hospitals from a combined baseline of 33% to a combined 56% at the end of the study period. Following intervention, 83% of providers began using braces for a majority of patients, (defined as >67%) although 2 providers continued to use casts 100% of the time. Patient preferences was cited as the most common reason for use of cast treatment. There was no change in the number of radiographs obtained per patient. The charges for brace treatment were $920 less per patient than for cast treatment, leading to an estimated cost savings following intervention of $82,800. Furthermore, 98% of patients treated in a brace did not return for follow-up, saving each patient an average of $70 per visit in lost wages and travel and childcare expenses.

Conclusion: Implementation of brace treatment for DRBF using QI methodology at two tertiary care centers resulted in a shift towards brace treatment in the majority of patients (56%), leading to substantial cost savings. Although patient preference was cited as the most common reason for persistent cast treatment, the data demonstrate the use of cast treatment to be more dependent upon individual provider preference.

Significance: Quality improvement methodology can be utilized to enact and track implementation of medical evidence into practice, although barriers still exist that may be individual provider-dependent.


Proportion of Patients Treated w/ Brace Per 100 Diagnosed Buckle Fractures
Oct 2015 thru Sep 2016
Chart Area
Proportion of Patients w/ Brace Tx per 100 Diagnosed Buckle Cases
100
90
80
70
60
50
40
30
20
10
0
Hospital B Intervention
Hospital A Intervention
Oct-15 (n=25)
Nov-15 (n=20)
Dec-15 (n=13)
Jan-16 (n=10)
Feb-16 (n=18)
Mar-16 (n=21)
Apr-16 (n=23)
May-16 (n=42)
Jun-16 (n=25)
Jul-16 (n=15)
Aug-16 (n=10)
Sep-16 (n=06)
Month
Hospital A Proportion Treated w/Brace
Goal (80)
Hospital B Median
Hospital A Median
Hospital B Proportion Treated w/Brace

Patient Satisfaction in a High Volume Academic Clinic: Do Physician Assistants and Residents Help or Hurt?

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Purpose: Patient satisfaction is a common metric to evaluate physicians and hospitals. Achieving high satisfaction scores is challenging in a high volume clinic. To improve access to care, mid-level providers are utilized, including physician assistants (PAs). It has yet to be reported whether a patient's satisfaction is influenced by the level or quantity of providers seen at a consultation visit. The purpose of this study was to determine if a patient's satisfaction with care is impacted by these factors.

Methods: English speaking patients who presented to a single tertiary outpatient pediatric orthopaedic clinic were prospectively surveyed over a six-week period. The survey included six questions from the institution's Press-Ganey satisfaction survey (score 0-5). In addition, the satisfaction responses were summed to achieve an overall satisfaction score (score 0-30). Patients were asked to report their estimated total visit time (perceived time). Actual total visit times were extracted from electronic medical record. The Press-Ganey results were compared using a two-tailed analysis of covariance (ANCOVA) with an alpha level of 0.05.

Results: A total of 429 surveys were returned for an overall response rate of 49%. Of those surveyed, 88 (21.2%) were seen by a PA only, 102 (24.6%) by a PA and attending, 122 (29.4%) by a resident and attending, and 103 (24.8%) by an attending only. In general, patients were more unsatisfied when seen by multiple providers, specifically a PA and an attending (p=0.0396), than a single provider (PA or attending). Also, satisfaction was lower at an initial consultation visit compared to follow-up (p=0.0175). As a patient perceives a longer overall time spent in clinic, they are more unsatisfied in terms of the adequacy of the explanation of care provided (p=0.007) and the likelihood of recommending the provider (p=0.006); However, there was no association with any measure of satisfaction when considering the actual time spent in clinic.

Conclusion: We found that a patient's perception of time spent at a pediatric orthopaedic office, rather than the actual amount spent, impacts patient satisfaction. Our findings further indicate that seeing multiple providers in a single visit may negatively impact their satisfaction with the care received. As patient reported satisfaction becomes increasingly important to healthcare systems, limiting the quantity of medical professionals seen in a single visit may help to both engage patients and increase their satisfaction with that visit.

Significance: A patient's perception of time is more impactful on satisfaction than actual time spent at pediatric orthopaedic outpatient visits.

The Anxiety of Pediatric Orthopedic Patients from Surgery Can Be Reduced by Neuropsychological Intervention

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Purpose: Anxiety had been reported in 40-60% of children awaiting surgery that might affect the dosage of anesthesia and postoperative compliance. Our research goal is to verify the effect of neuropsychological intervention in reducing the anxiety of children before orthopedic surgery.

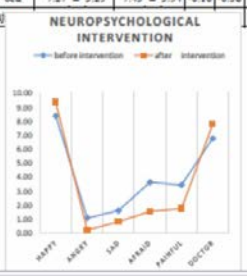
Methods: A group of 72 children aged from 4 to 12 years, 32 boys and 40 girls, awaiting orthopedic surgery was randomized to receive either neuropsychological intervention or plain accompany as control group for one hour. Self-assessment was done for visual analogue scare (VAS) on both anxiety (feeling happy, angry, sad, afraid and painful) and acceptance of the medical situation (doctor, gown, bed and injection) before intervention, after intervention and after orthopedic surgery. Covariant factors includingbackground information of children and parents were analyzed for the effect of intervention on reducing the stress and promoting acceptance.

Results: Before surgery, neuropsychological intervention reduced significantly the stress ($p<0.05$) in all emotional parameters and while accompany only reduced the angry emotion. Neuropsychological intervention significantly improved acceptance of doctor ($p<0.05$) while accompany could not. After surgery, the effect of intervention on feeling angry, sad and afraid remained while the feeling of angry increased in control group ($p<0.05$).

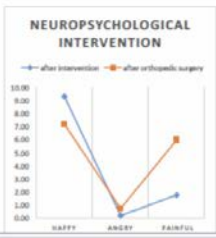
Conclusion: The emotional stress could be reduced and acceptance of medical situation improved by neuropsychological intervention before surgery while effect of some emotional parameters might remain after surgery.

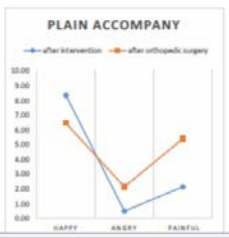
Significance: If the anxiety of children awaiting orthopedic surgery is a concern to either orthopedic surgeon or the family, neuropsychological intervention might be helpful in reducing it.

	neuropsychological intervention group (n=37)					plain accompany group (n=35)				
	before intervention mean ± SD	after intervention mean ± SD	mean	t	p	before intervention mean ± SD	after intervention mean ± SD	mean	t	p
status of stress (anxiety)										
happy	8.36 ± 2.13	9.34 ± 1.46	-0.97	-2.73	.010*	8.06 ± 3.08	8.42 ± 3.13	-0.35	-0.92	.366
angry	1.07 ± 2.03	0.19 ± 0.52	0.88	3.17	.003**	1.45 ± 2.89	0.73 ± 2.17	0.72	2.28	.029*
sad	1.61 ± 2.59	0.81 ± 1.88	0.80	2.20	.034**	1.45 ± 2.86	0.74 ± 2.39	0.70	1.83	.076
afraid	3.63 ± 3.94	1.54 ± 2.78	2.09	3.93	.000**	2.68 ± 3.72	1.49 ± 3.22	1.18	1.93	.063
painful	3.43 ± 3.65	1.74 ± 2.87	1.70	4.04	.000**	3.04 ± 4.12	2.32 ± 3.71	0.72	1.26	.217
medical situation acceptance										
doctor	6.77 ± 3.33	7.78 ± 2.79	-1.01	-2.22	.033*	7.59 ± 2.91	7.41 ± 3.52	0.18	0.35	.727
close	5.73 ± 3.71	5.02 ± 4.08	0.71	1.47	.149	5.90 ± 4.15	4.91 ± 4.49	0.99	1.54	.132
bed	7.27 ± 3.25	7.43 ± 3.54	-0.16	-0.38	.706	7.99 ± 3.02	8.18 ± 3.04	-0.19	-0.50	.624
inj										.563



	neuropsychological intervention group (n=37)					plain accompany group (n=35)				
	after intervention mean ± SD	after orthopedic surgery mean ± SD	mean	t	p	after intervention mean ± SD	after orthopedic surgery mean ± SD	mean	t	p
status of stress (anxiety)										
happy	9.32 ± 1.48	7.19 ± 3.63	2.13	3.43	.002**	8.33 ± 3.24	6.44 ± 3.98	1.89	2.53	.017*
angry	0.20 ± 0.52	0.74 ± 2.18	-0.54	-1.57	.126	0.49 ± 1.52	2.13 ± 3.87	-1.64	-2.45	.020*
sad	0.83 ± 1.90	1.46 ± 2.78	-0.63	-1.30	.202	0.50 ± 1.85	1.04 ± 2.73	-0.54	-0.91	.369
afraid	1.58 ± 2.81	1.48 ± 2.84	0.10	0.16	.871	1.32 ± 2.98	1.27 ± 2.88	0.05	0.08	.936
painful	1.78 ± 2.89	6.00 ± 4.25	-4.21	-5.26	.000**	2.13 ± 3.60	5.38 ± 4.45	-3.25	-3.81	.001**
medical situation acceptance										
doctor	7.72 ± 2.81	6.87 ± 3.64	0.85	1.59	.122	7.32 ± 3.61	7.68 ± 3.41	-0.36	-0.75	.461
close	4.88 ± 4.05	5.60 ± 4.03	-0.73	-1.20	.237	4.59 ± 4.51	5.09 ± 4.02	-0.50	-0.65	.518
bed	7.36 ± 3.57	7.57 ± 3.20	-0.21	-0.44	.66	8.01 ± 3.13	7.83 ± 2.94	0.18	0.38	.708
injection	2.70 ± 3.82	2.48 ± 3.84	0.22	0.57	.573	2.92 ± 4.15	3.39 ± 4.27	-0.47	-0.69	.496





Comparison of Rigid Synthetic Casts with Soft (Semi-Rigid) Casts for the Treatment of Minimally-Displaced Forearm Fractures in Children: A Randomized Controlled Trial

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Purpose: Immobilisation of minimally-displaced forearm fractures in either a rigid (Delta cast, BSN Medical) or semi-rigid cast (Delta-cast soft, BSN Medical) produces good radiological and functional outcomes in children. This study assessed the financial and logistical benefit of a semi-rigid casting tape which is removed by the caregiver at home, in comparison with rigid synthetic cast therapy.

Methods: This randomised controlled trial compared soft and rigid synthetic casts within the fracture clinic of a major paediatric hospital. Local ethical approval was obtained for the study protocol. 214 children presenting with minimally displaced forearm fractures were randomised to either rigid synthetic or soft cast. Those with soft casts were taught how to remove the cast at home at a specified time and those with rigid cast attended clinic for cast removal. Questionnaires were administered at 6 weeks to assess patient's comfort, ease of removal, time and money lost by patients and caregivers to attend clinic and overall satisfaction. Statistical analyses were performed with SPSS, median values quoted and range in brackets.

Results: 105 children were treated with rigid cast and 109 soft cast. Median ages in each group were comparable, 9.25 years (0-16 years) in rigid cast group and 9.17 years (0-15.5years) in soft cast cohort. Patient/caregiver-reported satisfaction was similar between the two groups, with a trend for improved comfort in the soft cast group ($p=0.09$). Immobilisation with rigid synthetic cast was associated with an additional clinic appointment for removal of cast. This extra clinic appointment conferred the following: median 45 minutes (range 5mins to 3 hrs) spent in clinic, 3 hours missed from school for the patient (0-7 hrs) and 3 hours of parental time off work (0-8hrs), financial loss for the caregiver in lost income was $160 ($50-$350) and transport costs $10 (0-$60). Additional hospital clinic costs for cast removal (including staff costs) were estimated at $120 per visit. 2 patients with rigid casts represented with discomfort and required recasting. No other adverse events were reported.

Conclusion: Use of soft cast immobilisation in non-displaced forearm fractures in children is effective, acceptable to patients and caregivers and associated with less time missed from school for the patient, fewer hours missed work for the caregiver and a smaller financial loss for the caregiver compared with rigid cast immobilisation.

Significance: This is the first study to evaluate time and financial losses associated with traditional rigid cast therapy for nondisplaced forearm fractures when compared with soft cast immobilisation.

Hoverboard Injuries in Children and Adolescents

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Purpose: Hoverboards have recently become popular among children. Multiple centers have noted orthopedic injuries in children while riding hoverboards. The common injuries associated with this new device have not been reported before. We report results of a multi-center study regarding hoverboard injuries in children and adolescents.

Methods: Children that presented with extremity fractures while riding hoverboards during a two-month period (12/1/20151/31/2016) were included in the study. The data was collected from twelve pediatric orthopedic centers. Patients with high energy trauma, bone cysts, and know metabolic bone diseases were excluded. Data was collected retrospectively using electronic medical records. Circumstances of the injury, location and severity of the fracture, associated injuries, and the required treatment were recorded for all patients. Descriptive analysis was performed to report the most common injuries.

Results: 78 patients (51 male, M/F ratio: 1.8) with average age of 11± 2.4 years were included in the study. Upper extremity fractures were seen in 86% (67 of 78) of the patients and lower extremity fractures were seen in 14% (11 of 78). From the 67 patients with upper extremity fractures, 43 (64%) were treated by immobilization alone, 14 (20%) were treated by closed manipulation, and 10 (14%) were treated by operative treatment including percutaneous or internal fixation. 6 open fractures of the distal phalanges were reported and all required surgical intervention. From the 11 patients with lower extremity fractures, 6 (55%) were treated by immobilization alone, 2 (18%) were treated by closed manipulation, and 3 (27%) were treated by operative treatment including percutaneous or internal fixation. Distal radius fractures were the most common fracture type (55%) followed by humerus fractures (15%), hand fractures (10%), and ankle fractures (8%). 8 patients (10%) required inpatient admission for the treatment of the fracture.

Conclusion: We report the first series of children with upper and lower extremity fractures associated with hoverboard injuries. Upper extremity injuries especially fractures of the distal radius metaphysis are the most common. Close to half of all the fractures are severe enough to require either closed manipulation or operative treatment. Open fractures of the distal phalanx were seen with an unusually high frequency in these injuries.

Significance: Due to the high rate of distal radius fractures, protective gear such as wrist guards may be beneficial while using this device. Children and guardians should be warned about the high risk of distal phalanx injury while using hoverboards.

Missed Scheduled Appointments in the Pediatric Orthopaedic Outpatient Clinics: A Root-cause Analysis

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Purpose: The purpose of our study is to identify characteristics of patients who miss scheduled pediatric orthopedic surgery clinic appointments at an urban academic center.

Methods: We queried the number of scheduled pediatric orthopaedic surgery outpatient clinical appointments via our electronic medical record system from July 2015-January 2016. We classified these appointments as: no-show, rescheduled, cancellation, or attended. In statistical analyses, visits that resulted in a no-show, rescheduled appointment, or cancellation were defined as absent. Absent and attended groups were then compared based on the following independent factors: visit type (new or return visit), and patient characteristics including age, sex, race, insurance status, and distance lived from clinic. A telephone survey of patients who missed appointments was also conducted. They were asked open-ended questions regarding what factors influenced their ability to attend appointments, and specific questions regarding transportation, weather, time off work/school, childcare, cost, appointment reminders, wait time in office, ethnicity, and language barriers.

Results: 1,712 clinic appointments were analyzed. 1,192 (70%) were defined as attended. The remaining 520 appointments resulted in an absence. There was a statistically significant difference between appointments that resulted in absence and appointments that resulted in attendance with respect to the patient's age ($p=0.0012$), distance lived from clinic ($p=0.0029$), insurance type ($p<0.0001$), and visit type ($p=0.0400$). The median age for the attended group was 7.6 years (IQR: 2.8, 12.4). The median age for the absent group was 9.0 years (IQR: 3.9, 14.1). The median distance for the attended group was 15 miles (IQR: 2.5, 27.5). The median distance for the absent group was 20 miles (IQR: 6.5, 33.5). For patients who were uninsured 44.3% of visits resulted in absences compared to 35.7% of Medicaid/Children's Special Health visits and 24.8% of private insurance visits. Return visits were more likely to result in absences (31.8%) than new patient visits (26.8%). Response rate for the telephone survey was 18% (28/154). Time off work/school, weather, transportation, lack of reminder, and schedule conflicts were cited as reasons for missed appointments.

Conclusion: Age, distance lived from clinic, insurance type, and visit type are statistically significant factors influencing attendance of scheduled pediatric orthopedic surgery clinic appointments at an urban academic center.

Significance: Based on these findings further efforts can be directed toward addressing these barriers to improve attendance at scheduled pediatric orthopaedic outpatient clinic appointments and support patient care.

Online Rating of Orthopaedic Surgeons on HealthGrades

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Purpose: With expansion of social media, patients are using physician online review sites to research physicians and select where they seek care. The largest of these online review sites is HealthGrades.com which primarily uses patient submitted data to rate providers. Previous studies looking at online reviews used only small data samples. The primary goal for this study was to analyze a near complete database of online reviews of orthopedic surgeons and to more accurately determine relationships between physician characteristics, the number of reviews and overall provider ratings.

Methods: Web scraping is a computer software technique of extracting information from websites. A proprietary web-scraping tool was programmed to pull data from HealthGrades.com and a catalog of every orthopedic surgery provider listed on the site. Data collected for each provider included: the surgeon's name, state of practice, zip code, overall rating, number of reviews, sex, type of degree, and number of years in practice. This data was then analyzed to determine the effect of sex, location, age and number of reviews on a providers rating.

Results: A total of 33,585 orthopaedic surgeons were listed on HealthGrades in which 26,062 (78%) had patient reviews consisting of 337,402 individual reviews. For those with online reviews, the average number of reviews was 14 with 50% having less than 10 reviews and 8% having only 1 review. Most reviews were positive with 71% of orthopedic surgeons having an overall positive online rating $\geq$ 3.7 out of 5. There were 9 times as many physicians with the maximum score of 5/5 (4,677) as there were physicians with the minimum score of 1/5 (522). We found no difference in the average rating between female and male physicians or MD and DO physicians. Regional variations were all minimal. Providers with more than 7 reviews, overall ratings were nearly always positive (average 4/5).

Conclusion: Most orthopaedic surgeons have been reviewed on HealthGrades.com with the majority of providers being rated positively. As most reviews were positive, an increasing number of reviews per provider correlated with an increase in the overall rating for that provider with most rated 4 of 5.

Significance: As the importance of physician online review sites increase, it is imperative that providers actively monitor their ratings on these sites. This analysis shows that increasing the number of reviews will generally result in a positive overall rating. Conversely, having few or no reviews puts the provider at increased risk for a poor overall rating.

Improved Follow-Up to Prevent Harm to Patients Undergoing Guided Growth of the Lower Extremity

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Purpose: In 2015, data was published showing a 12% rate of "lost to follow-up" in patients who underwent guided growth of the lower extremity. Of those who were found for follow-up, nearly one third required surgery beyond implant removal. The purpose of this project was to decrease the number of patients undergoing guided growth who develop iatrogenic deformity due to lack of appropriate follow-up.

Methods: Initially, a registry in our electronic medical record (EMR) was created, where patients had to be manually added by clinic staff when the surgery occurred. In a second phase, an automated registry in the EMR was implemented to track every patient associated with a CPT code for guided growth surgery. If any boy less than 17 years of age, or girl less than 15 years in the registry does not follow-up in orthopedic clinic within 6 months of their last appointment, a nurse is flagged. The nurse then calls the family with a defined script to set up an appointment. If they cannot be reached by phone, a letter is sent. If a patient is flagged for not following up for 3 consecutive months, social workers get involved to get the child back into clinic (unless they are getting follow-up elsewhere).

Results: With our initial registry, only 28% of the patients undergoing guided growth were captured in the registry. Phase two improved our tracking to 100%. From March 1 to Sept 1, 2016, 11 unique patients who did not follow up as recommended were identified. All but 2 have been contacted and brought back in for evaluation. No patients have developed an iatrogenic deformity since we started the Guided Growth Registry. Our current "lost-to follow-up rate" for this group is <2% which is significantly improved from the 12% rate prior to the registry ($p=0.003$).

Conclusion: The use of an automated registry system can prevent "lost to follow up" in patients undergoing guided growth surgery. By ensuring routine follow-up, the plates are removed when the deformity is corrected and before a new deformity is created. The EMR registry is the foundation for identifying and tracking patients, and in addition an effective protocol for getting the patients back in for follow up is critical.

Significance: Development of effective automated patient tracking systems and protocols for ensuring adequate follow-up of at risk patients can improve quality of care. Our registry and follow-up system is currently being expanded to other diagnoses/procedures.

Improved Safety and Cost Savings From Reductions in Cast Saw Burns After Simulation-Based Education for Orthopaedic Surgery Residents

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Purpose: Simulation-based training may improve healthcare value by improving outcomes and minimizing complications. However, there is limited information regarding the cost-effectiveness of simulation curricula. The purpose of this study was to estimate the cost effectiveness of simulation training aimed at reducing cast saw injuries by orthopaedic surgery residents.

Methods: Third-year orthopaedic residents rotating at a children's hospital underwent simulation-based instruction on distal radius fracture (DRF) reduction, casting, and cast removal using an oscillating saw. The incidence of cast saw injuries was analyzed before and after implementation of the simulation curriculum. Actual and potential costs associated with cast saw injuries included wound care, extra clinical visits, and potential total payment (indemnity and expense payments). Curriulum costs were calculated using time-derived activity-based accounting methodology. The costs of cast saw injury and the simulation curriculum were compared to determine overall savings and return on investment (ROI).

Results: In the 2.5 years prior to simulation, cast saw injuries occurred at a rate of approximately 5.5 per 100 casts cut by orthopaedic residents. For the 2.5-year period post-simulation, the cast saw injury rate decreased to approximately 0.7 per 100 casts cut (p=0.002). The total cost to implement the casting simulation-based workshop was $2,465.31 per 6-month resident rotation. Actual costs attributed to cast saw injuries per resident rotation were $65.83 before simulation, and negligible after simulation. Potential total payments for casting or cast saw injury ranged from $5,760 to $26,640 per adverse event. Total estimated savings using the low end of the payment range for the 2.5-year period post-simulation were $18,938, representing a 7 to 1 ROI. Using maximum payment estimates savings were estimated at $91,591 with potential return of 37 to 1.

Conclusion: The simulation-based training for orthopaedic surgical residents was effective in reducing cast saw injuries and had high theoretical ROI.

Significance: These results support further investment in simulation-based training as cost-effective means of improving patient safety and clinical outcomes.

Preoperative Checklists – Effect on Surgical Planning and Practice

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Purpose: Enhancing patient safety is a top priority, and in order to facilitate it a preoperative checklists are used focusing on patient details and the surgical procedure. This is helpful, but supplies only part of the information needed. Surgery is a complex team task with a considerable number of members taking part in the patient care chain. In order to enhance effective teamwork, quality of care and patient safety a two stage preoperative briefing checklist protocol was introduced in July 2014. The first stage includes only the surgeons and the second stage includes all staff members involved in the procedure. The purpose of this study is to present this briefing method and to evaluate the changes in practice in our department following the introduction of this protocol.

Methods: In this study a 2 stage briefing protocol was developed. It presents a broader perspective model of the patient and the planned procedure. In the first stage, performed on the day of the procedure in the briefing room, the surgeons review significant background information and surgical indications, required equipment etc. as listed below. The second stage is performed in the operating theatre with all staff members taking part in the surgery and includes information as listed below. The briefing forms are shown on large posters on the wall of the surgeons briefing room and in the operating room and are read orally as checklists.

Results: During a period of 14 month 164 elective surgical procedures were done and in 143 of them (87.20%) the briefing protocol was conducted and recorded. In 34 cases (23.78%) the surgical plan was changed, in 43 cases (30.07%) planed surgical equipment or patient positioning were changed. In 42.6% the surgical plan was reduced and in 57.8 the plan was enlarged.

Surgeons Briefing	OR Staff Briefing
PT. background + surgical indication	"Time Out"
Imaging review	PT. background + surgical indication
Patient positioning	Anesthesia
Surgical approach	Patient positioning
Detailed surgical stages	Imaging and radiation protection
Surgical instruments & fixation required	Monitoring
Key points	Surgical stages
Adverse events and solutions	Instruments and fixation
Role designation	Key points
Questions and comments	Adverse events and solutions
"Internal weather" (Personal issues)	Questions and comments

Conclusion: Detailed preoperative briefing immediately before surgery significantly changed surgical planning, and reduces time for surgical equipment retrieval.

Significance: Further research is needed to evaluate the effect of preoperative briefing on surgical time, operating room traffic and quality of decisions.

Subspecialty Training among Graduates of Pediatric Orthopedic Fellowships: Analysis of the Database of American Board of Orthopedic Surgery

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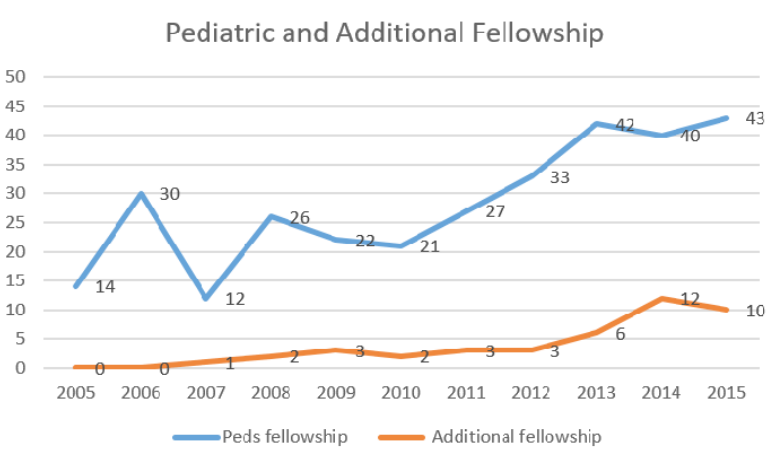
Purpose: A recent survey of pediatric orthopedic fellowship graduates conducted by the Pediatric Orthopaedic Society of North America (POSNA) has shown that a number of graduates seek additional subspecialty training in another discipline. The exact number of graduates and most popular subspecialties of those who pursue a second fellowship in a different subspecialty are unknown. We used the database of the American Board of Orthopedic Surgery (ABOS) to analyze the fellowship training of applicants from 2005 to 2015 taking the part II ABOS exam with a self-declared subspecialty of pediatric.

Methods: The study proposal was approved by the ABOS Research Committee. Fellowship training of part II ABOS pediatric orthopedic subspecialty applicants for the period from 2005 to 2015 was analyzed. Descriptive analysis was performed to calculate the percentage of the applicants with fellowship training in more than one subspecialty and to calculate the most commonly reported subspecialties.

Results: 319 applicants with a self-declared subspecialty of pediatric orthopedics took the part II ABOS oral exam from 2005 to 2015. 310 applicants had done fellowship training in pediatric orthopedic surgery. Fourteen percent (44 of 310) of all those applicants had fellowship training in more than one subspecialty. The number of pediatric orthopedic part II applicants increased from 15 applicants in 2005 to 44 applicants in 2015. Twenty-seven percent (22 of 83) of applicants in 2014-2015 completed two fellowships compared to twelve percent (12 of 102) of the applicants in 2011-2013, ten percent (7 of 71) of the applicants in 2008-2010, and five percent (3 of 56) of applicants in 2005-2007. Sports medicine fellowship was the most common second subspecialty fellowship reported by fifty percent (22 of 44) of the applicants with more than one fellowship. Subspecialty training in spine surgery and upper extremity surgery were each reported by sixteen percent (7 of 43) of the applicants with more than one fellowship (16% spine surgery, 16% hand and upper extremity surgery).

Conclusion: Close to one third of the recent graduates of pediatric orthopedic fellowships reported subspecialty training in another discipline. The percentage of graduates with subspecialty training has increased over the past decade and especially over the past 5 years. Sports



medicine followed by spine surgery and upper extremity surgery are the most common subspecialty trainings sought by pediatric orthopedic surgeons.

Significance: Due to the high number of graduates seeking subspecialty training, there may be a need to further evaluate the educational needs of young pediatric orthopedic surgeons and the training offered by traditional pediatric orthopedic fellowship training programs.

Surgeon Variability and Efficiency: Analysis of a Common Pediatric Orthopaedic Procedure

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Purpose: Operative time is a critical cost driver in orthopaedic surgery, and is an important target for provider organizations focused on improving value-based healthcare delivery. This study aimed to identify surgeon-dependent variability in duration of surgery for an archetypal pediatric orthopaedic procedure: closed reduction and percutaneous pinning (CRPP) of supracondylar humerus (SCH) fracture.

Methods: We performed a retrospective cohort study of consecutive patients treated with CRPP for closed, extension-type SCH fractures at a pediatric trauma center between 2007 and 2015. Fractures were stratified by Gartland classification to assess the effect of surgeon on operative time. Surgeon experience (in years) and quarterly case volume were also evaluated for effect on operative time. Non-parametric statistics were utilized. The cost of operative time was calculated with activity-based costing.

Results: 1,485 patients (49% female, mean age 5.6 ± 2.4 years) underwent CRPP for extension-type SCH fracture, including 57% Gartland type 2 and 43% type 3 fractures. Procedures were performed by 12 fellowship-trained pediatric orthopaedic surgeons with experience ranging from two weeks to 32.8 years. Surgeon's average operative time for type II fractures ranged from 21.3 to 33.7 minutes (mean 27.0 ± 4.0 minutes). For type III fractures, surgeon's averages ranged from 31.0 to 46.8 minutes (mean 36.1 ± 5.4 minutes). When stratified by Gartland type, there was significant surgeon-dependent variability in mean operative time ($p<0.001$, for both type II and III fractures) (Figure 1). Analysis demonstrated no significant effect of quarterly case volume on operative time. Surgeon experience was weakly, negatively correlated with operative time for type III fractures ($r=-0.17$, $p<0.001$). Costs for the bottom quartile of surgeons averaged $542.28 more per procedure ($p<0.001$) than the remaining 75% of surgeons based on a cost of $79.45 per minute (FY 2015).

Conclusion: Average operative time for CRPP of SCH fractures varies significantly by surgeon, but is not sufficiently explained by surgeon experience or quarterly case volume. Reducing unnecessary variation in operative time could yield substantial cost reduction.

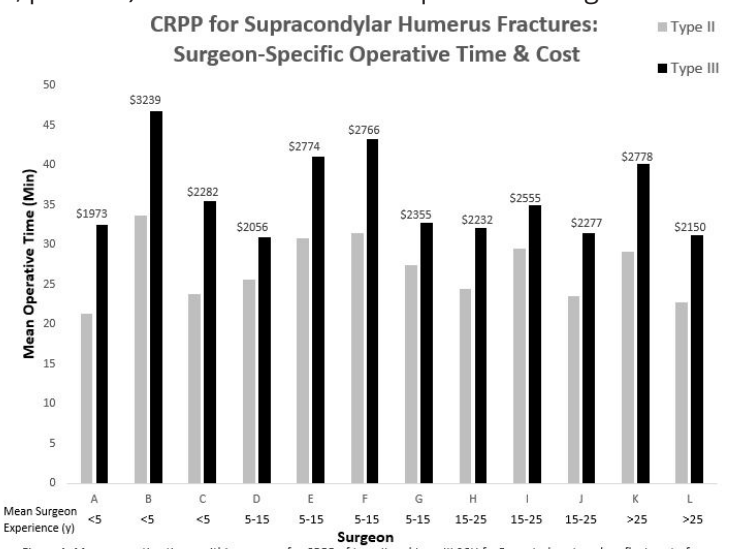

Figure 1: Mean operative times within surgeon for CRPP of type II and type III SCH fx. Reported costs only reflect cost of operating room, surgeon labor, anesthesia labor, and intra-operative nursing labor. Experience is reported as a surgeon's average years of experience within the study window on 2007-2015.

Significance: Differences in operative time between surgeons are not explained by experience or case volume, and suggest idiosyncratic differences in efficiency. The high cost of operative time compounded by the incidence of SCH fractures suggests that even small variations in efficiency have considerable impact on cost and value. Further understanding of surgeon performance and efficiency is needed to disseminate best practices and improve value-based healthcare delivery.

Effectiveness of Casting in Non-Idiopathic Scoliosis

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Purpose: Casting has been shown to be a safe and effective method to delay spinal deformity curve progression or definitively treat infantile idiopathic scoliosis. However, the outcome of casting in syndromic and other non-idiopathic scoliosis is unknown. This study aims to analyze the outcome of casting in non-idiopathic scoliosis.

Methods: An IRB approved review of a consecutive series of prospective EOS patients treated with casting at a single institution. Major coronal angle and thoracic height T1-T12 were collected at pre-treatment and after cast series completion. Cohort was divided into two groups based after cast treatment: operative and nonoperative.

Results: 31 patients completed casting. Diagnoses were categorized as stiff syndromic scoliosis (N=13), eg. arthrogryposis; hyperlax syndromic (N=5), eg. Ullrich dystrophy; static encephalopathy (N=6); NF (N=2); and congenital scoliosis (N=5).
The average age at first cast was 4 (1-9.2), casted for 11 mos (2.4-22.1) with 4.1 (2-9) casts. Pre-cast major curve was 64.8° (40-95) and thoracic height (T1-T12) was 14.4 cm (8.7-1.9); at the removal of the last cast, major curve was 59.4° (11-93) and thoracic height was 15.5 cm (11.6-21.9).
11 patients (35%) in the nonoperative group did not require further surgical intervention. Eight are currently being braced and 3 are under observation. The remaining 20 pts (65%) went on to operative treatments: spinal fusion (7), conventional growing rod (6), MAGEC rods (3), VEPTR (1), HGT with intent of surgery (2), and anterior tether (1). Compared to the operative group, nonoperative was casted at a younger age (3.3 vs. 4.3), has more casts (4.5 vs. 3.9), but was in cast for a shorter time (9.8 vs. 11 months) (Table). Nonoperative had a smaller precast major curve (61 vs. 66.7) and significantly smaller curve after cast (43.9 vs. 68.3, p <.001). There was no difference in diagnoses between operative and nonoperative groups.

	Nonoperative: brace/observe Mean (range)	Operative Mean (range)	All patients
N	11	20	31
First cast age	3.3 (1-6.4)	4.3 (1.5-9.2)	4 (1-9.2)
Number of casts	4.5 (2-9)	3.9 (2-7)	4.1 (2-9)
Months in cast	9.8 (4.7-17)	11 (2.4-22)	11 (2.4-22.1)
Pre-cast major curve (°)	61 (45-85)	66.7 (40-95)	64.8 (40-95)
Pre-cast thoracic height (cm)	14.1 (10.9-18.9)	14.6 (8.7-18.9)	14.4 (8.7-18.9)
Post cast major curve (°)	43.9 (11-67)	68.3 (36-93)	59.4 (11-93)
Post cast thoracic height (cm)	15.9 (13-20.3)	15.2 (11.6-21.9)	15.5 (11.6-21.9)

Conclusion: Casting in non-idiopathic scoliosis may achieve significant delay if the patient is treated at a younger age and obtains ~30% deformity correction. Older patients (> age 4) without obvious correction in cast can be expected to require surgical management and therefore casting is useful only as a delaying tactic.

Significance: Our study demonstrates that casting is an effective method in delaying curve progression in non-idiopathic scoliosis.

Infantile Idiopathic Scoliosis: Factors Affecting EDF Casting Success

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Purpose: Infantile Idiopathic Scoliosis (IIS) is a rare form of scoliosis that affects less than 1% of all patients with idiopathic scoliosis. 52-90% will resolve spontaneously. For those that do not resolve, when untreated it has a high mortality rate, yet early surgical intervention is associated with increased complications. EDF casting is a means of delaying and possibly preventing surgical intervention. The purpose of this study was to better understand which IIS patients respond favorably to EDF casting.

Methods: IRB approved retrospective cohort study. Patients with IIS treated with EDF casting with a minimum 24-month follow-up were included. Clinical records were reviewed for age at treatment, gender, curve type. Radiographs were reviewed for initial, in cast, traction, and final Cobb out of cast. Outcomes were defined by the Cobb angle at final follow-up out of cast. Patients were considered cured if final Cobb was <10°, palliated at 11-45°, and failed if they required surgical treatment.

Results: 57 patients with IIS were reviewed. 26 were excluded for incomplete records or insufficient follow-up leaving 31 patients. There were no failures of treatment. Patients with a Cobb angle >10° in the final cast were 7.3 times more likely to be palliated than if their final cobb was <10° even when adjusted for age. Earlier age at onset of casting (14.9 vs 21.1 months) trended towards statistical significance (p=0.059). Magnitude of initial curvature, flexibility, initial correction, gender, and curve type were not found to be significant. If the Cobb angle is <10° after the final cast, there was a 75% rate of cure.

	Post Treatment cobb <10°	Post Treatment cobb 11-45°	P value
Sex -M -F	 -7 -7	 -11 -6	0.48
Curve type -L thoracic -R thoracic	 -8 -6	 -12 -5	0.48
Age at Initial cast	14.9m	21.2m	0.059
Average cobb at initial treatment	48.2	46.4	0.73
Average percent correction in initial cast	48.9%	45.1%	0.50
Average initial flexibility	58.0%	51.5%	0.32
Duration of casting in months	14.3months	15.6 months	0.65

Conclusion: In our study we found EDF casting to be a valid treatment option with a

high rate of cure when started at less than 20 months of age. We found the highest association with cure was the Cobb angle at the end of casting. Initial curve magnitude, curve flexibility, gender and curve type were not predictive. No patient went on to surgery.
EDF casting is a valid treatment option with better results occurring in patients where casting was started at <20months of age and where curves were casted until <10° when out of their final cast.

Significance: IIS treated with EDF casting has a high cure rate. Final Cobb angle at end of casting is most predictive of outcome. Cobb angles >10° had 7.3x greater risk of not being cured vs cobb <10° when adjusted for age

Posterior Atlantoaxial Fusion with C1 Lateral Mass Screw for Atlantoaxial Instability in Children

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Purpose: In treating atlantoaxial instability, C1 lateral mass screws were reported to allow stronger fixation and drastic reduction of C1. However using C1 lateral mass screws in children is still challenging due to tiny vertebrae size and the bone pathology. The purpose of this study is to evaluate the efficacy of posterior atlantoaxial fusion with C1 lateral mass screw for atlantoaxial instability in children.

Methods: A total of 15 pediatric patients undergoing posterior atlantoaxial fusion with C1 lateral mass screw (6 boys, 9 girls; mean age 7.2 years) were followed for an average of 4.2 years. The pathology included 10 Down syndrome, 1 spondyloepiphyseal dysplasia, 1 cerebral palsy and 1 Coffin-Siris syndrome. Two cases were idiopathic and all the cases had os odontoideum. Bilateral C1 lateral mass screws with C2 pedicle or laminar screws were placed in all cases. We divided the patients into 2 groups (C1 reducible group and irreducible group) and investigated the radiological and clinical outcome of both groups. The data were analyzed by the Mann-Whitney's U test ($p<0.05$).

Results: ADI at extension position was less than 4.0 mm in 11 cases (reducible group), and 4.0 mm or more in 4 (irreducible group). Mean preoperative ADI at flexion was 6.4mm in reducible group and 8.5 mm in irreducible group. Just after surgery, mean ADI in reducible group was significantly smaller than that in irreducible group (1.9 mm and 3.9 mm respectively, $p=0.02$). But at the final follow-up, there was no significant difference in ADI (0.9 mm and 2.2 mm respectively, $p=0.21$), and in SAC (14.3 mm and 14.6 mm respectively, $p=0.71$). Solid fusion was obtained in all cases. Mean rotational range of motion was 62 degrees bilaterally at the final follow-up. Of the 13 cases immobilized in a halo vest after surgery, mean duration of halo vest immobilization was 49 days, but since 2011 it has been shortened to 35 days. No complications concerning screw placement were not observed.

Conclusion: C1 lateral mass screw allowed the reduction of C1 and C1-2 fusion in posterior atlantoaxial fusion for children who have atlantoaxial instability. Screws can be applicable even to children who have tiny vertebrae and bone pathology.

Significance: Posterior atlantoaxial fusion with C1 lateral mass screw is a feasible and an effective treatment for atlantoaxial instability in children.

The Relationship of Age, Skeletal Maturity and Menarche to Spinal Growth During Adolescence

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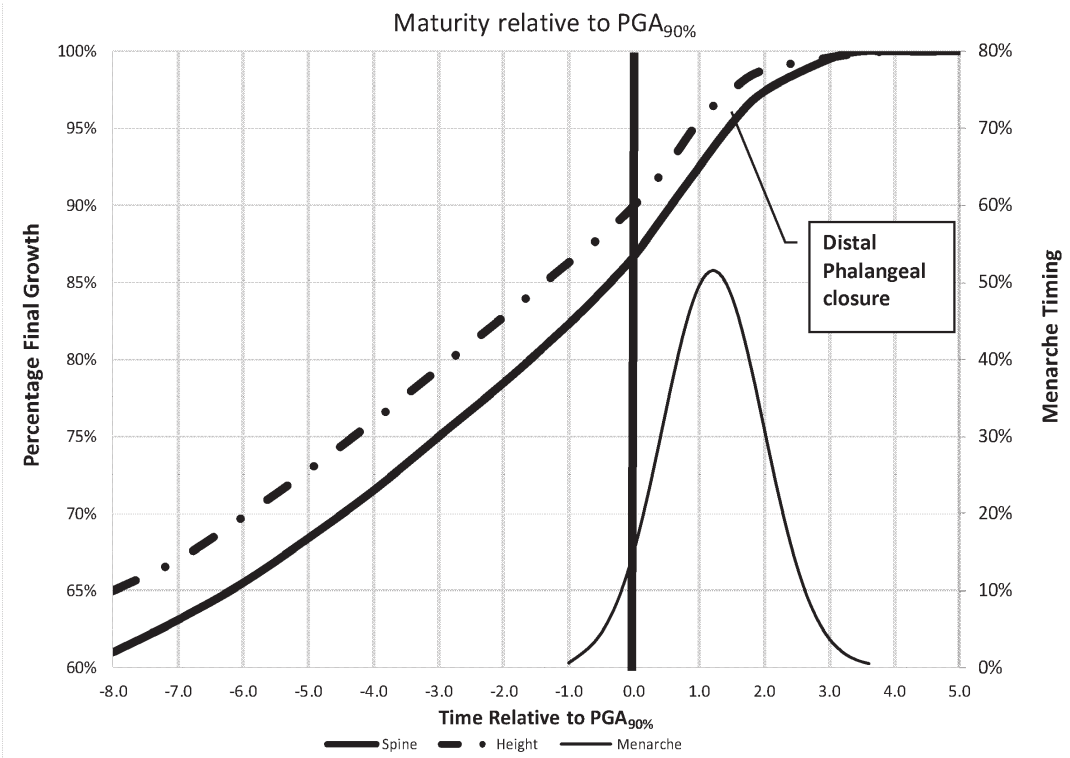
Purpose: Various maturity measurements are currently used to determine prognosis and the end of growth in spinal deformities. They have not been precisely related to either PHV timing or growth completion. This study compares the commonly used indicators of chronological age, menarche, and skeletal maturity of the hand, elbow, and Risser staging to PHV and spinal growth remaining in children.

Methods: A prospective longitudinal cohort of normal children were followed through growth with scheduled interval anthropometrics and radiographs. C1-T1 and T1-S1 lengths were identified by comparing radiographs to anthropometeric measurements. We compared normalized growth remaining (height and spine) and timing relative to peak height velocity (PHV) to concurrent age, hand, elbow, and pelvis skeletal maturity, and, in females, to menarche. Skeletal maturity scales included Greulich and Pyle (GP), Sanders, and Fels methods (hand), Sauvegrain and DiMeglio (elbow), and modified Risser (pelvis).

Results: 54 subjects completed their growth at the study terminus (35f, 19m). All of the maturity indicators correlated strongly with both timing relative to the PHV and spinal growth remaining.
Chronological age has wide distribution about PHV (0.9yr ♀, 0.7yr ♂) and substantial range for growth completion.
Both GP and Fels methods correlate highly with PHV timing (R^2 0.95F, 0.94M). Sanders stages correlate highly with PHV and growth remaining. Hand epiphyseal covering corresponded to growth spurt initiation, distal phalangeal closure to its terminus, and all digits closed to final height.
Both the Sauvegrain and DiMeglio scales correlate well with PHV timing but the elbow matures before growth completion at PHV +1yr.
Risser 1 occurs anytime from after the PHV to final height (rho 0.67) and final height may be achieved at Risser 0. Triradiate cartilage (TRC) status is closely related to PHV timing.
Menarche averages PHV +1.2yr (S.D. 0.6yrs) with a normal distribution having some girls menarchal just before PHV and others near growth completion.

Conclusion: Skeletal maturity is more predictive of spinal growth during adolescence than age. Different maturity assessment methods were informative at different growth stages. The hand and elbow relate closely to the PHV, but the elbow matures before growth termination. Risser sign except for the TRC status is the least reflective of growth remaining. Menarche typically occurs after the PHV but is variable in its timing.

Significance: Spinal growth remaining during adolescence is better determined with skeletal maturity than age or menarche. The hand provides wider ranges of information than the elbow or pelvis. Risser, except TRC and 5, is noninformative.



Risser	0 with open TRC	0 with closing TRC	Closed TRC				
			Risser 0-4				5
Sanders	1	2	3A, 3B	4, 5	6, 7	7, 8	8
Sauvegrain	<11	16 - 20	20.5-24	24-26	26-27	27	
DiMelgio	Pre	1	2,3	4	4,5	5	

Can Application of Best Practice Guidelines for Surgical Site Infection Eliminate Infections in Surgery for Adolescent Idiopathic Scoliosis?

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Purpose: Surgical site infection (SSI) is a known complication in surgery for adolescent idiopathic scoliosis with rates reported between 0.5% and 1.6%. In 2013, Vitale et. al. reported the development of a consensus-based best practice guideline (BPG) for prevention of SSI in high risk pediatric spine surgery patients. The consensus BPG supported 14 SSI prevention strategies: (1) Pre-op chlorhexidine skin wash (2) pre-op urine cultures; (3) patients should receive a preoperative Patient Education Sheet; (4) patients should have a preoperative nutritional assessment; (5) if removing hair, clipping is preferred to shaving; (6) perioperative intravenous cefazolin; (7) perioperative intravenous prophylaxis for gram-negative bacilli; (8) monitored perioperative antimicrobial regimens; (9) operating room access should be limited. (10) UV lights need NOT be used; (11) patients should have intraoperative wound irrigation; (12) vancomycin powder should be used in the bone graft and/or the surgical site; (13) impervious dressings postoperatively; (14) postoperative dressing changes should be minimized before discharge. The purpose of this study was to determine if application of this BPG in patients with AIS would reduce or eliminate infection in AIS surgery.

Methods: Since 2013, we have followed the SSI BPG for all patients having surgery for AIS. 351 consecutive AIS surgical patients were studied. 12 of 14 of the BPG recommendations were followed, with the exception being the routine use of perioperative prophylaxis for gram-negative bacilli, and routine urine cultures in otherwise healthy patients.

Results: All patients had posterior only instrumentation and fusion using reduced density screw constructs. A designated surgical team was developed for the spine service. The average operative time was 168 minutes. Epidural analgesia using two catheters was used for post-operative pain management. A drain was used in all patients and discontinued when output was < 1cc/kg/day. Antibiotics were continued until the drain was out. No patient received an allogeneic blood transfusion. There were no cases of deep surgical site infection in 351 consecutive AIS patients.

Conclusion: Hospital systems have made a strong emphasis regarding the concept of 'Target Zero" for SSI. Consensus-based BPG's are a tool to reduce variability in surgical practice to reduce complications. Eliminating infection in this population improves overall quality of care and lowers costs.

Significance: The BPG for prevention of SSI when applied to patients with AIS has effectively eliminated deep infections in our institution.

Proximal Rib-Based Constructs (VEPTR) in EOS: Survivorship at or near Skeletal Maturity

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Purpose: Rib-based constructs such as the vertical expandable prosthetic titanium rib (VEPTR) device are a commonly employed type of instrumentation for the treatment of early onset scoliosis (EOS). This study aims to examine the longevity of such constructs and to identify risk factors associated with revisions. We anticipate that revision rates of EOS patients with traditional VEPTR devices can be reduced by identifying risk factors.

Methods: We queried an EOS database collected from 15 major institutions for patients who had implantation of traditional VEPTR growing constructs between 2002 and 2011 with 4 or fewer proximal anchors. This yielded a total of 206 EOS patients. Constructs requiring removal or revision were evaluated. Statistical analysis was performed to evaluate the relationship between revision/failures and the following factors: age, Cobb, kyphosis, gender, unilateral vs bilateral constructs, BMI, ambulatory status, and etiology.

Results: Mean age at implantation was 5.8±2.8years. Mean follow-up 6.6±2.4years. Out of total 206 patients, 140 required construct revision or removal and 66 reached final fusion. Risk of revision/removal per each year was calculated as: 26% (year1), 18%(2), 17% (3-4), 16% (5), 13% (6), 11% (7), 0% (8-14). 90% of all revisions and removals occurred in the first 4 years. Severity of Cobb ($P<0.006$), kyphosis>50 ($p<0.021$), age at implantation ≤6 years old ($p<0.001$), and distal anchor fixation to the pelvis ($p<0.02$) were all found to be significant risk factors. Factors such as BMI, gender, unilateral vs bilateral architecture, and etiology did not demonstrate statistical significance.

Conclusion: Proximal hardware complication failures and reoperations are high although modern day rib-based constructs offer additional options. While proximal hardware complications decrease over time during implantation, rates of revision are quite high after traditional VEPTR. Revision rates can be improved with distal anchors to the spine, while younger patients with severe kyphoscoliosis are at greatest risk.

Significance: In the surgical treatment of patients with EOS using VEPTR, complication risks and reoperations are often high. While modern day rib-based constructs offer additional proximal fixation options, patient risk factors identified in this study need to be considered during preoperative planning.

Raising MAP Alone Restores 27% of Intraoperative Neuromonitoring Losses in Prospective Study

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Purpose: Our purpose was to assess the effect of raising blood pressure in restoring intraoperative neuromonitoring IONM signals in pediatric spine surgery.

Methods: In this multicenter, prospective study, patients age 1-18 undergoing posterior spinal fusions were enrolled at their preoperative appointment. Surgeons completed an intraoperative data form on patients who experienced a significant IONM change defined as 50% or greater decrease.

Results: 455 patients were enrolled, and 33 (7%) had IONM change. These 33 patients had the following diagnoses: idiopathic scoliosis (36%), neuromuscular scoliosis (15%), early onset scoliosis (9%), spondylolisthesis (9%), congenital scoliosis (3%), and other (27%). Mean age at surgery was 12 years. 27% (9/33) had return of signals due to an increase in blood pressure (BP) alone, with no other interventions, [mean arterial pressure (MAP) was increased from a mean of 71 (range: 51-84) to 84 mmHg (range: 55-100)]. Signals returned to baseline after a mean of 14 min (range: 1-45). In 52% of patients (17/33), MAP was raised from a mean of 71 mmHg (range: 60-84) to 85 mmHg (range: 70-100) in conjunction with other interventions, which included loosening set screws (29%), removing compression or distraction (24%), removing traction (18%), and providing warm saline (18%). In this group, signals normalized after a mean of 23 min (range: 3-59). Six (18%) patients had signals return to baseline after a mean of 11 minutes (range: 3-17) in which MAP did not change appreciably, with interventions included bending rods (67%), loosening set screws (50%), and removing compression or distraction (33%). All patients had return of signals at the conclusion of the procedure. 3 patients had neurological sequelae from presumed nerve root injuries (one patient with costal nerve sensory changes, two patients with 4/5 EHL and anterior tibialis following spondylolisthesis surgery).

Conclusion: In this prospective study of 455 pediatric spinal deformity surgeries, 7% experienced an IONM change. 27% of these returned to baseline signals with raising the MAP from a mean of 71 to 84 mmHg, while 52% of them returned to baseline after elevating the BP in conjunction with other interventions.

Significance: Raising MAPs to 85 mmHg should be considered the first step in response to IOMN signal changes, as this alone was successful in 27% of patients in this prospective series.

Natural History of Sagittal Spinal Alignment in Children with Achondroplasia

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Purpose: Sagittal spinal deformity is common in children with achondroplasia. However, there is little data on their normative sagittal spinal parameters. This study aimed to report the natural history of spinopelvic parameters in achondroplasia.

Methods: Lateral standing spine radiographs of children with achondroplasia were reviewed retrospectively. Children who had spinal surgery were excluded. A cross sectional analysis included one radiograph per patient per year. Radiographs were divided into yearly age groups. Measurements included thoracic kyphosis, lumbar lordosis LL, thoracolumbar kyphosis TLK: T10-L2, pelvic incidence PI, T1 pelvic angle TPA and sagittal balance SVA. A comparison between the age groups was performed.
A longitudinal subgroup of children with minimum five-year radiographic evaluation was identified. Evolution of radiographic measurements over follow up was assessed.

Results: Records of 315 children were reviewed, 33 had surgery and were excluded. In the cross sectional analysis, 745 radiographs from 282 children were measured. During the first 3 years of age, TLK decreased and LL and sacral slope increased significantly. After age 3 years, TLK decreased gradually until age ten and remained stable. PI increased gradually after age ten.
In the longitudinal subgroup, 81 children were followed for an average of 8.7 (5-19) years. TLK decreased and LL and PI increased significantly (Table). This was consistent with the cross sectional data. TPA and SVA remained within the normal range although changes with growth were statistically significant.

Children with minimum 5 year follow up (81 Children)	*First Radiograph*		*Last Radiograph*		*p values*
	Mean	*SD*	*Mean*	*SD*	
Age (years)	4.4	3.3	13.1	4.3	**<0.0001**
Thoracic Kyphosis	18	12	16	10	0.221
Lumbar Lordosis	57	17	63	18	**0.037**
Thoracolumbar Kyphosis	22	15	12	13	**<0.0001**
Sacral Slope	48	12	52	13	0.058
Pelvic Tilt	-5	13	-3	14	0.259
Pelvic Incidence	43	15	49	16	**0.016**
T1 Pelvic Angle	-5	11	-9	8	**0.010**
Sagittal Balance (mm)	7	28	-8	26	**0.0004**

Table: Tabular summary of longitudinal data of 81 children with a mean follow up of 8.7 years.

Conclusion: In children with achondroplasia, improvement in thoracolumbar kyphosis occurs primarily before three years of age and hyperlordosis at the lumbosacral level is the compensatory mechanism. Pelvic alignment and hip positioning are directly affected by this mechanism. Significant changes in the sagittal spinal parameters occur early in life suggesting the importance of attention to sagittal malalignment to prevent any possible clinical sequelae of severe hyperlordosis.

Significance: A cross sectional and longitudinal study of 315 children with achondroplasia showed that thoracolumbar kyphosis improves significantly during the first three years of age and hyperlordosis at the lumbosacral level is the compensatory mechanism. Pelvic alignment and hip positioning are directly affected by this mechanism. After three years of age, thoracolumbar kyphosis gradually improves until age ten. While pelvic incidence is stable before age ten, it increases gradually afterwards.

Postoperative Changes in Pulmonary Function 5 Years after Surgical Correction of Adolescent Idiopathic Scoliosis

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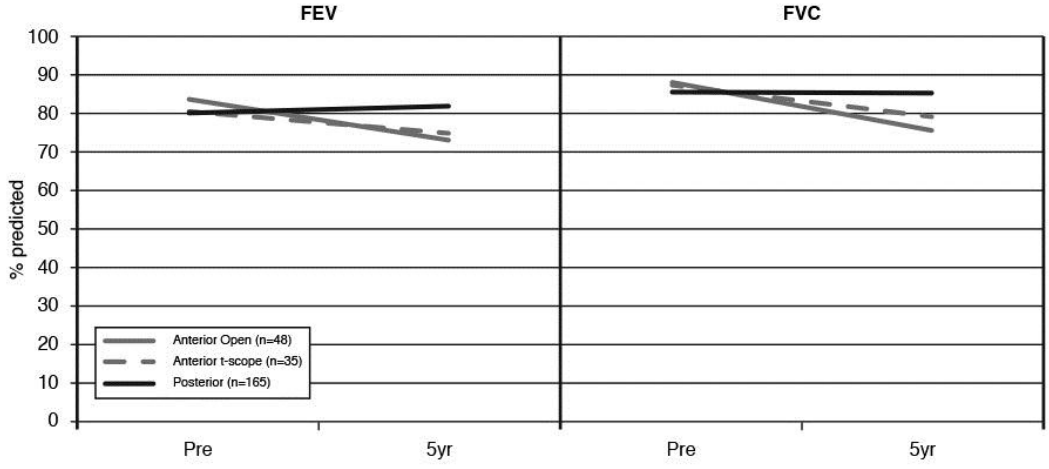
Purpose: Multiple studies have investigated the effect of adolescent idiopathic scoliosis (AIS) surgery on predicted pulmonary function tests (PFT) at 2yrs postop. The purpose of this study was to evaluate changes in PFT at 5yrs postop and determine whether these changes are progressive or static after 2yrs.

Methods: AIS surgical patients from a prospective multi-center registry with % predicted forced expiratory volume (FEV) and forced vital capacity (FVC) at pre-op and 5yrs after surgery were included. Pulmonary impairment was categorized using American Thoracic Society guidelines; >80% normal, ≤80 to >65% mild, ≤65 to ≥50% moderate, <50 severe impairment. A sub-analysis of patients with 2yr data as well was performed to determine if PFT changes were static or progressive over the 5yr period.

Results: 262 patients had preop and 5yr PFTs. Overall there was a decline in % predicted FVC ($p<0.05$) while FEV remained stable. There was no difference based on major curve (Lenke 1-4 vs 5-6, $p>0.05$). Anterior instrumentation cases (open & thoracoscopic) declined significantly between pre and 5yr in FEV and FVC ($p<0.02$), whereas the posterior cases remained stable ($p = 0.7$, $p=0.06$, Graph). At 5 years postop, 42% were normal, 41% had mild impairment, and 17% had moderate-severe impairment. A subgroup of 90 patients with 2yr PFTs had similar findings. Average percent predicted (FVC & FEV) showed gradual decline between pre, 2, and 5yrs; with significance between pre and 5yr ($p<0.05$). Differences over time existed based on approach; the anterior open group had an average of 9% decrease in FVC between 2 and 5yrs, which was significantly greater than the 0.7% increase in the posterior only ($p=0.015$).



Conclusion: From preop to 5yrs postop there is a decline in PFTs for patients who underwent anterior instrumentation (open & thoracoscopic). This decline was pro-

gressive with further decline beyond 2yrs postop of a modest 4-10%. Patients that underwent posterior instrumentation remained stable.

Significance: From preop to 5 years postop there is a significant decline in PFTs following anterior surgical correction of AIS. Patients who underwent posterior instrumentation remained stable over the 5 years.

A Comparison of Sublaminar Wires versus Pedicle Screws in Posterior Spinal Fusion in Patients with Cerebral Palsy: A Matched Cohort Analysis

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Purpose: Scoliosis requiring operative intervention is common in children with cerebral palsy (CP). Traditionally, spinal fusion was performed with sublaminar wires and unit rods. More recently, posterior-only pedicle screw fixation is being utilized with increasing frequency. The purpose of this study was to compare the outcomes of CP patients with scoliosis who underwent posterior spinal fusion using a pedicle screw construct versus those who underwent a sublaminar wire construct.

Methods: A retrospective review identified 27 patients who underwent PSF with sublaminar wires and Unit rods from 2010-2012. All patients had a diagnosis of CP, GMVCS level IV or V. This cohort was then matched to a group of patients from 2012-2014 who underwent PSF using all pedicle screw constructs.. The patients were matched for GMFCS level, age, weight, main curve Cobb angle, and medical comorbidities. All patients were followed for greater than 2 years. Data collected included age, surgical details,length of stay (LOS), complications, and Cobb angle correction. Comparisons were made with t-tests and Chi-squared analyses, or non-parametric equivalents, with significance set at $p<0.05$.

Results: 27 patients with a mean preoperative Cobb angle of 90^{o} in the sublaminar wire cohort were compared to an all pedicle screw matched cohort with a mean preoperative Cobb angle of 78^{o}($p=0.28$). The surgical time and EBL were statistically higher in the sublaminar wire group(5.5 hr vs 3.33 hr, $p<0.00001$, and 1070 cc vs 865 cc, $p=0.05$). There were more complications in the sublaminar wire cohort($p=0.03$). There was no differences in the %Cobb angle correction between the two groups (57 and 58%, $p=0.41$)

Conclusion: In a matched cohort of CP patients with scoliosis undergoing posterior spinal fusion surgery, the use of an all pedicle screw construct resulted in less operative time, less blood loss, and less complications when compared to the sublaminar wire group.

Significance: The use of an all pedicle screw construct versus a sublaminar wire technique may improve outcomes amongst CP patients undergoing scoliosis surgery. Future studies should investigate the value of using screws in this patient population to determine if outcomes are truly improved and cost beneficial.

Body Mass Index Affects Brace Wear Compliance in Children with Adolescent Idiopathic Scoliosis

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Purpose: Bracing is routinely used in the treatment of adolescent idiopathic scoliosis (AIS) to prevent curve progression. Prior studies have demonstrated increased body mass index (BMI) in children may influence curve progression or the need for surgery. The purpose of this study was to determine whether measured compliance with brace wear or the eventual progression to surgery is influenced by BMI.

Methods: One hundred and seventy-four patients with AIS were reviewed. All patients were prescribed brace wear and followed until bracing was completed or surgery was recommended. Brace wear compliance was objectively measured using thermal monitors in all braces. BMI was recorded when the decision to initiate bracing was made. Patients were divided into three groups based on BMI. Groups were analyzed as low BMI (<5th percentile for age as defined by CDC), middle BMI (5th to 85th percentile), and high BMI (>85th percentile). Those patients whose BMI was >95th percentile (obese) were analyzed separately within the high BMI group for brace compliance.

Results: The mean age at brace initiation was 12.3 years. Daily brace wear averaged 15.7, 12.6, 11.0, and 9.4 hours in the low BMI (n=15), middle BMI (n=129), high BMI (n=30), and obese groups (n=9), respectively. Brace wear compliance differed significantly in the low BMI group when compared to the high BMI group (p=0.004), and when compared to the middle BMI group (p = 0.038). Progression to surgery or curve magnitude ≥50 degrees was seen in 9 of 15 (60%) patients in the low BMI group. This was significantly higher compared to the middle and high BMI groups where 33 of 129 (25.6%) and 11 of 30 (36.7%) patients progressed to surgical curve magnitude, respectively (p=0.013). There was no significant difference in the rate of surgery between the middle and high BMI groups.

Conclusion: Patients in the low BMI group demonstrated the highest risk for progression to surgery. Low BMI appears to be an independent risk factor for brace failure despite increased wear hours. Increasing BMI, as demonstrated in the >85th percentile group, was associated with reduced brace wear compliance. Despite the reduction in brace wear hours in the high BMI group, there was not an increased risk of progression to surgery.

Significance: Brace wear in children with body mass indexes greater than the 85th percentile demonstrates lower rates of compliance, but does not result in significantly increased rates of progression to surgical magnitude curves.

Comparison of Operative versus Non-Operative Treatment of Scheuermann's Kyphosis

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Purpose: The purpose of this single institution study was to compare the presenting and two year radiographic and SRS-22 results of patients who self-selected either conservative or surgical treatment for their Scheuermann's kyphosis.

Methods: This study included prospectively enrolled patients presenting with Scheuermann's kyphosis from 2006-2014. Of the 55 originally enrolled patients, 45 returned for two year follow up. These patients were divided into operative (n=27) or non-operative (n=18) groups based upon their selected method of treatment. SRS-22 scores and radiographic data (including sagittal Cobb angle) were collected at initial presentation and at two year follow up.

Results: Operatively treated patients had larger initial sagittal Cobb angles and significantly lower SRS-22 scores in the pain and appearance domains (Table 1 and 2). At two years post-op, surgically treated patients had smaller radiographic measurements and better scores in these SRS-22 domains. The non-operatively treated patients displayed no significant changes between their initial presentation and two year follow up and also did not deteriorate over time.

Conclusion: Patients who elect to receive operative treatment for Scheuermann's kyphosis initially demonstrate greater sagittal Cobb angles, pain, and dissatisfaction with their appearance. At two year follow up, surgical patients experience significant improvement on all parameters; exhibiting smaller Cobb angles, less pain, and greater satisfaction with their outcomes (Table 3 and 4).

Significance: Patients selecting to undergo operative treatment for Scheuermann's kyphosis show improved SRS-22 scores at 2 years follow-up compared to patients who select non-operative interventions. Patients treated non-operatively do not demonstrate a negative progression of results over time.

Table 1. Initial Presentation

	Non-Operative	Operative	P-value
Sagittal Cobb	67.17°	82.19°	0.0004
SRS-22 Pain	4.18	3.67	0.0082
SRS-22 Appearance	3.73	3.07	0.0055

Table 2. Two Year Follow-Up

	Non-Operative	Operative	P-value
Sagittal Cobb	68.47°	49.63°	0.0000
SRS-22 Pain	4.09	4.40	0.1031
SRS-22 Appearance	3.61	4.28	0.0003

Table 3. Non-Operative Patients

	Initial Presentation	2 Year Follow-Up	P-value
Sagittal Cobb	67.17°	68.47°	0.2010
SRS-22 Pain	4.18	4.09	0.8130
SRS-22 Appearance	3.73	3.61	0.5740
SRS-22 Satisfaction	3.63	3.44	0.4140
SRS-22 Total	4.03	3.95	0.5580

Table 4. Operative Patients

	Initial Presentation	2 Year Follow-Up	P-value
Sagittal Cobb	82.19°	49.63°	0.0000
SRS-22 Pain	3.67	4.4	0.0002
SRS-22 Appearance	3.07	4.28	0.0000
SRS-22 Satisfaction	3.41	4.69	0.0003
SRS-22 Total	3.59	4.24	0.0000

Evaluation of Screw Trajectory and Safety Corridors for Pelvic Instrumentation in a Cerebral Palsy Population

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Purpose: Children with cerebral palsy (CP) frequently require pelvic fixation for operative correction of neuromuscular scoliosis. Although pelvic morphology for iliac bolt and S2 alar iliac (S2AI) screw placement has been studied in adults, the literature is limited in children. The purpose of this project is to use computed tomography (CT) scans in a pediatric CP population to determine insertion parameters for iliac bolt and S2AI screws and determine any predictive correlation based on patient factors.

Methods: An IRB-approved retrospective review identified 19 children meeting inclusion criteria with a diagnosis of CP with CT scan of their pelvis performed at a single pediatric institution from July 2012 to January 2015. Existing CT scans were reformatted to enable visualization of the iliac column running from the PSIS to ASIS in multiple planes based on both an iliac bolt and S2AI trajectory. Radiographic measures for each trajectory on both the right and left hemipelvis included iliac column length, inner and outer cortical distances, superior acetabular and superior notch distances, and lateral and caudal insertion angles. Demographic data obtained included age, weight, and height.

Results: For iliac bolt fixation, average screw length and inner and outer cortical diameters were 110.0, 7.3, and 13.1 mm, respectively. Lateral and caudal angles were 24.0 and 39.1 degrees, respectively. Weight had a strong positive correlation with iliac column length ($r = 0.814$, $p < 0.001$) and height a moderate positive correlation ($r = 0.529$, $p = 0.001$). For S2AI screw fixation, average screw length and inner and outer cortical diameters were 87.1, 8.1, and 14.4 mm, respectively. Lateral and caudal angles were 41.1 and 42.9 degrees, respectively. Weight had a moderate positive correlation with S2AI screw length ($r = 0.510$, $p = 0.001$) and height a weak positive correlation ($r = 0.375$, $p = 0.021$). Lateral and caudal insertion angles did not significantly correlate with either height or weight.

Conclusion: This is the first study to demonstrate that safe intraosseous insertion trajectories for iliac bolts and S2AI screws exist in children age 8 – 18 years with CP. Patient factors of weight and height correlate with screw length and insertion trajectory. Future studies will include the development of predictive models for safe screw sizes based on these patient factors.

Significance: Determining safe intraosseous insertion trajectories for iliac bolts and S2AI screws in a neuromuscular population will provide surgeons with additional options in the treatment of scoliosis.

Five or More Proximal Anchors Including UEV Protects Against Reoperation

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Purpose: Proximal anchor pullout and junctional kyphosis are common causes necessitating revision surgery during growth friendly treatment of early onset scoliosis (EOS). The purpose of this study is to assess the impact of the number, type and placement of proximal anchors on the rate of revision surgery and complications in growth friendly constructs.

Methods: Retrospective review of multicenter database of patients with growth friendly constructs for EOS. Inclusion criteria were patients with index instrumentation < 10 years of age and minimum of 2 years follow-up.

Results: 357 patients met inclusion criteria and had the following constructs: growing rods with spine anchors=306; growing rods with rib anchors=16 and VEPTR=35. Mean age at Index Instrumentation was 5.9 years. Mean preoperative Cobb angle was 76 degrees (range 25 to 147) and preoperative kyphosis was 54 degrees (range -28 to 119). Mean follow-up was 6.1 years. 21.6% (77/357) experienced anchor pullout. There was a significant trend toward lower anchor pullout rates with a higher number of proximal anchors ($p=0.003$, $r=-0.157$), and 5 or more anchors were significantly associated with lower rates of anchor pullout ($p=0.010$). Type of anchor (screw vs hook vs rib cradle) did not differ significantly in rate of anchor pullout ($p=0.850$). Additionally, kyphosis data was available for 200 patients in the cohort. 23.5% (47/200) of patients required proximal extension of their construct after index surgery. On multivariate analysis, initial instrumentation below UEV of kyphosis was associated with higher rates of subsequent proximal revision ($p=0.027$), with patients who were instrumented at or above the UEV of kyphosis being revised proximally in 20.0% (26/130) vs 30% (21/70) for those below the UEV. Preoperative kyphosis was not significantly associated with increased rates of anchor pullout ($p=0.944$) or proximal revision ($p=0.076$). Change in global kyphosis following surgery was not associated with increased rates of anchor pullout ($p=0.423$) or proximal revision ($p=0.528$). Change in thoracic kyphosis following surgery was not associated with increased rates of anchor pullout ($p=0.0943$) or proximal revision ($p=0.316$).

Conclusion: Five or more anchors are associated with lower rates of anchor pullout. Proximal anchor placement at or above the UEV of kyphosis resulted in a statistically significant decrease in rates of proximal extension of the construct.

Significance: Increased number of anchors and instrumentation at or above the upper end vertebrae (UEV) of kyphosis were associated with decreased rates of revision surgery.

Outcome of Conservative Management in the Treatment of Symptomatic Spondylolysis and Grade I Spondylolisthesis

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Purpose: Bracing, thoraco-lumbar-sacral orthosis (TLSO), has been accepted as mainstay of treatment for symptomatic spondylolysis (SP) and grade I spondylolisthesis (SPL1). However increasing costs and patient noncompliance can make bracing prohibitive and difficult to manage. The purpose of our study was to determine if SP and SPL1 can be effectively treated using physical therapy and other non-bracing conservative management techniques in order to relieve pain and restore physical function.

Methods: We performed a cross-sectional study in which patients who presented from June 1 2004 to May 1 2015 with symptomatic SP and SPL1 that were treated with non-bracing conservative management, entailing a universal 6-week physical therapy program and restriction of offending activity, were considered for the study. Physical therapy included core strengthening activities, hamstrings stretching, and spine range of motion exercises. Patients meeting inclusion criteria were contacted via phone interview and asked to complete an Oswestry Disability Questionnaire (ODQ) in order to generate a disability score to assess their current pain and daily function. Patients were then stratified into groups based on their level of disability as denoted by their disability score; minimal disability = disability score of 0%-19.9%, moderate disability = 20%-39.9%, severe disability = 40%-59.9%, crippled = 60%-79.9%, and bed bound or exaggerating = 80%-100%.

Results: 46 patients were identified as meeting inclusion criteria (28 with SP and 18 with SPL1). 23/46 were successfully contacted and agreed to complete the ODQ (10/23 with SP and 13/23 with SPL1). 22/23 (96%) patients had a minimal disability score (0%-19.9%), 1/23 (4%) patients had a moderate disability score (20%-39.9%), and 18/23 (78%) patients had a disability score of zero, denoting no pain or limitation of function.
Conclusion: The results of this study suggest that, in patients with symptomatic spondylolysis and grade I spondylolisthesis, pain relief and restoration of function can be achieved using conservative management techniques without use of a brace.

Significance: The TLSO commonly prescribed in the conservative management of spondylolysis and grade I spondylolisthesis have significant associated cost, poor compliance, and burden on quality of life. Given these drawbacks, showing that the use of bracing for these conditions is unnecessary would be beneficial in decreasing health care expenditure and improving patient satisfaction.

Pedicle Screw Safety: How Much Anterior Breach Is Safe?
A Cadaveric and CT Based Study

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Purpose: The purpose of this study is to determine the safety limits of an anterior/ anterior lateral misplaced pedicle screw in spinal deformity. While, the limits of medial breach (< 3mm) are known, the safe limits for anterior/ antero- lateraly breach are not yet defined.

Methods: This study had two parts. In part I, 8 cadavers were instrumented with 6 x 30mm and 6x40mm bilaterally from T1-S1. Screws were randomly inserted under navigation guidance into 3 positions: in, out medial, out anterior laterally. Ct scan was performed, followed by gross dissection to determine screw position. In part II, post-operative CT scans of 165 patients operated on for spine deformity were reviewed for screw misplacement (2800 screws). The amount of breach for Anterior/antero- lateral was measured. Protrusions were also evaluated for proximity to vital structures. All scans were reviewed by musculoskeletal radiologist.

Results: Part I: 285 screws were inserted. 93 were misplaced anterior/antero- laterally. On gross dissection, 89 were misplaced; 67 protruded through soft tissue and were easily visualized while 32 were covered entirely by soft tissue but were palpable. These 32 screws did not endanger any structures. All 32 screws protruded < 4mm on CT scan. Part II: 117(4.14%) screws were misplaced anterior/ antero- laterally. 31(26.5%) were adjacent to vital structures. Fisher's exact test showed < 4mm breach has significantly lower likelihood of impingement ($p<0.001$) and sensitivity 81%. Screws adjacent/impinging the aorta protruded an avg 5.7 mm (SE 0.6), while screws not involving the aorta breached an avg 3.9 mm (SE 0.2), $p=0.005$.

Conclusion: Anterior/ antero-lateral breaches < 4mm on CT poses no significant risk of impingement and therefore can be considered safe.

Significance: Pedicle screw anterior misplacement potentially can cause injury to vascular and visceral structure. CT scans utilized to assess these misplacements, tend to underestimate the pre-vertebral soft tissue and may overestimate screw misplacements.

Radiological and Clinical Outcomes for Children with Morquio Syndrome Presenting with Craniocervical Pathology

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Purpose: Myelopathy secondary to craniocervical pathology is the most common cause of neurological disability in patients with Morquio syndrome. This study is a single centre audit of craniocervical surgery in children with Morquio syndrome. Our aim is to assess surgical and clinical outcome; to develop an evidence-based algorithm for the management of craniovertebral anomaly in paediatric Morquio patients.

Methods: A retrospective case-based review of children with Morquio syndrome evaluated for craniocervical pathology 1992-present was performed. Surgical indications were clinical evidence of myelopathy and/or radiological evidence of cervicomedullary compression. Surgery comprised halo frame, C1 laminectomy and occiput to upper cervical fixation using calvarial graft in younger patients and instrumentation in older patients. Outcome measures included neurological status, mobility, fusion rates and requirement for further surgery.

Results: Twenty-six patients (14M:12F) were included. Average age at initial assessment was 6.5 years (range 1.2 – 15.9 years). Nineteen patients (73%) underwent fusion (mean age 7 years (range 3.5 – 15.9 years)) with average follow-up 8.1 years (range 1 – 12.2 years) post-surgery (13: calvarial graft, 6: instrumented). Non-operative patients were followed for average 7.7 years (range 4.5 – 11.5 years).
In 13/19 patients, surgery was indicated due to the combined clinical and radiological picture (11: deteriorating neurological status, 2: acute quadriparesis). In 6/19 surgery was recommended on radiological grounds alone. A further patient refused surgery. 7/26 were managed conservatively.
All surgical patients achieved solid radiological fusion. In 2 patients (1: recurrent cervical pathology post-surgery, 1: refused surgery) deteriorated mobility at final follow-up was attributable to craniocervical pathology. One patient with pre-operative myelopathy, developed incomplete paraplegia secondary to peri-operative thoracic spinal ischaemia. Four patients who were ambulatory at initial presentation were wheelchair dependent at final follow-up due to non-spinal pathology. The remaining 19 patients (73%)(14: surgery, 5: conservative) maintained or improved their mobility status throughout the assessment period.
Surgery for recurrent cervical spine pathology was planned in 2 cases but abandoned (1: parental refusal, 1: anaesthetic concerns).

Conclusion: Surgery to treat craniovertebral instability and compression is required in the majority of children with Morquio syndrome. Close clinical and radiological surveillance are essential for timely intervention. Occiput to cervical fusion is safe and feasible even in young Morquio patients and improves radiological and clinical parameters.

Significance: In this largest series of surgically treated paediatric Morquio patients with craniocervical pathology, we describe a reliable surgical technique for occiput to cervical fusions using calvarial graft in younger patients. We propose a management algorithm.

Risk of Postoperative Urinary Retention in Adolescents Undergoing Posterior Spinal Fusion for Idiopathic Scoliosis

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Purpose: Postoperative urinary retention (POUR) has been reported between 6%-18% after major orthopedic procedures (joint replacement or adult degenerative lumbar spine surgery). POUR may cause prolonged hospital stay, patient discomfort, increase risk of urinary tract infection, and even cause permanent detrusor muscle damage if left untreated. No data exist on the prevalence and risk factors of POUR in adolescents undergoing posterior spinal fusion for idiopathic scoliosis.

Methods: One hundred and two consecutive adolescents (mean age 15.7 [range, 10-21 years], 76 girls) undergoing posterior spinal fusion using bilateral pedicle screw construct were screened after removal of urinary catheter postoperatively (removal of the catheter at mean 2,8 day) for inability to void. Residual volume of urinary bladder was measured using ultrasound at least twice. POUR was defined as an ability to void after catheter removal or a significant residual volume after voiding (>2ml/kg or >100 mL). All patients received antibiotic prophylaxis during the entire period of urinary catheterization (intravenous cefuroxime 30mg/kg x 3/day) and in case of intermittent catheterization (oral trimetoprime 100mg x 1). All patients received intravenous opiod using patient controlled analgesia and none of the patients had epidural analgesia. We aimed to describe prevalence and risk factors POUR in this patient population.

Results: Mean major curve was preoperatively 53° (range 45-83) and was corrected to 12 (range 0 -25) at final follow-up. One patient experienced a unilateral transient spinal cord deficit while probing of pedicle screw channel but improved to baseline within ten days. 43 (42 %) of the patients were either unable to void or had a clinically significant amount of residual volume (>2ml/kg or 100 ml) after voiding. Those 43 patients required intermittent catheterization for a mean of 2 (range 1-5) days. Two of the patients experienced urinary tract infection postoperatively both of them were catheterized. Males (14/26, 54%) tended to have more often POUR than females (29/76, 38%) (p=0.16).

Conclusion: Postoperative urinary retention is a relatively common clinical incidence and should be actively screened in adolescents undergoing posterior spinal fusion.

Significance: Adolescents should be informed about the risk of postoperative urinary retention and this should be actively screened and treated in this patient population to prevent urinary tract infections and permanent disability.

Spinopelvic Parameters Predict Development of Proximal Junctional Kyphosis in Early Onset Scoliosis

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Purpose: Proximal Junctional Kyphosis (PJK) is diagnosed radiographically using the proximal junctional angle (PJA) and clinically with the requirement for proximal extension of the upper instrumented vertebrae (UIV) during revision surgery. Our hypothesis was that abnormal spinopelvic alignment will increase the risk of developing PJK in children with early onset scoliosis (EOS).

Methods: Retrospective cohort study of children treated with distraction based implants from 2 EOS registries (min 2 yr f/u). Sagittal radiographs were analyzed to measure spinopelvic parameters and PJA (angle between caudal endplate of the UIV to the cephalad endplate 2 vertebrae above UIV). Risk ratios were calculated and analyzed using chi squared testing.

Results: 135 children with EOS who were treated with distraction surgery and had >2 yr f/u were identified. Etiologies included 54 congenital, 10 neuromuscular, 37 syndromic, 32 idiopathic, and 2 unknown etiology patients. N=89 rib-based and n=46 spine-based implant surgeries were performed with mean age 5.2 yrs, scoliosis 71°, kyphosis (TK) 39°, lumbar lordosis (LL) 52°, pelvic incidence (PI) 49°, and pelvic tilt (PT) 11°. 24 children required revision surgery with proximal extension of UIV. Final f/u: 56° scoliosis, TK 42° kyphosis, LL=55°, and PT=13°.
Pre-op TK>50° had risk ratio of 1.67 (CI: 0.98-2.83)* for final PJA>10°. Increased pre-op LL, PI and PT did not increase the risk for final PJA>10°. None of these pre-op parameters were associated with increased risk of revision surgery with proximal extension. Final PI-LL>20° and PT>30° were each associated with increased risk for revision surgery with proximal extension (risk ratios of 2.1* and 2.5*). *denotes statistically significant.

Conclusion: For patients undergoing growth-friendly surgery, pre-op **hyperkyphosis** increased the risk for developing **post-op PJK**. Final post-op PI-LL>20° and final post-op PT>30° were each associated with increased risk for revision surgery with extension of UIV. Pre-op thoracic kyphosis and post-op spinopelvic parameters influence the development of PJK in children undergoing growth friendly surgery for early onset scoliosis.

Significance: The International Spine Study Group (ISSG) has established several links between sagittal plane spinopelvic alignment and the development of PJK in adult scoliosis. Several novel concepts were introduced, such as age-adjusted surgical correction goals and thoracic compensation that help to identify risk for development of PJK. These concepts have not yet been studied in young children with scoliosis. The results will enable better understanding and evaluation of these principles in the early onset scoliosis population.

T1 Tilt and Clavicle Angle are the Best Predictors of Postoperative Shoulder Balance

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Purpose: Shoulder imbalance after PSF is a major concern. Most studies have analyzed multiple radiographic parameters associated with postop uneven shoulders. However, there is paucity in the literature analyzing predictors for balanced shoulders. This study evaluated XRs of AIS patients who underwent PSF, and control patients (no spinal curvature) to identify radiographic predictors of shoulder balance.

Methods: Radiographic shoulder height (RSH) was used as our proxy for shoulder height. RSH <2cm was considered normal. T1 tilt and CA in the same orientation as RSH was defined as concordant.
Part I: XRs of control patients were evaluated with T1, clavicle angle (CA) and RSH recorded to determine 'normal' T1 and CA values. Kruskal-Wallis tests were performed.
Part II: Preoperative, postoperative, and final follow up XRs of AIS patients who underwent PSF were measured. Spearman's correlation was used to evaluate correlation between radiographic parameters and RSH. Fisher's exact test was used to evaluate distribution of abnormal postop RSH.
Part III: XRs from multiple surgeons were evaluated to predict RSH. Fisher's exact test was used to evaluate distribution of abnormal postop RSH.

Results: Part I: 211 control patients were evaluated. 191 had normal RSH and 20 were abnormal. T1 tilt (2.0 vs 4.1) and CA (1.1 vs 4.95) were significantly different between the two groups ($p<.05$).
Part II: In 186 patients, preoperative and postoperative CA correlated very strongly with RSH ($r = 0.856/0.921$). T1 tilt correlated moderately with RSH ($r = 0.399$), but was better when concordant ($r = 0.51$). RSH did not change significantly from immediate postop to final follow up ($p=0.423$). Restoring CA below 3 degrees yielded normal RSH postop. ($p<0.0001$) Restoring Concordant T1 tilt below 3 degrees yielded normal RSH in nearly all cases. ($p<0.006$)
Part III: In 59 patients across 4 surgeons, restoring CA below 3 degrees yielded normal RSH at postop in all cases. Restoring concordant T1 tilt below 3 degrees yielded normal RSH at postop in nearly all cases.

Conclusion: Restoring or maintaining shoulder balance in PSF for AIS patients is a challenging aspect of the surgery. In this study, we show that restoring the CA below 3 degrees will yield normal RSH postoperatively. In addition, when T1 is concordant with RSH, restoring it to below 3 degrees can yield normal RSH.

Significance: T1 tilt and CA play a role in predicting shoulder balance status. The restoration of these angles to near 'normal' levels can aid in yielding normal RSH postoperatively.

The Treatment of Spinal Scoliosis in Patients with Rett Syndrome

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Purpose: Rett syndrome, a neurodevelopmental disorder identified primarily in females, is associated with a mutation in the methyl-CpG-binding protein 2 (MECP2) gene in 90–95%. Major clinical features associated with Rett Syndrome include growth failure, gastrointestinal and pulmonary dysfunction, ataxia, seizures and intellectual disability. Spinal Scoliosis is a common clinical manifestation in Rett syndrome, with increased prevalence with age. Compared with idiopathic scoliosis curves arise earlier, progress more rapidly, and not always halt with skeletal maturity.
As Rett Syndrome is rare, clinicians usually have limited experience with the management of scoliosis in patients with Rett syndrome.

Methods: Clinical and radiographic data were collected including: MECP2 mutation type, scoliosis characteristics including curve type and severity, preoperative treatment, surgical treatment, functional status and postoperative followup.

Results: 102 patients with Rett Syndrome, 36 patients presented with scoliosis,18 patients were treated surgically. 17 patients had a c-type neuromuscular curve and 19 had an idiopathic type curve.
Scoliosis treatment onset was 8.76 years in the c-type group and 13.88 years in the idiopathic type group.
The average curve at time of surgery was 52.42 degrees. the average time until surgery was 2.44 years. 17 patients underwent PSF and 1 patient underwent PSF + ASF. The average correction was 40 degrees. All patients maintained their functional status. The most common mutation was in the R255X nucleotide (30% of cases). The most severe curves had mutations in the R168X and R270X nucleotides.

Conclusion: Followup and monitoring should be initiated early due to early and rapid progression.
Attention should be given to mutations R255X, R168X and R270X. Bracing is recommended if tolerated, in order to delay surgery. Surgery should be considered in patients with a curve above 45 degrees independently of age.
Physiotherapy should be aggressive to maintain functional state.

Significance: Rett syndrome is a rare neurodevelopment syndrome and therefore clinicians have little experience in treating scoliosis in these patients.
This study describes our experience in treating patients with Rest Syndrome and can help clinicians plan the treatment for scoliosis i these patients.

Understanding Cost Variability in the Surgical Treatment of Adolescent Idiopathic Scoliosis

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Purpose: The cost of treating AIS is significant. A review of cost data from 43 Children's Hospitals participating in the Pediatric Health Information System (PHIS) database showed that calculated cost variability ranged from $30,000 - $140,000. However, the sources for this degree of cost variance were unclear. The purpose of this study was to analyze cost categories for scoliosis surgery and determine where opportunities exist for cost reduction.

Methods: The Intermountain Enterprise Data Warehouse tracks cost data for specific procedures. We reviewed cost data for AIS surgery over 9 consecutive years to understand surgical costs and look for opportunities for cost reduction.

Results: 590 patients from our institution with a diagnosis of AIS (ICD-9: 737.30) and complete cost data were reviewed (2006-2015). The average cost per encounter was $36,000 (R $33 to $40K). The largest component of surgical cost was OR supplies. While operating room costs increased by 7% over the period, the overall cost per surgical encounter decreased by 22%. The largest component of OR supply costs were spinal implants, accounting for 89% of total OR costs. However, despite inflation, the overall cost of implants showed a 13% decrease over time. Screws accounted for 57% of the implant costs while the average number of screws per surgery did not change. Operative times decreased 13% and length of stay decreased from 5.5 to 4.4 days.

Conclusion: In the new paradigm of shared accountability and bundled payments, Surgeons need to control costs while maintaining value and quality. Understanding the specific components of surgical cost identifies opportunities for cost reduction and process improvement. In this study, although surgical times and hospital length of stay was reduced over time, the largest component of cost reduction was a *negotiated* decrease in the cost of implants by a large hospital system.

Significance: The ability to negotiate a reduction in the cost of implants represents the largest opportunity to reduce costs of AIS surgery. Implant density and negotiated costs may explain the significant regional variability in surgical costs in the US.

Willingness to Enroll in a Surgical RCT: Patient and Parent Preferences Regarding the Minimize Implants Maximize Outcomes Clinical Trial

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Purpose: Surgical randomized controlled trials are infrequently performed, particularly in a pediatric population. The Minimize Implants Maximize Outcomes (MIMO) Clinical Trial proposes to randomize patients to more versus fewer screws (high or low density) for Lenke 1A curve patterns. It is unclear whether families and patients are willing to enroll in such a trial. We hypothesized that patients and families would be willing to enroll in a randomized controlled trial evaluating the effect of number of implants on curve correction for scoliosis fusion surgery.

Methods: This study was undertaken at 4 of the 14 sites participating in the MIMO Clinical Trial. Only AIS patients with Cobb>45 degrees were included. Patients with Lenke 1A curve types were excluded because they were eligible for the actual MIMO Clinical Trial. The survey was administered by the study coordinator. Patients and families reviewed the identical MIMO education module describing proposed advantages and disadvantages of high (> 1.8) vs. low (< 1.4) density screw constructs. Parents and patients each completed a custom survey outlining their preferences about the trial.

Results: 136 individuals were surveyed (66 families), including 69 parents, 1 guardian, and 66 patients. Of those surveyed, overall 62% wanted to participate in the trial (Table 1), and 94% stated that they mostly or completely understood the trial. Parents and patients who completely understood the trial were more likely to enroll (p=0.013). At the 4 sites, the percentage of those surveyed who completely understood the study ranged from 47-72%.

Table

	Parents	Children
Completely Understood Trial	54/66 (82%)	41/66 (61%)
Would Choose to Participate in Trial	41/66 (62%)	41/66 (62%)
Would Prefer to Talk to Surgeon about Trial (vs. Study Coordinator)	48/66 (72%)	46/66 (70%)
Prefer High Density	6/66 (9%)	9/66 (14%)
Prefer Low Density	11/66 (17%)	8/66 (12%)
No Preferred Density	28/66 (42%)	30/66 (45%)
Who Decides Whether to Enter Trial		
Parent Alone	10/66 (15%)	14/66 (21%)
Child Alone	19/66 (29%)	18/66 (27%)
Both Parent and Patient	39/66 (59%)	29/66 (44%)

Conclusion: Randomization in the MIMO Trial was acceptable to the majority of patients and parents, but those who did not completely understand the trial were less likely to enroll. Clear education materials and access to the surgeon may facilitate enrollment in the trial. Parents and patients afforded the child much autonomy when considering enrollment, although most families agree both child and parent should

be in agreement before entering the trial.

Significance: Over 60% of families were willing to enter a proposed clinical trial randomizing patients to high vs. low implant density constructs for AIS fusion surgery. Better understanding of the study was associated with higher rates of enrollment.

A Cadaveric Study on Safety and Device Functionality of Magnetic-Controlled Growing Rods after Exposure to Magnetic Resonance Imaging

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Purpose: Magnetic controlled growing rods (MCGRs) are new and promising devices for the treatment of early onset scoliosis (EOS). A significant percentage of EOS patients have concurrent spinal abnormalities that need monitoring with magnetic resonance imaging (MRI). There are major concerns of the MRI compatibility of MCGRs due to the reliance of the lengthening mechanism on strongly ferromagnetic actuators. The purpose of this study is to establish the safety and efficacy of MCGRs after exposure to MRI in a cadaveric model.

Methods: Six fresh frozen human adult osteoporotic cadaveric torsos were utilized. After thawing, MRI was performed four times per specimen: 1) baseline scan, 2) after implantation of T2, T3 thoracic rib hooks and L5, S1 pedicle screws, and 3-4) twice after MCGR implantation. Dual MCGRs were implanted in varying configurations and connected at the proximal and distal ends with cross connectors, creating a closed circuit to maximize MRI-induced heating. Temperature measurements were performed at potential sites of significant heating after each scan, including a control site and sites adjacent to the actuators and cross connectors. These sites were biopsied and evaluated histologically for signs of thermal injury. MCGRs were explanted and tested for changes in rod length, functionality, and structural integrity. The quality of MRI images obtained before and after MCGR implantation was evaluated.

Results: Average temperatures increased incrementally at sites of interest by 1.1, 1.3, and 0.5°C after each subsequent scan, similar to control site temperature increases of 1.1, 0.8, and 0.4°C. Greatest cumulative temperature change of +3.6°C was observed adjacent to the right-sided actuator, which is below the 6°C threshold cited in literature for clinically detectable thermal injury. Histologic analysis revealed no signs of heat-induced injury. All MCGR actuators continued to function properly to the manufacturer's specifications and maintained structural integrity without significant changes to rod length or maximal lengthening force. Significant imaging artifacts on standard T1 and T2 MRI sequences were observed, with the greatest amount observed with dual MCGRs in the standard/offset configuration.

Conclusion: We demonstrate minimal MRI-induced temperature change, no observable thermal tissue injury, preservation of MCGR lengthening functionality, and no structural damage to MCGRs after multiple MRI scans. Expectedly, the strongly ferromagnetic actuators produced substantial MR imaging artifacts.

Significance: Our findings suggest that multiple MRI scans of MCGRs implanted in human cadaveric torsos do not pose a significant risk with respect to tissue injury or device damage. Imaging artifacts may limit MRI evaluation of underlying spinal pathology.

A Comparison of Maximal Voluntary Ventilation (MVV) and Forced Vital Capacity (FVC) for Evaluation of Pulmonary Function in AIS Patients

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Purpose: Evidence of compromised pulmonary function in patients with severe adolescent idiopathic scoliosis (AIS) has been well-established. The purpose of this study was to compare maximal voluntary ventilation (MVV) and forced vital capacity (FVC) as measures of pulmonary function in the setting of AIS. We hypothesized that MVV, a measure of sustained respiratory effort, would be a more sensitive indicator of early respiratory compromise than FVC.

Methods: 82 AIS patients with thoracic curves of 20 degrees or greater were prospectively enrolled in this study. Each patient performed spirometry tests using the Carefusion MicroLoop Spirometer. MVV (liters/min), percent predicted MVV (%pMVV), FVC (liters), and percent predicted FVC (%pFVC) were collected. Percent predicted values were based on age, ethnicity, height, and sex of participants. Results were considered reliable or "passing" when ATS/ERS criteria were met according to the incentive spirometer guidelines. Patients made 3-5 attempts to perform a reliable test.

Results: 81/82 patients (99%) passed the MVV test. %pMVV measurements did not have a significant correlation with Cobb angle, but had a significant correlation with thoracic scoliometer measurements ($r=-0.23$, $p=0.04$). 41/82 patients (50%) passed the FVC test. %pFVC measurements did not have a significant correlation with either Cobb angle or scoliometer measurements. 40/82 patients (49%) passed both the MVV and FVC test. Notably, comparison of patients' scores demonstrated that when %pFVC was considered within the "normal" range at 80% predicted, %pMVV was well below normal threshold at 68%.

Conclusion: Nearly twice as many AIS patients could perform a MVV test compared to an FVC test. %pMVV is significantly associated with thoracic rotation but not Cobb angle, suggesting rotation may be more a factor in AIS pulmonary dysfunction that Cobb Angle. When %pFVC values were at "normal" threshold, %pMVV values were significantly decreased suggesting %pMVV may be a more sensitive indicator of pulmonary dysfunction in AIS. Of the patients with normal %pFVC scores, 50% had %pMVV scores below normal threshold.

Significance: MVV testing is abnormal earlier than FVC among children with AIS. It appears to be a more sensitive measure of pulmonary impairment in children with AIS compared to FVC. Rotation in the transverse plane may have a greater effect on pulmonary function than frontal plane deformity as measured by Cobb angle in AIS.

A New Specific Classification for AIS Describing the Sagittal Alignment to Optimize the Surgical Correction

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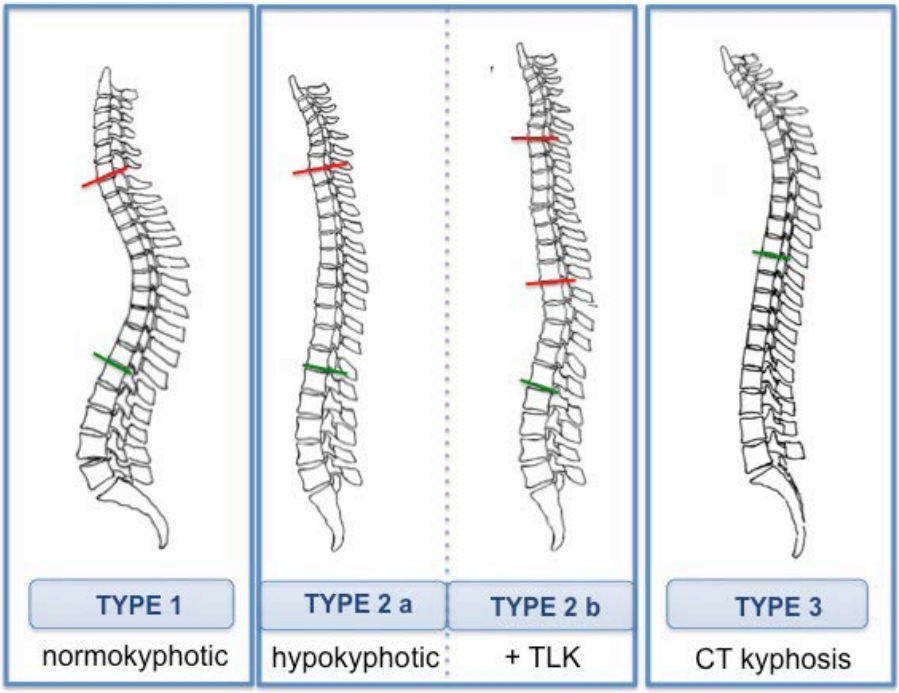
Purpose: The aim of the study is to design a new classification system to describe the global sagittal alignment of AIS spine as a rationale for the surgical strategy, in terms of rod contouring, indications for osteotomies and implant strategy.

Methods: We analysed a cohort of 100 consecutive AIS patients aged between 12 and 17 years who were surgically treated between 2011 and 2013. Full-length AP and lateral X rays of the spine in reference position were analysed through Keops (Smaio®, France).
Based on a preliminary work (Yu et al. 2013), we proposed a new classification in 3 types modified into a 4 types system. Each case was categorized according to the Lenke classification and the type of sagittal pattern 1, 2a, 2b or 3. The following radiographic parameters were measured and compared between each groups: spino pelvic parameters, thoracic kyphosis, T10 L2, C7 slope, C2C6.

Results: Half of the patients were categorized in type 1 group (normal sagittal shape) with standard repartition of Lenke types. Mean thoracic kyphosis was 30°.
Around 40% were hypokyphotic type 2 (type 2b with TL kyphotic 9%). Type 2a were thoracic curves (79% Lenke type 1 or 2). Type 2b were mostly double curves (33% type 3C or 4C) or TL/L curves (33% type 5C, 6C).
Type 3 with cervicothoracic kyphosis and long lumbar lordosis (11%) were mainly type Lenke type 1 curves.
Three factors strongly differenciate the different patterns : thoracic kyphosis, thoraco lumbar junction and C7 slope. The thoraco lumbar area is flat in type 1 and 2, kyphotic in type 2 with TLK and lordotic in type 3. C7 slope was more than 20° in the type 1 normal type whereas it was diminished around 10° in types 2 and 3.

Conclusion: This new classification allows integrating all the pathological segmental components of the sagittal plane deformity of AIS
In type 1, thoracic kyphosis is normal around 30° with straight or lordotic cervical spine
In type 2, the thoracic spine is flattened. C7 slope is reduced, inducing cervical kyphosis.
Thoracolumbar kyphosis occurs specifically in type 2b (double major or TL/L curves)
In type 3, TL junction is hyperextended due to a TL/L curve; kyphosis is expressed in the cervico thoracic spine

Significance: A specific surgical planning of the sagittal correction of AIS deformity can be extrapolated for each of the three types in terms of rod contouring, need for Ponte osteotomies and implant placement strategy (type, density).


TYPE 1
normokyphotic
TYPE 2 a
hypokyphotic
TYPE 2 b
+ TLK
TYPE 3
CT kyphosis

A Novel Posterior Rod-Link-Reducer System Provides Safer Easier and Better Correction of Severe Scoliosis

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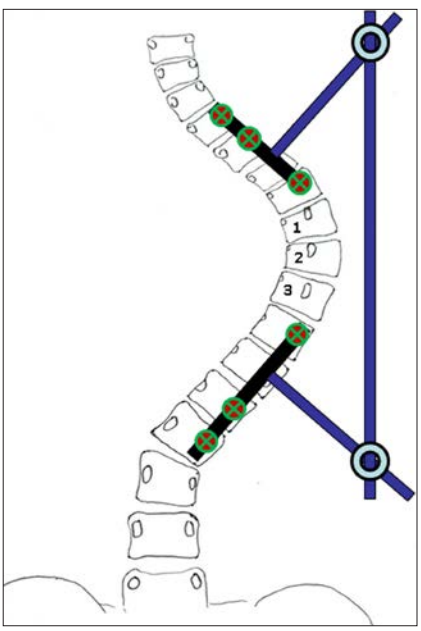
Purpose: Current implant strategies provide for good correction especially for moderate curves, however, severe spinal deformity continues to be challenging to obtain correction in a safe and effective manner. A novel correction device was developed so that two provisional rods are placed on the convex side of the scoliosis proximally and distally which are then linked to an external reduction device termed the rod-link-reducer (RLR). The significant lever arm forces generated allow the surgeon to easily and simultaneously derotate, translate and correct the spine in the coronal, sagittal and axial planes. The apical segment becomes "unhinged" allow for improved apical correction. When correction is maximized, the contralateral rod is placed and secured and the RLR is removed. The purpose of this study was to compare the >75° scoliosis correction obtained utilizing the RLR versus traditional corrective techniques (TCT) in patients with severe AIS.

Methods: A retrospective analysis was performed comparing the radiographic results and patient reported outcomes of spine deformity surgery for large curves (Cobb >75°) comparing the RLR and TCT. The mean follow-up period was 32.3 months.

Results: A total of 36 patients were evaluated (RLR-18, TCT-18). The data sets were similar for age, gender, coronal Cobb, curve flexibility, fusion levels (RLR-13.1 vs. TCT-13.4), and follow-up period. The mean Cobb for RLR was 91.7° (76°-113°) and TCT 91.8° (78°-108°). The mean coronal Cobb correction was significantly greater for RLR (73.1% vs. 56.6%, p<0.0001). The mean operative time was 74.8 mins shorter in RLR (316.6 mins vs. 391.4 mins, p=0.03). There were 2 infections and 3 neuro-monitoring changes during the correction maneuver in TCT compared with none in RLR (p=0.02). There were no differences in the EBL (RLR-1022.2 cc vs. TCT-1250.0 cc, p=0.52). There were no differences in self-image, mental health, satisfaction, and total score at 2 years postoperatively between the RLR and the TCT. However, the pain (4.6) and function scores (4.4) in the RLR were significant greater than the TCT group (pain 3.8, function 3.8).



Conclusion: In a matched cohort, the use of the rod-link-reducer system exhibited greater coronal Cobb correction, shorter operative time, better patient outcomes, and was less likely to have critical neuro-monitoring changes compared with the traditional techniques.

Significance: A powerful novel posterior rod-link-reducer system provides safer, easier, and improved correction for severe scoliosis without adding surgical risk.

Adolescent Scoliosis and Chiari I Malformations - Does Decompression of Chiari Malformations Alter the Natural History of Scoliosis

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Purpose: It is unclear if surgical decompression of Chiari malformations alters scoliosis progression in the adolescent idiopathic scoliosis (AIS). The purpose of this study is to assess the effect of Chiari decompression on the natural history of AIS.

Methods: Retrospectively, patients >10 years at scoliosis(Cobb>10°) diagnosis and Chiari malformations(>4mm) over a 20 year period were identified. Patients with concomitant causes of scoliosis were excluded. 61(43M, 18F) patients with mean age of 12.8(10-19) and 12.5 years(10-16) at scoliosis diagnosis and decompression, respectively were included. Indications for decompression included scoliosis, headache, or back pain. Clinical and major curve characteristics were recorded at diagnosis, before decompression and at last follow-up. Statistics were completed using Mann Whitney Test, Analysis of variance, and regression analysis.

Results: 31 patients presented with associated syringomyelia and 30 patients without. Of 31 patients with syringomyelia, 20(64.5%) presented with single major curves and 15(48%) with atypical (left sided) curves,.24/31 patients underwent decompression. Mean preoperative curve was 37°(14-57); 8(33%) had curve improvement(≥-5°), 8(33%) had no progression (<5°), and 8(33%) progressed(≥5°). At latest follow up, mean Cobb angle was 45°(10-120) and 9(37.5%) required spinal fusion. 7/31 patients with syringomyelia and a mean Cobb of 25°(11-38) did not have neurosurgical decompression; 1(14%) had curve improvement(≥-5°), 3(43%) no progression(<5°), and 3(43%) progressed(≥5°). Mean Cobb at follow-up was 36° and 1(14.3%) required spinal fusion. No association between syrinx size, curve type, tonsillar ectopia and scoliosis progression was found(p>0.05). Left thoracic curves were likely to progress regardless of decompression (p<.05).

Of the 30 syingomyelia negative patients, 16(53%) presented with single-major curves with 15(50%) had atypical curves. 6/30 had neurosurgical decompression with a preoperative Cobb of 25°(14-57); 4(40%) had no progression (<5°), 2(33%) progressed (≥5°). Mean Cobb at latest follow up was 27° and none required spinal fusion. Of the 24 syingomyelia negative patients treated with observation, mean Cobb angle was 38°(9-74); 5(21%) had curve improvement(≥-5°) , 6(25%) no progression(<5°), 13(55%) progressed(≥5°). At follow up mean Cobb was 43° and 11(45.8%) required spinal fusion. No difference in rate of Cobb improvement with decompression was found p=1 and severe curve were likely to progress to surgery regardless of intervention p<0.01.

Conclusion: Many patients with AIS associated with Chiari Malformations experienced curve progression requiring surgery regardless of decompression, 67% of patients with syringomyelia who had decompression improved or did not progress suggesting benefit.

Significance: Decompression of Chiari Malformation in AIS may alter curve progression.

All that Glitters is Not Gold – Serial Casting for EOS Negatively Affects Health-Related Quality of Life even after Discontinuation of Serial Casting

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Purpose: The treatment of children with early onset scoliosis (EOS) is controversial and evolving. Serial body casting is a safer method compared to surgical intervention in correcting spinal deformity. It is thus critical to discern the impact of casting on patients and their caregivers. This study aims to compare the health-related quality of life (HRQoL) of patients with EOS and their caregivers' burden of care before, during, and after casting. We hypothesized that HRQoL declines and burden of care increases during casting treatment and is restored post-casting for patients with both idiopathic and non-idiopathic EOS.

Methods: This retrospective cohort study identified 59 EOS patients from two multi-center databases. Mean index casting age was 2.2±1.2yr; mean Cobb angle pre-cast was 52±21°. 25 had non-idiopathic and 34 had idiopathic EOS. HRQoL and burden of care were assessed by the EOSQ-24 survey. Child and Parent Satisfaction were also assessed. EOSQ scores were compared pre-, during, and post-casting (in/post-brace). Pre-cast EOSQ scores were obtained at mean 17 days (non-idiopathic and idiopathic) before index casting. In-cast EOSQ scores were obtained at an average of 224 days (non-idiopathic) and 306 days (idiopathic) since index casting. Post-cast EOSQ evaluation was performed at mean 249 days (non-idiopathic) and 206 days (idiopathic) after cast removal. Scores were compared to age-matched healthy norms.

Results: In all EOSQ domains, non-idiopathic EOS patients had lower scores than idiopathic for all time periods. Pre-cast, idiopathic scores were equivalent to age-matched norms except in the burden domains, while non-idiopathic's were consistently lower. In-cast, non-idiopathic patients declined in Transfer, Emotion and Child Satisfaction ($p<0.01$), while idiopathic patients declined in those 3 plus Physical Function, Daily Living, Overall HRQoL and Burden($p<0.01$). In-cast scores for both groups were significantly lower than norms. In-brace, non-idiopathic scores slightly increased while idiopathic scores did not change. Post-brace, non-idiopathic scores rose from in-cast scores in all but 1 domain, while idiopathic scores again remained unchanged.

Conclusion: Idiopathic EOS patients' HRQoL begins within a normal range but declines while in cast, and remains lower after the treatment. While non-idiopathic patients begin with lower HRQoL, their decline in-cast is relatively small, and recovers post-casting. An explanation is that before casting, idiopathic patients have comparatively higher HRQoL and thus more negatively impacted by the restrictive casting.

Significance: Understanding the impact of serial body casting on HRQoL and burden of care in different patient populations with EOS can help clinicians make more informed decisions about treatment options.

Table 1. Mean EOSQ Scores Pre-Casting vs. In-Cast by Etiology

EOSQ Domains	Idiopathic Pre-Cast	Idiopathic In-Cast	*P*	Non-Idiopathic Pre-Cast	Non-Idiopathic In-Cast	*P*
General Health	72.6 ± 21.5	76.7 ± 16.1	0.410	65.4 ± 20.5	63.1 ± 14.3	0.657
Pain/Discomfort	88.3 ± 19.6	84.0 ± 13.2	0.478	82.8 ± 14.3	81.2 ± 17.9	0.712
Pulmonary Function	94.5 ± 11.2	95.2 ± 10.1	0.867	87.5 ± 23.8	83.9 ± 18.9	0.548
Transfer	98.4 ± 6.3	88.0 ± 12.5	0.004*	85.9 ± 27.3	68.8 ± 13.8	0.010*
Physical Function	90.6 ± 10.0	70.9 ± 13.7	<.001*	68.6 ± 37.2	56.4 ± 30.9	0.131
Daily Living	83.3 ± 19.3	67.7 ± 16.8	0.010*	39.7 ± 34.6	35.8 ± 32.3	0.652
Fatigue/Energy Level	91.1 ± 12.4	86.0 ± 13.4	0.338	72.0 ± 31.1	66.8 ± 29.6	0.544
Emotion	98.2 ± 4.5	90.6 ± 9.2	0.014*	89.8 ± 17.7	75.6 ± 19.7	0.006*
Parental Burden	63.3 ± 14.8	64.3 ± 11.2	0.764	56.6 ± 18.8	54.7 ± 17.2	0.726
Financial Burden	81.7 ± 24.0	71.9 ± 26.8	0.117	63.3 ± 29.7	59.2 ± 23.4	0.583
Overall HRQoL	89.0 ± 8.9	80.1 ± 9.2	0.012*	73.9 ± 17.9	66.2 ± 15.4	0.078
Overall Burden	72.5 ± 15.7	63.6 ± 18.3	0.050*	58.0 ± 24.2	56.3 ± 18.1	0.777
Child Satisfaction	94.6 ± 10.6	78.7 ± 16.4	0.010*	73.4 ± 28.1	54.6 ± 19.6	0.011*
Parent Satisfaction	87.5 ± 20.4	79.2 ± 23.3	0.312	70.3 ± 27.7	61.7 ± 23.4	0.330

*Statistically different at $P < 0.05$

Are there Changes in Sagittal Alignment of Cervical Spine after Posterior Spinal Instrumentation in Adolescent Idiopathic Scoliosis?

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Purpose: Sagittal alignment in thoracic and lumbar spine and its vital association with quality of life have been well documented. While the compensation of cervical spine on sagittal plain in AIS patients with different curve types remains unclear. This study aims to analyze postoperative changes of cervical alignment in AIS patients with different curve patterns.

Methods: Radiographic data were retrospectively reviewed in 51 AIS patients with right thoracic major curve Vs 50 with major lumbar curve with a minimum of 2-year follow-up. Radiographic parameters analyzed in this study including cervical sagittal parameters (cervical lordosis (CL), T1 slope, TS-CL, T1-Spi, TPA and C2-C7 SVA) and spinopelvic sagittal parameters (PI, PT, SS, TK, LL, C7-S1 SVA, PI-LL) obtained from standardized full length standing PA and Lateral radiographs. Paired t tests were used for comparison with 0.05 as statistical significant threshold.

Results: No significant differences in the mean age and follow up time were observed between thoracic and lumbar AIS groups. At baseline, larger cervical lordosis (5.69° VS. -5.11°, p=0.002) and smaller TS-CL (9.26° VS 17.09°, p=0.001) was noted in L-AIS patients, while pre-op TK showed no difference between two groups. When the immediate post-op sagittal profiles were compared between two groups, larger TK (23.72° VS. 18.86°, p=0.009) and more obvious cervical lordosis (7.26° VS -2.60°, p=0.001) were noticed in L AIS group. During the follow up, larger TK and CL were still maintained in L-AIS group. In addition, a significant correlation was found between the improvement of CL and TK restoration in L-AIS patients (r=-0.473, p=0.002).

Conclusion: Correlations between the improvement of cervical lordosis and thoracic kyphosis highlighted the importance of restoration of normal TK in AIS patient.

Significance: Due to this reciprocal changes hypokyphosis of thoracic spine may be responsible for loss of cervical lordosis or even cervical kyphosis in AIS patients which may impact the posture or even function of cervical spine in future.

Correlation Analysis

T-AIS

	TK		T1 slope		TPA		TS-CL		CL		C2-SVA	
	R	P value	R	P value	R	P value	R	P value	R	P value	R	P value
TK			0.337	0.029	-0.169	0.285	0.031	0.843	-0.166	0.294	-0.008	0.960
T1 Slope					-0.041	0.799	-0.044	0.783	-0.604	0.000	0.276	0.076
TPA							-0.005	0.974	0.012	0.939	0.093	0.057
TS-CL									0.822	0.000	0.228	0.147
CL											0.018	0.910
C2-SVA												

L-AIS

	TK		T1 slope		TPA		TS-CL		CL		C2-SVA	
	R	P value	R	P value	R	P value	R	P value	R	P value	R	P value
TK			0.554	0.000	-0.211	0.196	-0.259	0.112	-0.473	0.002	-0.367	0.022
T1 Slope					-0.112	0.497	-0.259	0.111	-0.700	0.000	0.120	0.466
TPA							-0.015	0.930	0.049	0.765	-0.038	0.817
TS-CL									0.871	0.000	0.492	0.001
CL											0.300	0.063
C2-SVA												

Can Surgery for Adolescent Idiopathic Scoliosis be an Allogeneic Blood Transfusion Free Event?

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Purpose: Allogeneic transfusion rates during or after AIS surgery are reported to range from 0-55%. Transfusions are associated with significant risk and cost. Transfusions may be related to surgical time, surgeon experience, reduction technique, imaging methods, anesthesia, pharmacologic intervention, and technologies to reduce intra-op blood loss. The aim of this study was to look at a single institution 10-year surgical experience with a dedicated spine team in treating AIS to identify factors that may eliminate the need for allogeneic transfusions.

Methods: This is an IRB approved review of a single surgeon (JTS) surgical experience over a 10-year period treating AIS using the Intermountain Data Warehouse.

Results: 486 AIS surgical cases were reviewed between 2006-2015. In 2006, we established a dedicated spine team for all cases. Over the study period, operative times steady declined from 192 minutes to 152 min. Total intravenous anesthesia, (TIVA), somatosensory evoked potentials, and trans-cranial motor evoked potentials were utilized in all cases. Surgical technique used reduced density screw constructs (0.75/level). No systemic anti-fibrinolytic agents were given, but topical gel-foam/thrombin was used. Fluoroscopy with free hand pedicle screw placement technique was used. Following the introduction in 2008 of a dynamic pedicle finder (Spine Guard) and irrigated bi-polar cautery, we observed a reduction in intraoperative blood loss and since then, no allogeneic blood products have been given for AIS surgery. Surgical costs have remained flat.

Conclusion: Allogeneic blood transfusion in AIS surgery has been associated with operative times >6 hours and blood volume loss >30%. The use of an experienced dedicated spine team including anesthesia, surgical technicians, nurses, imaging, neuro-monitoring, along with time saving and blood sparing technologies can shorten surgical time and reduce blood loss eliminating the need for allogeneic blood for most AIS surgery.

Significance: Eliminating the need for allogeneic blood transfusion through refining the surgical process contributes to reducing an element of risk, error, and potential for complications in AIS surgery.

Caregiver Perceptions Regarding the Relative Impact of Spinal Fusion Surgery on Quality of Life of Children with Cerebral Palsy

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Purpose: Cerebral palsy is not curable and all interventions are aimed to improve the health of the patient. Children with cerebral palsy (CP) have several major surgical interventions in their lives. Spinal fusion surgery is one of the more invasive and complicated. We aimed to compare the impact of this surgery on the quality of life and health relative to other common surgical interventions they receive. We hypothesized that caregivers of children with CP consider spinal fusion surgery as having the greatest impact on their child's life compared to other common surgical interventions.

Methods: A multicenter prospective registry of operatively treated children with cerebral palsy with spinal deformities was studied. Of 193 patients with 2-year clinical and radiographic follow-up, 152 (79%) caregivers answered additional survey questions regarding impact and relative importance of spinal fusion surgery on their child's life.

Results: At the 2-year follow-up, 91% caregivers reported that the overall quality of life, and 80% reported that the overall health of their child, improved "a little" or "a lot" as a result of spinal fusion surgery. At the 2 year follow-up, 73% caregivers ranked or co-ranked spine surgery as the #1 (most important) surgical intervention that the child had received. Of the 64 caregivers who reported that the child had received both spine surgery and hip surgery, 20 (31%) co-ranked both as #1, 26 (41%) ranked spine surgery as #1, and none ranked hip surgery as #1 (Table 1). Of 78 caregivers who ranked both spine surgery and gastrostomy tube (G-tube) placement, 31 (40%) co-ranked both as #1, 38% ranked G-tube as #1, and only 13% ranked spine surgery as #1. Spine surgery was ranked or co-ranked as the most important intervention in 16 of 20 (80%) patients who received a baclofen pump, in 14 of 32 (44%) patients who underwent Nissen fundoplication, in 19 of 27 (70%) patients who underwent foot surgery, and in 8 of 14 (57%) patients who underwent knee surgery.

Table 1: Ranking by CP caregivers of relative utility of a procedure in their child's life

Comparison	Relative Ranking	% Caregivers
Spinal Fusion vs. Hip Surgery	Ranked Only Spinal Fusion #1	41% (26 of 64)
	Ranked Only Hip Surgery #1	0% (0 of 64)
	Ranked Both #1	31% (20 of 64)
Spinal Fusion vs. G-tube Placement	Ranked Only Spinal Fusion #1	13% (10 of 78)
	Ranked Only G-tube #1	38% (30 of 78)
	Ranked Both #1	40% (31 of 78)
Spinal Fusion vs. Baclofen pump placement	Ranked Only Spinal Fusion #1	20% (4 of 20)
	Ranked Only Baclofen pump #1	5% (1 of 20)
	Ranked Both #1	60% (12 of 20)
Spinal Fusion vs. Nissen Fundoplication	Ranked Only Spinal Fusion #1	3% (1 of 32)
	Ranked Only Nissen #1	16% (5 of 32)
	Ranked Both #1	41% (13 of 32)
Spinal Fusion vs. Foot Surgery	Ranked Only Spinal Fusion #1	48% (13 of 27)
	Ranked Only Foot surgery #1	0% (0 of 27)
	Ranked Both #1	22% (6 of 27)
Spinal Fusion vs. Knee Surgery	Ranked Only Spinal Fusion #1	43% (6 of 14)
	Ranked Only Knee surgery #1	0% (0 of 14)
	Ranked Both #1	14% (2 of 14)

Conclusion: Caregivers of children with cerebral palsy who undergo spinal fusion surgery usually rank or co-rank spinal surgery as most important intervention in their child's life, secondary only to G-tube placement.

Significance: The findings of this study demonstrate the perceived increase in

quality of life in CP patients following spinal fusion surgery relative to other surgeries by caregivers. These results permit more effective counseling for CP patients and caregivers during the surgical evaluation of spinal deformities.

Changes in Vertebral Body Shape in Sagittal and Coronal Planes Correlate with Scoliosis Severity

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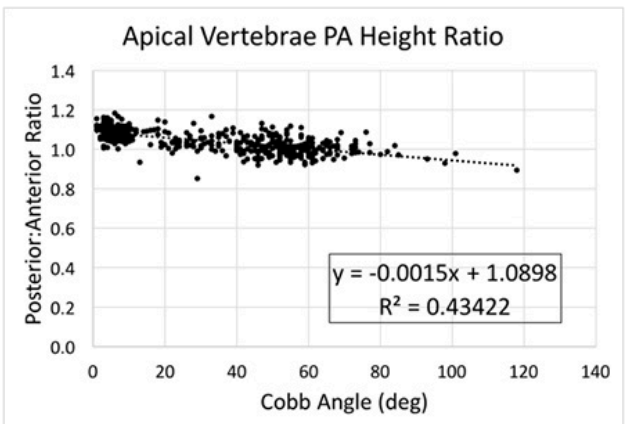
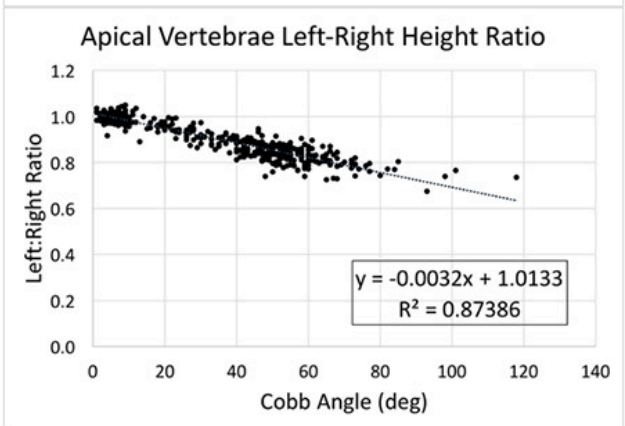
Purpose: New, low-radiation imaging systems afford the opportunity to perform non-invasive anatomic 3D imaging analysis of vertebral body shape changes associated with scoliosis with large sample sizes. The purpose of this study was to evaluate the relationship between vertebral body shape and severity of scoliotic deformity in patients with main thoracic adolescent idiopathic scoliosis (MT-AIS).

Methods: Patients seen in scoliosis clinic (normal screening or AIS) who underwent upright, biplanar radiographs with 3D reconstruction were analyzed. Patients were divided into normal (<11°), midrange (bracing pts), and surgical cohorts. Anteroposterior (AP) and left-right (LR) midpoints of each vertebral body were identified on 3D images. Anterior, posterior, left, and right vertebral body height (VBH) was measured and summed over the apical 5 vertebrae. AP and LR height difference and ratio was calculated and compared using MANOVA with post-hoc Bonferroni corrected multiple pairwise comparison. Linear regression was performed between height differences and ratios and the thoracic Cobb angle.





Results: 3D data for 445 patients was collected. Cobb angles ranged from 1°-118°. Increased scoliotic severity was associated with increased anterior relative to posterior VBH and right relative to left VBH. AP and LR height differences and height ratios were significantly different between normal, midrange, and surgical cohorts (all $p<0.001$). All regression comparisons yielded significant correlation with Cobb angle ($p<0.001$). Regressions for AP height difference and ratio resulted in R^2 of 0.42 and 0.43 with Pearson correlation coefficients of -0.65 and -0.66, respectively. Regressions for LR height difference and ratio resulted in R^2 of 0.86 and 0.87 with Pearson correlation coefficients of -0.92 and -0.93, respectively.

Conclusion: Increasing scoliotic severity in MT-AIS is associated with increased anterior relative

to posterior and right relative to left VBH in the thoracic spine. This trend is significant in cohort analysis and shows a strong effect size in linear regression modeling.

Significance: A 3D evaluation of vertebral body shape change and scoliotic severity in main thoracic AIS revealed that increasing severity was associated with increased anterior and right vertebral body heights.

Cobalt and other Metal Ions Released in Children Having Spinal Fusion for Scoliosis

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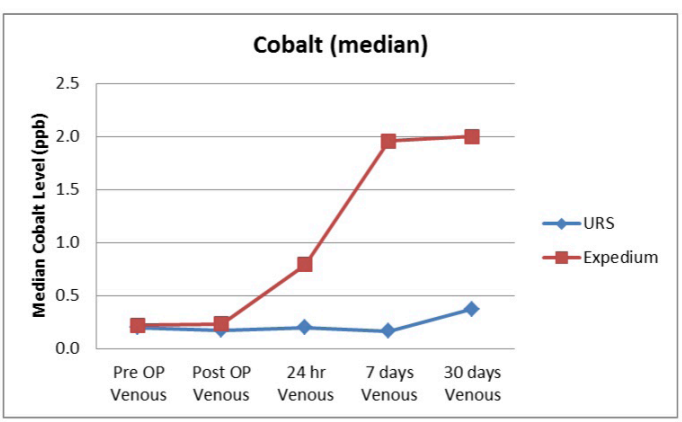
Purpose: This prospective study measured titanium, niobium, cobalt and chromium levels at various intra-operative and post-operative times following instrumented spinal fusion.
Raised serum metal ion levels occur after instrumented spinal fusion in adolescent idiopathic scoliosis (Cundy TP et al 2013). Recent literature suggests an immediate rise in serum metal ion levels within the first post-operative week and maintained up to 2 years after surgery.

Methods: Titanium, niobium, cobalt and chromium metal ion levels were measured in serum and local intra-operative fluid samples obtained from 22 consecutive pediatric patients undergoing posterior instrumentation for idiopathic scoliosis.
Two different spine constructs were compared – 1) Universal Reduction Screw (URS) System (DePuy Synthes) (all titanium screws and rods) and 2) Expedium (DePuy Synthes) (titanium screws and cobalt chrome rods).
Specimens were collected in trace element-free tubes and analysed using high resolution inductively coupled plasma mass spectrometry at a commercial laboratory (ALS Scandinavia AB, Lulea, Sweden). Limit of detection for titanium, niobium, cobalt and chromium was 0.315 parts per billion (ppb), 0.005, 0.097 and 0.145 respectively.

Results: An immediate post-operative rise in serum titanium (URS implants) and niobium metal ion levels (both URS and Expedium implants) was observed. These serum metal ion levels rose most abruptly between the first post-operative day and one week post-operatively.
By 30 days, the titanium levels were 83% higher in venous samples of patients with Expedium instrumentation compared to those with URS instrumentation (p=0.01)
Cobalt levels in Expedium patients were significantly raised by 24 hours post op and continued to rise at 30 days (median 2.0 ppb).
By contrast, niobium levels were significantly higher at all time periods in the venous samples of URS patients in comparison to Expedium patients.

Conclusion: Titanium, niobium, cobalt and chromium metal ions are released following spinal instrumentation.
Titanium metal ion release was significantly higher in the Expedium group compared to the URS Group.
Cobalt metal ion release from the Expedium instrumentation was observed with levels similar to pre-



sumed safe ranges for adults undergoing Metal-on-Metal bearing hip replacement surgery.

Significance: The long-term clinical effect of raised metal ions in children who have had scoliosis surgery remains unknown, however deposition in solid organs is anticipated. Cobalt, chromium, titanium and niobium metal ions are consistently found in the blood of paediatric scoliosis surgery patients.

Complication Severity Score for Growth-Friendly Surgery has Very Strong Inter and Intra Observer Agreement

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Purpose: Growth friendly surgery has high complication rates. The complication severity score for growth-friendly surgery was developed in an effort to maintain consistency when reporting complications. This published scheme is shown in the table below. This study evaluates the inter-observer and intra-observer agreement of the complication severity score for growth-friendly surgery.

Methods: After institutional review board approval, complications from 2 institutions were drawn from a prospectively collected database of patients with early onset scoliosis. Previous validation studies and a 10 case pilot survey were used to determine that 60 cases were needed to represent a minimum of substantial agreement. 63/496 cases were selected randomly to evenly represent each score. The cases comprised an internet survey for classification sent to faculty and research coordinators involved in early onset scoliosis research, 2 weeks apart, with questions shuffled between iterations. Fleiss and Cohen's Kappa were used to assess inter- and intra-observer reliability, respectively.

Results: A total of 20 participants, 12 faculty and 8 research assistants, completed the survey twice. The overall Fleiss Kappa coefficient for inter-observer reliability from the second round of the survey was 0.86, which represents substantial agreement (95% CI, 0.86-87). Reviewers agreed almost perfectly on categorizing complications as Device I (0.85), Disease I (0.91), Disease II (0.94), Device IIB (0.92), and Disease IV (0.98). There was substantial agreement for categorizing Device IIA (0.73) and Device III (0.76) complications. Disease III and Device IV were not evaluated in this survey since none of these occurred in the database. There was almost perfect intra-rater agreement among faculty (0.87), research coordinators (0.85), and overall (0.86).

Conclusion: There is strong inter and intra-observer agreement, both overall and based on individual severity score, for the published complications classification scheme for growing spine surgery.

Significance: The complication severity score scheme is a reliable tool for standardizing reports of complications with growth friendly surgery. Adoption of this classification when

Grade	Device Related	Disease Related
I	Does not require unplanned surgery	Outpatient medical management only
II		Inpatient medical management
IIA	Requires 1 unplanned surgery	
IIB	Requires multiple unplanned surgeries	
III	Requires abandoning growth-friendly strategy	Requires abandoning growth-friendly strategy
IV	Death	Death

Complication Severity Score for Growth Friendly Spine Surgery.
Smith JT, Johnston C, Skaggs D, Flynn J, Vitale M. A New Classification System to Report Complications in Growing Spine Surgery: A Multicenter Consensus Study. Journal of Pediatric Orthopaedics. 2015 Dec; 35(8): 798-803.

reporting on growth-friendly surgery is recommended to allow for comparison of complications between treatment modalities.

Consumptive and Dilutional Coagulopathies During Posterior Spinal Fusion: Risk Factors for Transfusion

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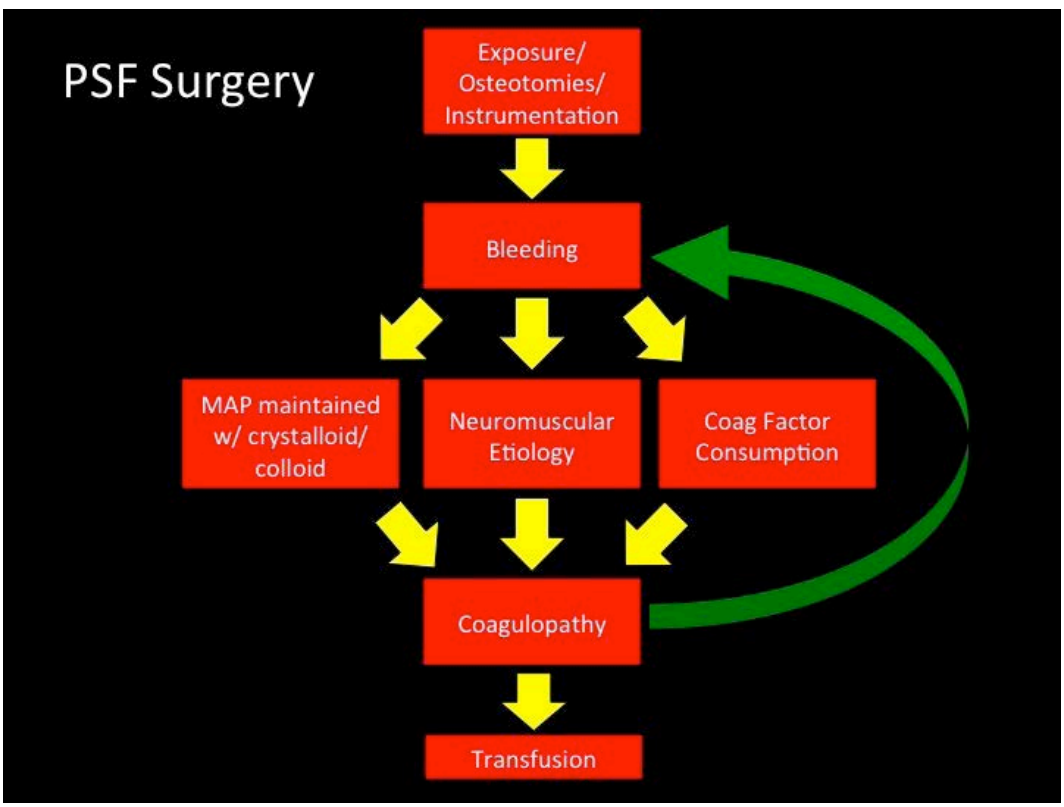
Purpose: Despite the use of antifibrinolytics, children undergoing posterior spinal fusion (PSF) for scoliosis experience high volume blood loss and frequently require blood transfusions. Major blood loss during surgery may produce a coagulopathy, which if not addressed puts the patient at risk for transfusion. The purpose of this study was to determine the presence and type of coagulopathy experienced by children undergoing PSF for spinal deformity and also to determine the factors associated with blood transfusion either during or after surgery.

Methods: IRB-approved single institution study of patients undergoing PSF >6 levels for spinal deformity with a standardized, prospective anesthetic protocol utilizing antifibrinolytics, cell saver, specific thresholds for intraoperative hematologic labs, and pre-determined triggers for transfusion. Hematologic data was gathered pre-, intra-, and post-operatively. The transfused volume of blood product (autologous and allogeneic), plasma product, and non-blood product (colloid and crystalloid) was normalized to weight. The development of a coagulopathy was defined as an Prothrombin Time-International Normalized Ratio (PT-INR) greater than or equal to 1.5. Factors associated with the need for blood transfusion were determined.



Results: Among 103 patients with a mean age of 14.5 years, 59% were idiopathic and 25% neuromuscular. Overall, 45% required allogeneic blood transfusion; neuromuscular patients had the highest transfusion rate (69%). 34% of patients developed a coagulopathy as determined by PT-INR assay (median 1.4 +/- 0.2). The development of an intra-operative coagulopathy, was significantly associated with increased blood product transfusion ($p<0.001$). The following factors were significantly associated with the total volume of blood transfused per kg: neuromuscular etiology ($p<0.02$); increased transfusion volume of either non-blood products ($p<0.002$) or plasma ($p<0.001$); increased intra-operative fibrinogen loss ($p<0.007$); and elevated intra-operative prothrombin time (PT, $p<0.02$).

Conclusion: Patients who develop a coagulopathy during PSF for scoliosis have an increased need for blood transfusion. This coagulopathy appears to be related to hemodilution and clotting factor consumption during surgery. Neuromuscular etiology is also a risk factor for an increased need for blood transfusion.

Significance: Protocols designed to address and mitigate consumptive or hemodilutional coagulopathies may reduce blood loss and the need for blood transfusion during PSF, especially for neuromuscular patients.

Cost Effectiveness of Magnetically Controlled Growing Rods: Who Really Benefits?

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Purpose: Treatment of early onset scoliosis is challenging and costly. To control curve progression and allow thoracic development, growing rods (GR) have become standard of care. While effectively controlling deformity, traditional systems (TGR) require surgical lengthening bi-annually. Newer magnetic systems (MCGR), while more costly, control curve progression and eliminate required repeat surgical lengthenings. Although initial implantation of MCGR is more expensive than TGR, cost analyses have suggested MCGR results in lower overall cost after 3 years compared to TGR systems due to the elimination of repeat surgeries. While MCGR appear to offer cost savings over time, the benefactor of these savings is unclear. The purpose of this study was to evaluate the cost difference between MCGR and TGR surgeries at initial implantation and determine the recipient of the reported long-term cost savings.

Methods: All patients who underwent initial implantation of GR from 05/2011-01/2016 at a tertiary-care children's hospital were included for a total of 37 cases (16 MCGR, 21 TGR, 4 TGR to MCGR conversions). Financial information included insurance provider, and amount billed to and reimbursed from the payor. Charges across the inpatient stay at the time of implantation were divided into service categories (surgery time, room/board, anesthesia, implant cost, lab, radiology, therapy, medications, neuromonitoring, OR materials, and recovery room) and reimbursements converted into percentage of total charge. Variables were compared using T-tests to determine differences between charges and reimbursements overall and per category.

Results: The average overall charge for MCGR implantation was 25% greater than TGR implementation, which was significantly more expensive ($p=0.04$). Average charges were statistically similar across all categories, except implant costs, which were significantly more expensive for MCGR cases (MCGR 2.8x greater vs. TGR, $p<0.0001$). Despite this charge difference, the average percent reimbursement of total charges was similar between systems (MCGR 43% vs. TGR 45%, $p=0.66$).

Conclusion: MCGR has a significantly higher initial charge than TGR, which appears to be due to the higher expense of the MCGR implants. Despite this, total institutional reimbursement is similar between the two procedures. While MCGR have been shown to be "cost effective" after 3 years, our findings suggest healthcare institutions solely bear the cost of this new technology while payors gain the long-term financial benefit.

Significance: Given the known future cost savings of this technology, healthcare institutions should be fully reimbursed for MCGR implants to appropriately balance the initial cost increase and future cost savings from this new technology.

Discrepancy between Programmed Lengthening and Sonographic Measured Obtained Lengthening in Magnetically-controlled Growing Rods

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Purpose: Magnetically-controlled growing rods (MCGR) allow frequent rod distractions without the need for additional surgeries in Early Onset Scoliosis (EOS). The use of ultrasonography reliably documents rod distractions, reducing the number of radiographs required to monitor the distractions and therefore minimizing ionizing radiation exposure in early-onset scoliosis (EOS) patients. Our goal was to analyze the discrepancy between Programmed Lengthening (PL) and Obtained Lengthening (OL) measured by ultrasonography, and associated clinical factors.

Methods: A retrospective medical record review was performed of all children with EOS treated for scoliosis with MCGR at our institution from March 2014 to January 2016. PL and OL values were recorded at each distraction and differences between them were calculated. Correlations between PL and OL with clinical parameters (gender, age, weight, Cobb angle and rod position in relation to the curve) were investigated. For longitudinal comparisons, the Freidman test was applied. Comparisons between groups were made using the Mann-Whitney U test. Correlations were determined using the Spearman test ($p<0.05$ significant).

Results: Seventeen patients with at least 6-months follow-up (10 male and 7 female) met the inclusion criteria. Patients underwent rod distraction at 2 month intervals. Their mean age at the MCGR insertion was 90.3 months. The mean total PL measured on the external remote control (ERC) was 15.9 mm for the right and 15.1 mm for the left rod. The mean total OL achieved measured by ultrasonography was 16.5 mm for the right and 14.9 mm for the left rod. This gives a ratio PL/OL of 0.96 for the right and 1.01 for the left rod. The correlation between total PL and OL was very high for both rods ($p<0.001$). We also found a significant increase in PL/OL ratio along time only for the right rod ($p=0.016$). We did not find associations between PL/OL and other clinical parameters, except for the Cobb angle. Thus, a strong negative correlation between the PL/OL and the preoperative ($p=0.003$), and final follow-up Cobb angles ($p=0.009$) was found.

Conclusion: There is a discrepancy between PL and OL values along the follow-up time. This disparity seems to be related with Cobb angles, being the amount of distraction reduced in patients with higher Cobb.

Significance: Even though our results are preliminary, and should be supported with larger series, we consider the discrepancy between the Programmed Lengthening and Obtained Lengthening measured with ultrasonography should be taken into account when calculating the amount of distraction applied to MCGR.

Efficacy of Intra-operative Traction in Patients with CP Scoliosis

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Purpose: Multiple studies have demonstrated the value of intra-operative traction in patients with severe scoliosis. Few studies have focused on the benefits in the cerebral palsy (CP) population. The purpose of this study was to evaluate the efficacy of intra-operative traction use in patients with CP scoliosis.

Methods: Subjects who underwent posterior spinal fusion for their scoliosis related to CP (coronal curve magnitude >50°) with minimum 2 years follow-up were included. Subjects were grouped based on whether intra-operative traction was used or not. Patients in which preoperative traction was used were excluded.

Results: 170 subjects met inclusion. Traction was utilized in 101 cases. The traction and no traction groups were similar in age and GMFCS (p>0.05). Preoperatively, the traction group had a greater average coronal curve (91° vs 81°, p=0.005; Table), but no other significant differences were observed (p>0.05). The majority of both groups were fused to the pelvis. The groups had similar length of ICU and hospital stays, EBL per blood volume, and percentages of subjects with neuromonitoring alerts (p>0.05). The traction group had a significantly shorter mean operative time (420 vs 366min, p-0.009). At 2yrs, the traction group had greater percent correction (65% vs 61%, p=0.009) and less lumbar lordosis (-51° vs -57°, p=0.008). The revision rate was 3.9% in the no traction group and 0% in the traction group.

Conclusion: Intra-operative traction is a valuable adjuvant to the surgical correction of CP scoliosis that is both safe and effective. Even though utilized in larger curves, the use of intra-operative traction resulted in greater percent correction with shorter operative times.

Significance: Intra-operative traction is a safe and effective technique that can significantly facilitate the scoliosis correction in patients with CP.

		Traction Used?		
		No	Yes	p-value
Coronal Cobb angle (°)	**Pre**	**81**	**91**	**0.005**
	2 yr	32	29	0.25
	% correction	**61%**	**68%**	**0.009**
Pelvic Obliquity (°)	Pre	28	32	0.092
	2 yr	10	9	0.53
	% correction	60%	66%	0.42
Pelvic Obliquity from Horizontal (°)	Pre	22	26	*0.052*
	2 yr	8	8	0.92
	% correction	55%	61%	0.47
Kyphosis T2-T12 (°)	Pre	41	39	0.69
	2 yr	35	31	*0.053*
	Change	-5.9	-6.7	0.83
Lordosis (top of T12-S1) (°)	Pre	-42	-41	0.83
	2 yr	**-57**	**-51**	**0.008**
	Change	-15	-9	0.15

Bold values represent statistical significance, p≤0.05.
Italicized values represent a trend toward statistical significance.

How are We Affecting Spinopelvic Parameters in Patients with Adolescent Idiopathic Scoliosis (AIS)

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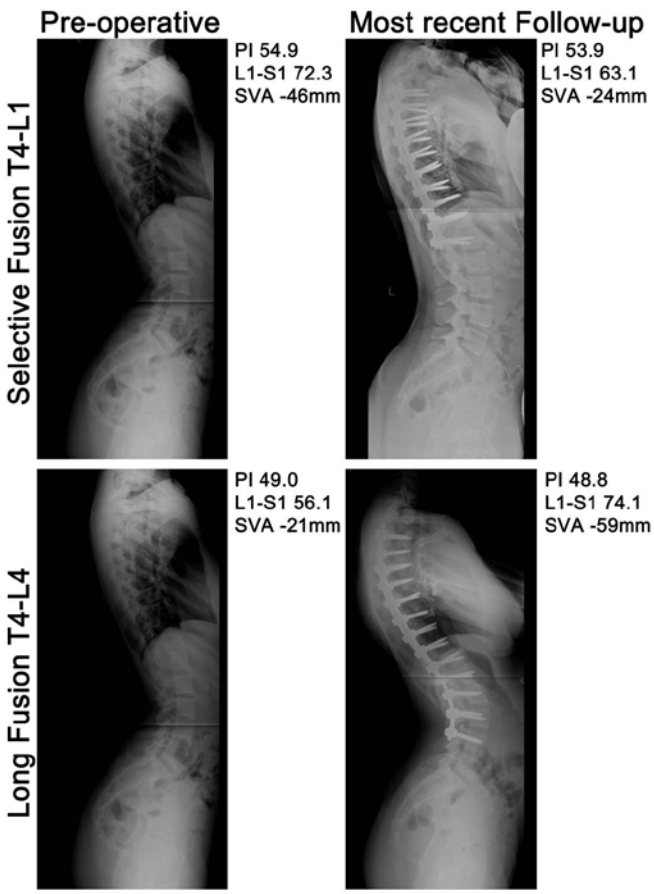
Purpose: The purpose of this study was to examine spinopelvic parameters in AIS-patients after posterior spinal fusion (PSF) according to their fusion level. We hypothesized that patients with longer fusions into the lumbar spine (L3,L4) would have altered spinopelvic parameters compared to patients with selective-fusions (T12,L1,L2).

Methods: We conducted a retrospective review of 84 AIS patients, 26 males and 58 females, who underwent PSF with instrumentation at an average age of 15.0 ±2.5 years by 5 surgeons in the same institution between 2007 and 2014. Radiographic parameters were measured pre- and post-operatively at most recent follow-up, average follow-up 2.9 years (range 2-8.2 years), on full spine standing lateral and AP radiographs: pelvic incidence (PI), lumbar lordosis (LL) from L1-S1 and L4-S1, C7 plumb line (sagittal vertical alignment-SVA), and Cobb angle (CA). PI-LL mismatch was calculated: PI-LL(L1-S1). Spinal alignment is considered acceptable when LL is within 10° of the PI in adult patients (Schwab et al., 2010). Paired student t-tests were used for analysis.

Results: 32 patients underwent a selective-fusion with lowest instrumented vertebra (LIV) T12-L2, and 52 patients underwent a long-fusion with LIV L3-L4. Pre-operatively, both groups had similar LL (L1-S1) (selective-fusion 62.9° ±11.8 vs. long-fusion 60.1° ±11.8, p=0.29) and PI-LL (selective-fusion -7.1°±10.5, long-fusion -9.1°±11.2; p=0.43). Post-operatively, LL increased in the long-fusion group (pre 60.1°±11.8 vs. post 66.1°±13.6, p=0.017), but did not change significantly in the selective-fusion group (pre: 62.9°±11.8 vs. post 59.3°±14.7, p=0.28). This change in LL in the long-fusion group affected the PI-LL significantly (post: selective fusion -4.9°±10.2 vs. long-fusion -13.6°±14.2, p=0.003). Post-operatively, other measures between the fusion groups were not significantly different: selective fusion vs. long-fusion



PI 54.5°±11.6 vs. 52.6°±12.4, p=0.49; SVA -23.9mm ±27.4 vs. -17.1mm ±38.6, p=0.39. When evaluating segments L4-S1, no change in LL L4-S1 was observed (selective fusion: pre 40.2°±7.3 vs. post 37.6°±7.7, p=0.18; long-fusion: pre 37.5°±6.7 vs. post 35.4°±9.5, p=0.19).
In both groups, the mean preoperative major CA was significantly reduced at most recent follow-up (selective fusion 53.6° to 22.8°, p<0.005; long-fusion 55.8° to 19.4°, p<0.005).

Conclusion: In patients with long-fusion, lordosis was increased, which altered the PI-LL relationship, putting this group outside the acceptable range for adults.

Significance: Surgeons should attempt to maintain normal LL in AIS patients when performing non-selective fusions to avoid alterations in spinopelvic parameters that could create difficulties for patients as they age and could potentially increase the progression of PJK due to attempt of the patient to remain balanced.

Intra-operative Halo Traction May Obviate the Need for Anterior/Posterior Surgery in Cerebral Palsy Scoliosis

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Purpose: Little is known about the differences in the characteristics and outcomes of patients treated with intraoperative halo traction compared to patients treated with anterior/posterior surgery for cerebral palsy scoliosis.

Methods: Retrospective review of patients with cerebral palsy scoliosis with a curve magnitude ≥100° whose treatment included a posterior spinal fusion and had minimum two years of follow-up. 20 patients were treated with intraoperative halo traction and 13 patients (5 one-day and 8 two-day) were treated with anterior/posterior surgery without intraoperative halo traction. The baseline characteristics, functional status, and preoperative and two-year follow-up data for health related quality of life (HRQOL) and radiographic measures were compared.

Results: Both groups had similar baseline characteristics, with no statistical difference in age, gender, preoperative total protein or albumin, seizure status, or GMFCS level. Both groups had similar changes in their HRQOL at two years, with no statistical differences in the change in any CPCHILD domain or HUI overall score. Both groups had similar major Cobb angles, but the anterior/posterior group had less flexible curves (26.6% vs 39.2%, p= 0.006) and less pelvic obliquity (29.4° vs 41.4°, p= 0.005). The only significant difference in postoperative radiographic measures was that the anterior/posterior group had a smaller absolute change in pelvic obliquity (15.7° vs 32.9°, p= 0.007) but the percent correction of pelvic obliquity expressed was not different (p= 0.854). The anterior/posterior group had longer anesthesia (895.2 vs 416.2 minutes, p <0.001) and surgical times (670.4 vs 344.0 minutes, p <0.001), longer hospital (16.08 days vs 10.05 days, p= 0.010) and ICU (8.08 days vs 5.55 days, p= 0.039) stays, but no difference in days intubated. There was no difference in total EBL (p= .531), cell saver used (p= .419) or RBCs transfused (p= .261).

Conclusion: Compared to intraoperative halo traction with posterior only fusion, patients undergoing anterior/posterior surgery have longer hospital and ICU stays, and longer operative times, but do not benefit from improved deformity correction or change in quality of life.

Significance: Both halo traction and anterior/posterior surgery are utilized in cases with a large magnitude of deformity. Surgeons tend to use halo traction for greater pelvic obliquity and an anterior/posterior approach for stiffer curves. However, anterior/posterior surgery does not seem to offer superior deformity correction or improvements in quality of life over intraoperative halo traction but increases hospital stay and operative times. Intraoperative halo traction may be a viable alternative to a combined anterior/posterior approach.

		Intra-Operative Halo Traction	*Anterior/Posterior Approach*	*P-Value*
Preoperative Radiographic Measures	Major Coronal Cobb Angle (degrees)	112.8	116.1	.223
	Curve Percent Flexibility	39.2	26.6	***.006***
	Pelvic Obliquity (degrees)	41.4	29.4	***.005***
Perioperative Outcomes	Anesthesia Time (minutes)	416.2	895.2	***< .001***
	Surgical Time (minutes)	344.0	670.4	***< .001***
	Total EBL (cc)	1792.0	1896.5	.531
	Total Cell Saver (cc)	346.3	497.7	.419
	Total RBCs transfused (cc)	1260.5	607.2	.261
	Total Hospital Length of Stay (days)	10.05	16.08	***.010***
	ICU stay (days)	5.55	8.08	***.039***
	Days Intubated	3.85	3.50	.183
2-Year Postoperative Radiographic Measures	Major Coronal Cobb Angle (degrees)	34.2	42.3	.133
	Absolute Coronal Cobb Change (degrees)	78.6	73.8	.427
	Percent Coronal Cobb Correction	69.7	63.4	.181
	Pelvic Obliquity (degrees)	8.26	15.6	.503
	Absolute Pelvic Obliquity Change (degrees)	32.9	15.7	***.007***
	Percent Pelvic Obliquity Correction	79.5	60.5	.854

Juvenile Idiopathic Scoliosis Brace Treatment and Progression Risk Factors

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Purpose: Juvenile idiopathic scoliosis (JIS) treatment outcomes are limited in the literature. Young age, long follow-up, and varying treatment methods make studying this population difficult.

Methods: This is a retrospective review of 178 patients with JIS who underwent brace treatment between the ages of 4-10, with 102 patients to skeletal maturity. Family history, MRI results, curve type, Cobb angle, brace type, duration of wear, number of brace changes, compliance by report, and surgical procedures were recorded.

Results: Standard protocol for a child with a Cobb angle >20° is treatment in a brace for 18-20 a day (81%). MRI was obtained in the majority (97%) of patients and demonstrated abnormalities in 29 patients (16%). 23/29 intraspinal anomalies required operative intervention and were excluded. Family history of scoliosis was positive for 48% of patients, 29% with a history of surgical correction. Of the positive family history of surgical correction, 40% of children underwent surgery. Noncompliance was 72% in the operative group and 25% in the nonoperative group. Overall, patients who underwent surgical correction (46%) had a greater mid-thoracic Cobb angle ($p<0.01$), less correction in the brace ($p=0.01$), and were younger at age of bracing ($p<0.05$) but not at presentation ($p=0.6$). The most common curve characteristics at presentation were main thoracic and lumbar modifier B curves. Double thoracic and triple major curves or lumbar modifier C were most likely to undergo surgery, while main thoracic, double major and thoracolumbar curves or lumbar modifier B were least likely to undergo surgery. At the end of growth, both operative and non-operative curve patterns were main or double thoracic or lumbar modifier B.

Conclusion: Age at curve progression, degree of curve, curve correction in brace, lumbar modifier C, and noncompliance are all risk factors in JIS progressing to surgical correction.

Significance: This is the largest series of JIS patients with a standardized treatment protocol in this population. Important risk factors are identified for progression as well as successful brace treatment in the Juvenile population.

Long Term Results of the Galveston Technique for Spinopelvic Fixation in Pediatric Spinal Deformity

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Purpose: Neuromuscular and syndromic scoliosis are challenging disorders. A variety of techniques have been described for spinopelvic fixation. The best technique remains controversial. Our goal was to analyze the long term results of the Galveston technique with respect to spinopelvic stability, pelvic obliquity correction with an emphasis on associated complications.

Methods: We retrospectively reviewed the clinical and radiographic data of 130 consecutive patients with neuromuscular or syndromic scoliosis that underwent posterior spinal fusion (PSF)± anterior spinal fusion (ASF), with LRI and Galveston technique between 1992-2014. We are reporting the results and complications directly related to the Galveston technique occurring at L4 or lower. With a minimum of 2-year follow-up.

Results: 114 patients were neuromuscular, 16 were syndromic. Mean age at surgery was 13± 3.6 years (range, 5 -30 years). Mean follow-up was 7.1± 3.9 years. Ninety-one patients had PSF while 39 patients (30%) had an ASF as well.
All patients had sublaminar wires, 23 patients (18%) had hybrid constructs with pedicle screws or hooks. The mean preoperative major curve was 77°(range, 26-140°) with postoperative correction to 35° (range, 0-88°) at last follow up for a mean correction of 55% (range, 6-100%). Mean preoperative pelvic obliquity was 17.5° (range, 5-50°) and at the last follow-up it was 7° (range, 1-26°) for a mean correction of 60%.
Six patients (4.6%) had late complications directly related to Galveston technique. All at one year or later postoperatively. Four patients had rod complications including one rod migration and 2 prominent iliac rods. All rod breakages occurred at the lumbosacral junction. Five patients (3.8%) needed revision for the broken or prominent rods. Among the 6 complications, 3 patients had cerebral palsy, 2 had myelodysplasia and one had paraplegia from a spinal cord injury. A halo around the intrapelvic portion of the iliac rod was a common finding observed in 41 patients (32%). The presence of the halo was not associated with complications, resolved with maturity of the fusion and was attributed to motion at the sacroiliac joints.

Conclusion: Neuromuscular and syndromic scoliosis patients are more prone to perioperative complications compared to idiopathic. Newer methods of sacropelvic fixation allows satisfactory correction, do not require complex rod bending. The Galveston technique however has low complication rate , lower costs and lower risk for revision surgery making it ideal for spinopelvic fixation.

Significance: Study evaluates the long term results and complications related to the Galveston technique in spino pelvic fixation in Neuromuscular scoliosis.

Adverse Reactions to Intra-Wound Vancomycin Powder in Early Onset Scoliosis: A Multicenter Study of 1398 Children ≤ 12 Years Old

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Purpose: Topical vancomycin has been shown to be effective in reducing Surgical Site Infection (SSI) in posterior spine surgery for Early Onset Scoliosis (EOS), but there is no published safety data for this specific population.

Methods: We analyzed the use of topical vancomycin for SSI prevention in posterior spine surgery in children ≤ 12 years of age. 11 major pediatric spine centers contributed cases January 1, 2009 to December 9, 2015. Procedures included VEPTR and growing rod implantation, lengthening, and removal, as well as spinal fusions. Those with less than 90 days of postoperative follow-up were excluded. Each case was reviewed for any evidence of adverse reactions, including Red Man Syndrome, rash, nephrotoxicity, proteinuria, hepatotoxicity, and ototoxicity.

Results: The 11 centers reported 1398 consecutive cases of topical, intra-wound vancomycin use for posterior spine surgery in children ages 7 months to 12 years. Weights varied from 7.3kg-127.4 kg. There were 480 cases of children <30kg. Dosage ranged from less than 250 mg up to 2000mg. 1/1398 (0.07%) had an adverse reaction (transient skin rash, resolved; no systemic effects). No other adverse reactions or problems were noted. Five patients who previously had Red Man Syndrome with IV vancomycin had no reaction to topical vancomycin. With regards to vancomycin dosing practices, 4/11 sites adjusted dosages based upon patient age or weight. One site adjusted dosages based upon surgery type. Two sites reported that dosage varied with surgeon preference.

Conclusion: Despite varied dosing practices ranging up to 2000mg per case, topical intra-wound vancomycin for SSI prevention in EOS surgery was safe and symptom-free in 99.93% of children. The single adverse reaction was a transient skin rash.

Significance: Because SSI is much more common in EOS procedures such as VEPTR and growing rod operations (compared to adolescent spinal fusions), pediatric spine centers are using all measures possible to lower risk. This data confirms empirical observation that intra-wound vancomycin is safe in children as young as 7 months and as small as 7kg, with a (transient) adverse reaction rate of 0.07%.

Intramedullary Fixation for Displaced Clavicle Fractures in the Adolescent Athlete

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urpose: Recent studies support the role of surgical fixation, particularly plate fixation of displaced midshaft clavicle fractures in adolescents. The role of intramedullary (IM) fixation in this population is not reported. The purpose of our study is to evaluate the role of IM fixation of acute, displaced, mid-shaft clavicle fractures in the adolescent patient.

Methods: This was a retrospective review of pediatric patients with acute, midshaft clavicle fractures treated with an intramedullary clavicle pin (Rockwood Pin, DePuy, Warsaw, IN), between March 2007 and August 2013. Outcomes of interest were activity level, fracture pattern, time to union, time to return to sports and complications. A small cohort of patients were available for final clinical evaluation, which included assessment of range of motion and strength, American Shoulder and Elbow Society (ASES) score and evaluation of radiographic shortening.

Results: Twenty-nine patients (25 male, 4 female) underwent IM pin fixation for a displaced, middle third clavicle fracture by eight orthopaedic surgeons. Mean age was 14.8 years (range 11.4 17.9). Twenty five patients (86.2%) were athletes. Complete displacement (>100%) occurred in 27/29 patients (93.1%) with mean shortening of 18 mm. Fractures were classified as simple (length stable) in 22 patients (75.9%) or multi-fragmentary (length unstable) in 7 patients (24.1%). Union occurred in all patients, at a mean of 8 weeks. Scheduled hardware removal occurred in 28/29 patients (96.6%) at 13 weeks after fixation (range 5 36 weeks). Among athletes, average return to sport was 18 weeks postinjury. Complications were reported in 4/29 patients (13.8%) and consisted of wound breakdown (3 patients) and pin breakage at time of removal (1 patient) that resulted in partially retained but asymptomatic hardware. All wound complications resolved with hardware removal and oral antibiotics and did not compromise outcome. Nine patients returned for an independent functional assessment (See Table 1). Patient satisfaction averaged 9.8/10. There was no difference in ASES score (97.3 vs. 99.0), strength and ROM between injured and uninjured side (p>0.05 nor in clinical outcomes for simple and multi-fragmentary fractures (p>0.05).

Table 1: Outcomes of Cohort of 9 Follow-up Patients

Sex	Age (yrs)	Injury Side (Dominant Arm? Y/N)	Athlete? (Y/N)	Return To Sport (Weeks)	Fracture Type	Complication	Δ Post-op Length (mm)	ASES Injured Side	ASES Normal Side	FF ^{O} Injured Side	FF ^{O} Normal Side	Satisfaction (out of 10)
M	16.8	Right (N)	Y	24	Simple	--	0	100	100	180	180	8.8
M	13.9	Right (Y)	Y	10	Comminuted	--	-4	100	100	170	170	10
M	15.3	Left (N)	Y	20	Simple	--	-6	98.3	98.3	180	180	10
M	13.3	Left (N)	N	N/A	Comminuted	--	+6	98.3	100	160	160	10
F	12.3	Right (Y)	Y	12	Simple	--	-9	79.2	92.5	170	180	9.5
M	15.0	Left (N)	Y	20	Comminuted	--	+2	100	100	180	180	10
F	13.4	Left (N)	Y	19	Simple	--	-2	100	100	180	180	10
M	14.7	Left (N)	Y	21	Simple	--	No XR	100	100	180	180	10
M	14.9	Right (Y)	Y	38	Z-Type	Broken pin at removal	No XR	100	100	180	180	10
*FF= Forward Flexion in Degrees ^{O} ASES = American Shoulder and Elbow Surgeons Total Score (Range 0-100)							p= 0.37	p =0.29		p= 0.35		

Conclusion: IM fixation achieved a 100% union rate with minimal shortening, excel-

lent clinical outcomes and high patient satisfaction in adolescent patients with both simple and multi-fragmentary midshaft clavicle fractures. IM pinning offers stable fixation of clavicle fractures without the morbidity of plate fixation.

Significance: Locked intramedullary fixation is an excellent surgical option for treatment of acute, displaced mid-shaft clavicle fractures in the young, active patient.

The Impact of Transphyseal ACL Reconstruction on Lower Extremity Radiographic Alignment

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Purpose: ACL reconstruction in skeletally immature patients aims to facilitate return to sport and to decrease the risk of meniscal and chondral injuries. A transphyseal technique may provide anatomic graft positioning but increase the patient's risk for physeal injury at the distal femur and/or proximal tibia resulting in growth disturbances. The purpose of this study was to evaluate for coronal and sagittal plane lower extremity radiographic anomalies following transphyseal ACL reconstruction.

Methods: An IRB-approved retrospective review identified 21 patients who had undergone transphyseal ACL reconstruction between 2007-2015 by a single surgeon and were followed to skeletal maturity. Patient height was recorded for pre-operative and last post-operative evaluations. Bone age at the time of surgery was determined via a PA radiograph of the left hand. Mechanical lateral distal femoral angle (mLDFA), mechanical medial proximal tibial angle (mMPTA), zone of the limb mechanical axis, and mechanical axis deviation (MAD) were measured on standing full-length lower extremity AP x-rays obtained pre-operatively and on post-operative evaluations of the operative and non-operative limbs. Tibial slope was measured on lateral knee x-rays of the operative limb, referencing the anterior tibial cortex. Measures were completed by four investigators using an electronic picture archiving and communication (PACS) imaging system. Manney-Wilcox analysis was performed to compare the changes in coronal and sagittal plan measures between operative and non-operative limbs over time.

Results: The 21 patients comprised 13 males and 8 females. Mean chronologic at surgery was 12.2 years (range 7.2 - 16 years) and bone age 12.8 years (range 9 - 15.7 years). Mean time to skeletal maturity was 34 months (range 6.2 - 92 months). Height increased by a mean 13.7 cm (range 1.1 - 45.5 cm). One patient was treated with proximal lateral tibial hemiepiphysiodesis for developing varus in the operative limb. The mean change in tibial slope was +0.4 degrees (range -8.3 to +12.6 degrees). Overall, there were no statistically significant differences in any radiographic parameter between the operative and non-operative limbs: mLDFA ($p = 0.76$), mMPTA ($p = 0.37$), axis zone ($p = 0.48$), or MAD ($p = 0.81$).

Conclusion: In this limited series, transphyseal ACL reconstruction was only sporadically associated with coronal or sagittal plane radiographic anomalies.

Significance: This study provides a radiographic basis to augment existing literature describing functional outcomes of transphyseal ACL reconstruction. Regular follow-up of growing patients who have undergone transphyseal ACL reconstruction is essential to allow for optimal management of any deformities, should they occur.

The Typical Resting Position of the Adolescent Scapula

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Purpose: Scapular position has been studied through fluoroscopic, three-dimensional computed tomography, and clinical examination. While shown to be accurate these assessment methods are costly and may not be suitable for clinical practice. To our knowledge no study has focused solely on the static position of the adolescent scapula. The purpose of our investigation was to describe the typical resting position of the adolescent scapula in asymptomatic subjects through clinical, palpatory examination and assess the inter-rater reliability of the measurements performed.

Methods: Adolescents age 12 to 17 were recruited. Exclusion criteria included: prior history of shoulder pain, shoulder surgery, fracture of the shoulder girdle, overhead athletes, scoliosis, and body mass index greater than 25. A single observer in Group 1 and two observers in Group 2 measured both scapulae of each subject. All measurements were performed with either a digital caliper, goniometer or measurement tape and compared. Measurements included: Shoulder width (lateral acromion to lateral acromion) and scapular spine length. Scapulothoracic translation and tilt was measured via vertebral column to medial border distance relative to T3 and T7 (T3-MB, T7-MB) and inferior medial prominence (IP). Forward shoulder posture was evaluated by measuring the distance from the exam room wall to the anterior and posterior acromion (W-AA, W-PA). Sex and hand dominance were recorded. Intraclass Correlation Coefficient (ICC) was performed to assess inter-rater reliability.

Results: 90 adolescents (35 males, 31 right handed and 55 females, 51 right handed) were included and measured by a single observer and comprised Group 1. 20/90 comprised Group 2 and was measured by two observers. Average age was 14.7 years (12 – 17).
For the 7 measures performed the ICC ranged from 0.21 to 0.87. 5/7 of the measurements yielded good to excellent inter-rater reliability ranging from 0.52 to 0.87. The measures are displayed in Table 1 with data expressed as mean +/- standard deviation.

Measurement	Right (cm)	Left (cm)	ICC	
			Right	Left
T3-MB	7.3 (± 1.4)	7.5 (± 1.7)	0.72	0.76
T7-MB	8.7 (± 1.2)	8.4 (± 1.5)	0.70	0.87
IP	0.99 (± 0.6)	0.93 (± 0.6)	0.76	0.87
W-AA	12.2 (± 2.2)	12 (± 2.3)	0.82	0.78
W-PA	9.0 (± 2.3)	8.7 (± 2.1)	0.52	0.60

Conclusion: Understanding the typical resting position of the adolescent scapula in an asymptomatic "normal" population is crucial when evaluating patients presenting with shoulder pain and their response to intervention. Through our study we were able to establish the typical resting position of the adolescent scapula through a feasible method that demonstrates good to excellent inter-rater reliability.

Significance: Normative values for the resting position of the adolescent scapula have been established in an asymptomatic cohort. This will enable comparative evaluation in future studies for children and adolescents with shoulder pathology.

Medial Patellofemoral Ligament Reconstruction and Simultaneous Guided Correction of Genu Valgum for Patellar Instability in Skeletally Immature Patients

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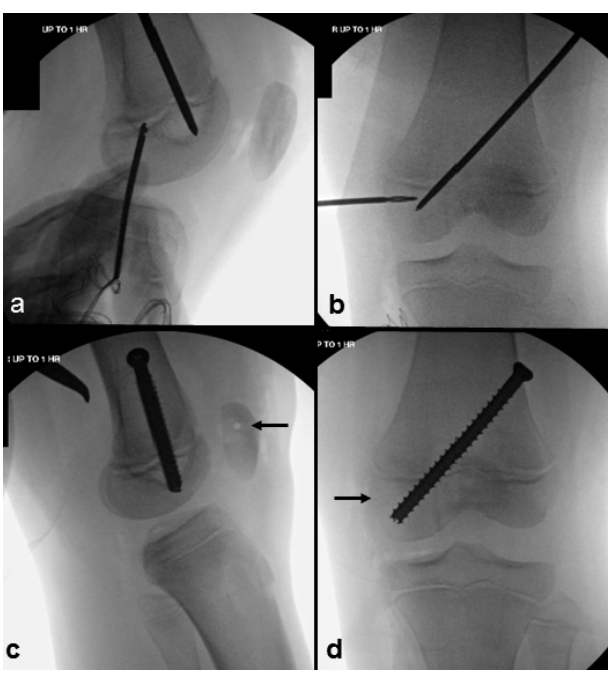
Purpose: Patellar Instability is frequently encountered in skeletally immature patients. Genu Valgum is an important risk factor for patellar instability. Patellar stabilization by MPFL Reconstruction in skeletally immature patients has been well documented. However, there is a potential for MPFL graft stretch and failure in the presence of genu valgum. The purpose of this study was to report on preliminary results of MPFL reconstruction and simultaneous genu valgum correction using guided growth technique.

Methods: 10 patients (11 knees) underwent simultaneous MPFL reconstruction and guided growth. MPFL reconstruction was performed using physeal-sparing technique with femoral attachment below the distal femoral physis. The first 3 patients had medial hemi-epiphysiodesis using tension-band plate. These plates interfered with MPFL femoral attachment; plate placement on the MPFL graft would shorten the effective length of the graft and plate placement underneath the MPFL graft would cause friction and attrition of the graft. Hence alternative technique was sought. 7 subsequent patients (8 knees) underwent MPFL reconstruction with medial hemi-epiphysiodesis using transphyseal screw. Guide pin for transphyseal hemi-epiphysiodesis screw was inserted from the lateral distal femur, anterior to the MPFL femoral pin (Figure 1a,1b). A 6.5 or 7.0 mm fully-threaded cannulated screw was inserted for guided growth (Figure 1c,1d). All patients were followed for minimum 2 years or till skeletal maturity.

Results: Mean age was 11 years (range, 7-14 yrs). There were 3 females. 4 patients had Left knee involved. Mean preoperative femoro-tibial angle corrected from 13° valgus (range, 8°-16°) to 0° (range, -4°-6°). Mean duration to achieve correction was 16 months (range, 6-27). 2 patients (3 knees) underwent removal of transphyseal screw; 2 patients had reached skeletal maturity without need for removal of screw. No patients had recurrent patellar instability during valgus correction. There were no growth disturbances or complications related to transphyseal screws.



Conclusion: Transphyseal screw during MPFL reconstruction could achieve correction of genu valgum without interference with MPFL graft, compared to tension band plate. Preliminary results do not show any deleterious effect of gradual

correction of genu valgum on stability of MPFL reconstruction.

Significance: Genu valgum correction by guided growth during MPFL reconstruction can obviate the need for varus-producing osteotomy later.

Hop Distance Symmetry Does Not Reflect Normalization of Biomechanics in Pediatric Athletes Post-ACL Reconstruction

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Purpose: Single-leg hop distance symmetry is commonly used in return-to-sport (RTS) decision making. This study assessed symmetry and biomechanics of adolescent athletes with recent anterior cruciate ligament reconstruction (ACLR) during a single-leg hop.

Methods: 39 patients with recent unilateral ACLR (62% female; age 13-18 years; 5-12 months post-surgery) and 29 controls (58% female) performed a single-leg hop for distance. Subjects were classified as asymmetric if hop distance on the operative limb or control limb with the shorter distance was <90% of the contralateral limb. Lower extremity 3D biomechanics between initial contact and maximum knee flexion were compared among operative, non-operative (contralateral), and control limbs using ANOVA with Bonferroni post hoc tests.

Results: 10/29 controls (34%) and 12/39 patients (31%) were classified as asymmetric. Compared with symmetric controls, asymmetric patients hopped a shorter distance on the operative side compared with contralateral and control limbs (op: 1.3 leg lengths, non-op and control: 1.6 LL, $p \leq 0.04$). Symmetric patients tended to hop a shorter distance on both sides (1.4 LL, $p=0.17$) with lower peak ground reaction force (op and non-op: 2.8 body weights; control: 3.1 BW, $p<0.10$).
For asymmetric patients, the primary kinematic difference compared with controls was landing more plantarflexed (op: -17.9°, control: -2.2°, $p=0.002$) with greater pelvic drop (op: -12.9°, control: -9.7°, $p=0.055$) and less knee varus (op: 0.1°, control: 2.7°, $p=0.045$). Operative limbs had lower knee flexion moments ($p=0.004$) and greater power absorption at the ankle ($p=0.045$), with a trend of higher dorsiflexion moments ($p=0.084$).
Symmetric patients had greater peak hip flexion on both sides compared with controls (op: 70.6°, non-op: 68.3°, control: 55.2°, $p \leq 0.001$) and less varus at initial contact on the operative side (op: 0.8°, control: 2.7°, $p=0.033$). This resulted in higher hip flexion moments ($p \leq 0.002$), higher power absorption ($p \leq 0.02$), and lower knee valgus moments on both sides compared with controls, as well as lower knee flexion moments on the operative side ($p<0.001$).

Conclusion: A similar percentage of patients and controls were classified as asymmetric based on single-leg hop distance. This suggests hop distance symmetry may not reflect single leg function and RTS readiness. Although both symmetric and asymmetric patients demonstrated biomechanical differences compared with controls, they employed different movement strategies. Asymmetric patients offloaded the knee to the ankle, while symmetric patients offloaded the knee to the hip and decreased task performance on the non-operative side.

Significance: Symmetric hop distance does not indicate normal biomechanics and RTS readiness in young athletes with recent ACLR.

Larger Graft Diameter is Associated with Increased Odds of Arthrofibrosis after Primary Anterior Cruciate Ligament Reconstruction in Children and Adolescents

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Purpose: Arthrofibrosis after anterior cruciate ligament reconstruction (ACL-R) can impact quality of life, delay return to play and necessitate additional surgical procedures. The reported rate is 2-8% for young patients. Associated risk factors include female gender, increased age, associated meniscal procedures, use of patellartendon-bone (PTB) autograft, and decreased pre-operative range of motion (ROM). We hypothesized that certain modifiable factors are associated with increased risk of arthrofibrosis among pediatric and adolescent patients.

Methods: A 1:3 retrospective case-matched-control study was performed at a major tertiary care children's hospital. Patients who underwent primary ACL-R between 2007 and 2015 were identified, and those who had subsequent knee manipulation under anesthesia (MUA) or lysis of adhesion (LOA) procedures were included as "arthrofibrosis cases." Each arthrofibrosis case was paired with three "controls" best matched for gender, age at time of ACL-R, calendar year of ACL-R, and the surgeon performing the ACL-R. Multivariable logistic regression was used to assess the independent association of graft diameter, graft type, fixation method, time from initial injury to ACL-R, associated ligament, meniscal and chondral pathologies, sport played at time of injury, preoperative physical therapy, postoperative CPM machine use, and patient BMI.

Results: The cumulative incidence of arthrofibrosis was 1.9%. (21 cases among 1,121 ACL-R patients) Each case was successfully matched with 3 controls, resulting in 63 total controls. The age span was 7 to 21 years-old. An increase of 0.5 mm graft diameter independently resulted in 3-times increased odds of arthrofibrosis (OR = 5.92, p=0.017, Table 1). The other studied variables were not independently associated with arthrofibrosis. The mean graft diameter was 9.2 mm (range, 7 to 12) for the arthrofibrosis cases vs. 8.8 mm (6 to 11) for the controls. Female gender appeared more likely to have arthrofibrosis. Soccer accounted for the highest incidence of ACL-R. (Table 2) All patients included in the present study had full extension and over 120 degrees flexion prior to ACL-R. All 21 arthrofibrosis cases reached full extension and mean flexion of 134 degrees after MUA or LOA without documented cyclops lesion or graft impingement.

Conclusion: The odds of arthrofibrosis increases with graft size. The decision on graft size must strike a balance between risking re-injury with a smaller graft and risking subsequent arthrofibrosis with a larger graft. For young patients, counseling can integrate that the other factors in the present study may not alter the odds.

Significance: This study introduces the effect of increased ACL-R graft diameter on arthrofibrosis.

Table 1. Demographic and clinical characteristics of patients who underwent ACL reconstruction with or without subsequent Arthrofibrosis. (OR: Odds ratio; CI: Confidence interval; SD: standard deviation; *REF*: reference group for logistic regression; n.a.: non-applicable)

Variables	with arthrofibrosis n=21	without arthrofibrosis n=63	Adjusted OR (95% CI)	p value
Age, months (mean±SD)	177.0±35.9 14.8±3.0 (years)	177.8±28.6 14.8±2.4 (years)	prematched- n.a.	prematched-n.a.
Gender [female, No. (%)]	14 (66.7%)	42 (66.7%)	prematched- n.a.	prematched-n.a.
Graft diameter, mm (mean±SD)	**9.15 (1.17)**	**8.82 (1.10)**	**5.92 (1.38 - 23.43)**	**0.017**
BMI, kg/m^2 (mean±SD)	21.6±2.9	23.2±7.0	0.77 (0.55 - 1.08)	0.127
Time between injury to surgery, days (mean±SD)	74.75±84.21	62.26±58.29	1.00 (0.99 - 1.01)	0.956
Type of injury, No. (%)				
ACL tear only [*REF*]	4 (19%)	14 (22.2)	1.00	–
ACL tear + meniscal injury	14 (66.7%)	37 (58.7)	7.28 (0.65-81.55)	0.107
ACL tear + meniscal + fracture / chondral pathologies / other ligament injuries	3 (14.3%)	12 (19)	0.67 (0.037-12.07)	0.786
Sports type played at time of ACL injury, No. (%)				
Non-sports related	0 (0.0%)	3 (4.8%)	–	0.999
Full contact [*REF*]	16 (76.2%)	37 (58.7%)	1.00	–
Limited contact	2 (9.5%)	10 (15.9%)	0.12 (0.034 - 2.95)	0.312
Non-contact	1 (4.8%)	5 (7.9%)	0.061 (0.001-3.17)	0.165
Physical therapy before ACL-R [yes, No. (%)]	4 (19.0%)	9 (14.3%)	0.157 (0.01 - 1.94)	0.149
Type of Graft				
autograft	14 (66.7%)	46 (73.0%)	0.75 (0.11-5.35)	0.774
allograft [*REF*]	6 (28.6%)	10 (15.9%)	1.00	–
combined autograft + allograft	0 (0.0%)	5 (7.9%)	–	0.999
Type of fixation				
suspensory	4 (19.0%)	13 (20.6%)	0.061 (0.002 - 2.25)	0.128
interference screw	4 (19.0%)	8 (12.7%)	0.139 (0.006 - 2.98)	0.207
hybrid (suspensory + interference screw) [*REF*]	13 (61.9%)	42 (66.7%)	1.00	–
CPM machine use after ACL-R [yes, No. (%)]	7 (33.3%)	20 (31.7%)	0.30 (0.033 - 2.73)	0.286

Table 2. Distribution of sports played at time of initial ACL injury.

Sports Type	with arthrofibrosis (n=21) No. (%)	without arthrofibrosis (n=63) No. (%)	total (n=84)
Non-Sports related	0	3 (5%)	3 (4%)
Full Contact	16 (76%)	37 (59%)	53 (63%)
Basketball	4 (19%)	7 (11%)	11 (13%)
Field/Ice Hockey	0	2 (3%)	2 (2%)
Football	3 (14%)	6 (10%)	9 (11%)
Lacrosse	2 (10%)	2 (3%)	4 (5%)
Soccer	6 (29%)	19 (30%)	25 (30%)
Wrestling	1 (5%)	1 (2%)	2 (2%)
Limited Contact	2 (10%)	10 (16%)	12 (14%)
Baseball / Softball	0	1 (2%)	1 (1%)
Cheerleading	0	4 (6%)	4 (5%)
Gymnastics	0	1 (2%)	1 (1%)
Skiing / Snowboarding	2 (10%)	1 (2%)	3 (4%)
Volleyball	0	2 (3%)	2 (2%)
Skateboarding	0	1 (2%)	1 (1%)
Non-contact	1 (5%)	5 (8%)	6 (7%)
Running	0	2 (3%)	2 (2%)
Biking	1 (5%)	0	1 (1%)
Surfing	0	1 (2%)	1 (1%)
Frisbee	0	1 (2%)	1 (1%)
Dancing	0	1 (2%)	1 (1%)
Not recorded	2 (10%)	8 (13%)	10 (12%)

Non-operative Treatment of Stable JOCD of the Knee: Effectiveness of Unloader Bracing

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Purpose: Stable juvenile osteochondritis dissecans (JOCD) lesions of the knee are initially treated via non-operative methods. The outcomes of unloader bracing compared to other forms of non-operative treatment for lesions of the femoral condyles have not been established.

Methods: This retrospective study assessed the clinical course of patients who underwent non-operative treatment for stable JOCD of the femoral condyle at a single institution from 2001 through 2014. Treatment for each patient was based on physician preference. Unloader bracing was compared to other (i.e. "non-unloader") modalities, with successful non-operative treatment defined as the avoidance of subsequent surgical intervention.

Results: 298 patients, 219 (73%) male, underwent non-operative treatment for stable JOCD of the femoral condyle. The mean (±SD) age at diagnosis was 11.5 (±1.6) years. 35 patients were diagnosed with bilateral OCD, resulting in a total of 333 knees (157 left, 176 right). 187 knees (56%) were treated with unloader bracing for a minimum of 3 months, while 146 (44%) were treated with other non-operative modalities. In the non-unloader group, 44/146 (30%) were prescribed an alternative form of bracing or immobilization. Weight-bearing restrictions were applied for a total of 83 cases (25%), for durations ranging from 19 to 196 days (median 46) and at similar rates across groups.

Non-operative treatment was successful in 189 knees (57%) with median follow-up of 9.5 months (IQR 5.9 to 15.7). In 144 knees (43%) requiring subsequent surgical intervention, the median time to surgery was 6.0 months (IQR 4.1 to 10.5). Non-operative treatment was successful in 94/187 knees (50%) that underwent unloader bracing, compared to 95/146 of knees (65%) that did not (p=0.02). Male sex (p=0.05) and Hefti stage I (p=0.05) showed possible associations with successful non-operative treatment.

Conclusion: Non-operative treatment for stable JOCD of the knee leads to the avoidance of subsequent surgical intervention in 57% of cases. Unloader bracing is not associated with significantly improved outcomes when compared to other non-operative treatment modalities.

Significance: This high volume study provides adequate statistical power to substantiate preliminary investigations demonstrating healing in over half of cases of stable juvenile OCD and helps elucidate differences in outcomes based on non-operative treatment modality.

Adolescent Athletes Cleared to Return to Sport After ACL Reconstruction Have Asymmetric Kinematics and Kinetics Compared to Controls

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Purpose: To compare the knee kinematics and kinetics of adolescent athletes who were post-ACL reconstruction to an uninjured control group.

Methods: Adolescent athletes who were post-ACL reconstruction (ACLR) and uninjured control group were included in this study. The athletes completed our institution's return to sport (RTS) assessment by a sport trained physical therapist which included: running (Run), drop vertical jump (DVJ), single leg long hop (LH), single leg triple hop (TH) and single leg crossover triple hop (CH) with simultaneous three-dimensional motion capture. The subject's LH, TH, and CH trial of maximum hop distance were selected on each side and a representative DVJ and running trial was used for analysis. Paired t-tests were used to compare differences in peak knee flexion (PKF), peak knee extensor moment (PKEM) and peak knee power absorption (PKPA) during loading between the ACLR and healthy knees in the RTS subjects and the preferred (Pref) and non-Preferred (Non-Pref) knees in the control subjects.

Results: Thirty adolescent athletes (15.9±1.5 years old, 20 males) who were 6.9±1.75 months post-ACLR and were deemed ready to RTS based on the clinical assessment by a sport trained physical therapist and the treating orthopedic surgeon were included in the RTS group. Thirty healthy adolescent athletes (15.6 ± 2.15 years old, 16 males) served as a control group. .The Group means for the motion analysis measurements of PKF, PKEM and PKPA were statistically different between the ACLR and healthy knees in for all tasks in the RTS group ($p \leq 0.05$, Table 1). In the control group PKF, PKEM in the LH, and PKPA in the LH and CH were statistically different between the preferred and non-preferred kicking leg ($p \leq 0.05$, Table 1).

Conclusion: ACLR subjects had significant side to side differences in knee kinematics and kinetics during loading in all functional assessment tasks at the time of RTS approval following standard institutional assessments. These side to side differences, which involve eccentric loading of the quadriceps, were not as prevalent in the control group.

Significance: The increased prevalence of asymmetrical knee kinematics and kinetics in adolescent athletes cleared to return to sport after ACL reconstruction when compared to age matched uninjured controls may explain one cause for the high incidence of re-injury and contralateral injury in this patient population. Future investigation into implications of asymmetry in eccentric knee loading may help direct rehabilitation and return to sport protocols, and reduce the number of second ACL injuries.

Table 1. Mean ± SD knee kinematics and kinetics during the loading response of functional tasks for Post-ACL Reconstruction Return to Play (RTP) and control subjects.

			Run	DVJ	LH	TH	CH
PKF (°)	RTP Subjects	Healthy Knee	47 ± 5	90 ± 12	69 ± 13	59 ± 6	62 ± 6
		ACLR Knee	43 ± 6	88 ± 12	64 ± 12	55 ± 7	57 ± 8
	Controls	Pref Knee	44 ± 5	87 ± 15	58 ± 8	56 ± 6	57 ± 7
		Non-Pref Knee	43 ± 5	87 ± 15	55 ± 10	53 ± 7	57 ± 7
PKEM (Nm/Kg)	RTP Subjects	Healthy Knee	1.94 ± 0.48	1.82 ± 0.58	1.95 ± 0.67	2.14 ± 0.69	1.96 ± 0.64
		ACLR Knee	1.59 ± 0.40	1.51 ± 0.54	1.68 ± 0.59	1.67 ± 0.62	1.71 ± 0.54
	Controls	Pref Knee	1.64 ± 0.52	1.57 ± 0.35	1.82 ± 0.60	1.95 ± 0.44	1.93 ± 0.57
		Non-Pref Knee	1.66 ± 0.54	1.47 ± 0.40	1.61 ± 0.55	1.83 ± 0.51	1.79 ± 0.38
PKPA (W/kg)	RTP Subjects	Healthy Knee	11.54 ± 4.39	13.49 ± 6.98	15.55 ± 7.79	13.73 ± 6.21	12.03 ± 6.41
		ACLR Knee	9.40 ± 3.70	10.64 ± 5.64	11.76 ± 5.01	10.63 ± 4.84	9.36 ± 4.95
	Controls	Pref Knee	9.76 ± 4.46	11.36 ± 3.78	13.64 ± 5.92	12.54 ± 3.2	10.32 ± 4.11
		Non-Pref Knee	10.51 ± 4.84	11.42 ± 4.56	11.25 ± 5.24	10.92 ± 4.24	9.00 ± 4.19

PKF = Peak knee flexion; PKEM = Peak knee extensor moment; PKPA = Peak knee power absorption; ACLR = reconstructed anterior cruciate ligament side; Pref = preferred kicking side; Non-Pref = non preferred kicking side; DVJ = drop vertical jump, LH = single leg long hop; TH = single leg triple hop; CH = single leg crossover triple hop, Grey shaded cell = $p \leq 0.05$ paired t-test between sides.

Outcomes of Medial Patellar Tendon Transfer with Proximal Realignment in Young Skeletally Immature Children with Patellar Instability

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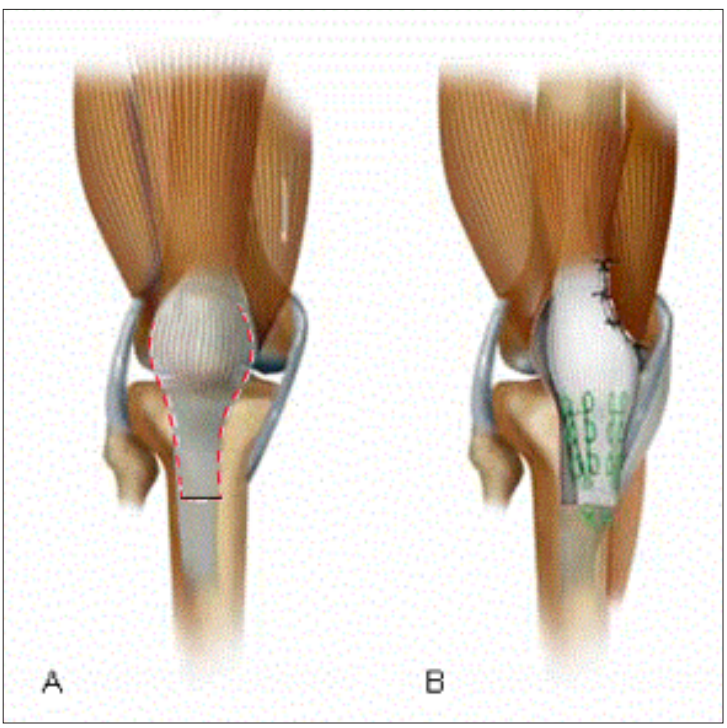
Purpose: Treatment of severe developmental patellar instability is challenging due to the inability to correct underlying bony deformity with distal procedures prior to skeletal maturity. Medial transfer of the patellar tendon has been previously reported in small series. The purpose of the current study was to report the outcomes and rates of complications of medial patellar tendon transfer with proximal realignment.

Methods: A retrospective cohort of patients undergoing soft tissue transfer of the patellar tendon with proximal realignment for the treatment of skeletally immature patellar instability by 3 surgeons was performed. Forty-eight knees treated between 2004 and 2014 were included. Postoperative complications, including patellar tendon rupture, were reviewed in all patients. The patient-reported outcomes, need for revision surgery, and rates of recurrent dislocation/subluxation of thirty-five knees (73%) at a minimum 18 month follow-up were analyzed, including 15 with underlying genetic syndromes/developmental delay (Group A) and 20 without underlying syndrome (Group B). Patellar tendon transfer was performed with suture fixation to the periosteum and bone and proximal realignment with open lateral release and VMO advancement/medial plication. Medialization of the patellar tendon average 65% of the width of the patella (range 50-150%). All patients were immobilized in extension with toe touch weightbearing for 4-6 weeks postoperatively.

Results: Overall complication rate during the perioperative period was 4%. No patellar tendon ruptures (0%) were noted. Thirty-five knees in 22 patients had a mean follow-up of 57.8 months (range 18-129 months). The mean age of Group A was 7.6±1.9 years (range 5.1-12.2) In Group B, the mean age at surgery was 8.5±1.9 (range 5.9-11.5) with 85% of patients under 10 years of age. At final followup, the mean age was 13.9 years (range 8.3 to 22.6) and 11% of patients reported recurrent patellar subluxation, while 0% reported



recurrent patellar dislocation. All patients reported being “very satisfied” and would have the surgery again. In Group B, 89% reported participation in moderate or strenuous activities including sports. Subsequent surgery was performed in 4% of patients including one revision patellar tendon transfer three years postoperatively.

Conclusion: While this technique was initially reported in the setting of underlying genetic or developmental syndromes, it appears to be a safe and effective treatment for this challenging problem in normal children with high levels of activity.

Significance: Medial patellar tendon transfer with proximal realignment is a safe and effective treatment option for severe patellar instability presenting in young skeletally immature patients (generally under 10 years of age).

Relationship between Trochlear Dysplasia and the Distal Femoral Physis in Pediatric and Adolescent Patients with Patellar Instability

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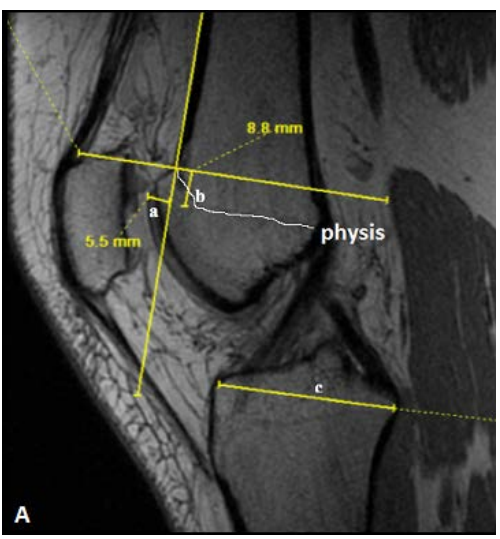
Purpose: There is an increasing interest in evaluation and management of trochlear dysplasia to address patellar instability. In children and adolescents, the spatial relationship between the distal femoral physis and trochlear dysplasia is unknown. The purpose of our study was to evaluate this relationship, the knowledge of which can help elucidate the role of the physis in development of trochlear dysplasia and safety of trochleoplasty in younger patients.

Methods: 159 patients (175 knees) with trochlear dysplasia were identified after radiologic review of 345 patients who underwent patellar stabilization at one institution (2008-2015). Trochlear bump height (TBH) and trochlear bump – femoral physis distance (TPD) were calculated using digital software on a mid-sagittal MRI image. A standardized TPD ratio was calculated by dividing TPD by AP length of the tibial plateau to control for varied knee sizes (Fig 1A, label C). Correlation between age, TBH and TPD and intra-rater reliability was statistically analyzed.

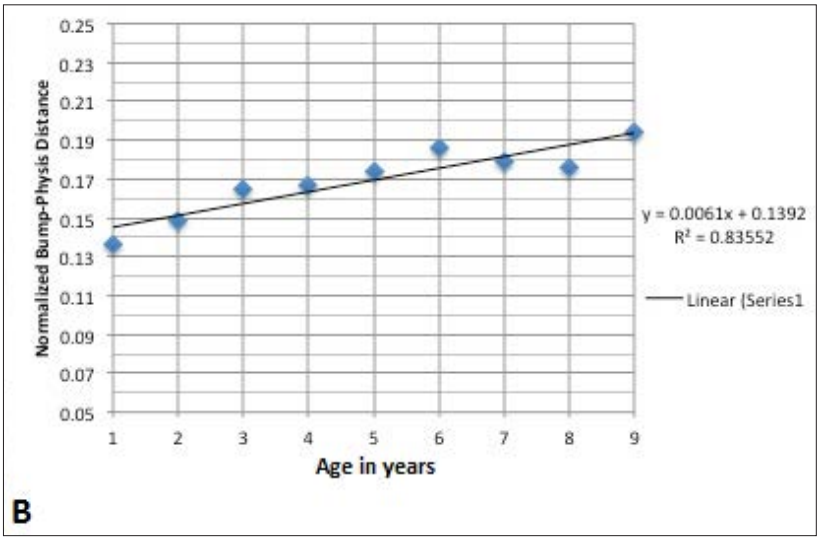
Results: Mean age for the sample was 14.7 + 2.1 yrs. Mean TBH was 5.3 + 1.8 mm. The proximal-most edge of trochlea was below distal femoral physis in all knees. Mean TPD was 8.2 + 2.4 mm; mean TPD ratio was 0.18. There was a strong positive correlation (R^2 = 0.84) between age and TPD ratio, i.e with increasing age, there was a corresponding increase in TPD (Fig 1B). There was moderate correlation (R^2= 0.57) between age and TBH, i.e with increasing age, there was corresponding increase in TBH. There was excellent intra-rater reliability (ICC: 0.93).

Conclusion: This study shows that there is an age-based spatial relationship between the trochlea and distal femoral physis. Thus, per Heuter-Volkmann principle of bone growth, patellar instability at young age and inadequate pressure on trochlea could be related to development of trochlear dysplasia. A chronically unstable patella during development could result in less pressure on the trochlear groove and could contribute to the development of a dysplastic trochlea. Alternatively, an early subluxation may have caused physeal injury that resulted in stunted trochlear development. These are both hypotheses based off the current study's results.



Significance: The current results suggest that trochlear dysplasia may be developmental in nature and thus secondary to, rather than a cause of, patellar instability. Consequently, patellar stabilization at a young age may aid in remodeling of trochlear

groove. Additionally, the close proximity of physis poses theoretical risk of iatrogenic growth disturbances during trochleoplasty in younger patients.



Segond Fracture: A Risk Factor for Anterior Cruciate Ligament Reconstruction Failure?

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Purpose: Segond fractures may be identified when an anterior cruciate ligament (ACL) tear is diagnosed and likely represent an avulsion of the anterolateral ligament. It is unclear whether these fractures can be ignored at the time of ACL reconstruction or if they should be addressed surgically. The purpose of this study was to compare the incidence of Segond fractures in patients undergoing a primary ACL reconstruction compared to those undergoing a revision ACL reconstruction in an attempt to determine if the presence of a Segond fracture predisposes to ACL reconstruction failure.

Methods: A retrospective review of all patients undergoing a primary or revision ACL reconstruction between January 2007 and June 2014 was performed. Demographic data (age, gender, and BMI), injury variables (acuity, mechanism of injury), and radiographic features (concomitant ligamentous injuries, growth plate status) were documented. Each Segond fracture was analyzed for its specific location, size, displacement, and healing using both radiographic images and MRI. Statistical analysis was performed using a p value of <0.05.

Results: There were 599 ACL tears identified, with Segond fractures present in 31 (6%). The fracture fragment averaged 6.6 mm in height, 2.3 mm in width, and was displaced 5.0 mm. The fracture fragment bed was localized at the tibial attachment site of the anterolateral ligament 21 mm posterior to Gerdy's tubercle in nearly all cases. Post-ACL reconstruction, the Segond fracture healed in 90% of cases. The incidence of a Segond fracture was twice as common in male patients ($p=0.02$), otherwise its presence was not associated with any other demographic data, injury variables, or radiographic features ($p>0.05$) (Table 1). No patients undergoing a revision surgery had a Segond fracture and no patient with a Segond fracture had a graft failure.

Table 1: Patient demographic, injury variable, and graft failure rates in patients with Segond fractures compared to those with no Segond fracture.

	Segond Fracture (N = 31)	No Segond Fracture (N=568)	p-value
Age (years)	15.6 ± 1.7	16.0 ± 1.3	p = 0.25
Gender (% male)	74.2%	53.2%	p = 0.02
BMI	26.2 ± 5.8	25.7 ± 5.4	p = 0.63
Growth plate status (% closed)	83.9%	82.6%	p = 0.94
Mechanism of injury (% non-contact)	48.4%	44.7%	p = 0.95
Multi-ligament knee injury (%)	19.4%	12.3%	p = 0.25
Graft Failure	0%	8.3%	p = 0.09

Data is presented with means and standard deviations or a percentage.
P-values in bold represent a value less than 0.05.

Conclusion: Segond fractures are relatively uncommon in adolescent patients undergoing ACL surgery, with an incidence of 6%. These fractures have a high union rate and graft failure after an ACL reconstruction in the setting of a Segond fracture are uncommon.

Significance: Patients with a Segond fracture are at no higher risk to require a revision ACL reconstruction compared to patients without a Segond fracture. This may be attributable to its high union rate. At the time of primary ACL reconstruc-

tion, if a Segond fracture is identified, it can be ignored (not repaired or reconstructed) and this approach does not appear to predispose to ACL graft failure.

3D Characterization of Juvenile Osteochondritis Dissecans

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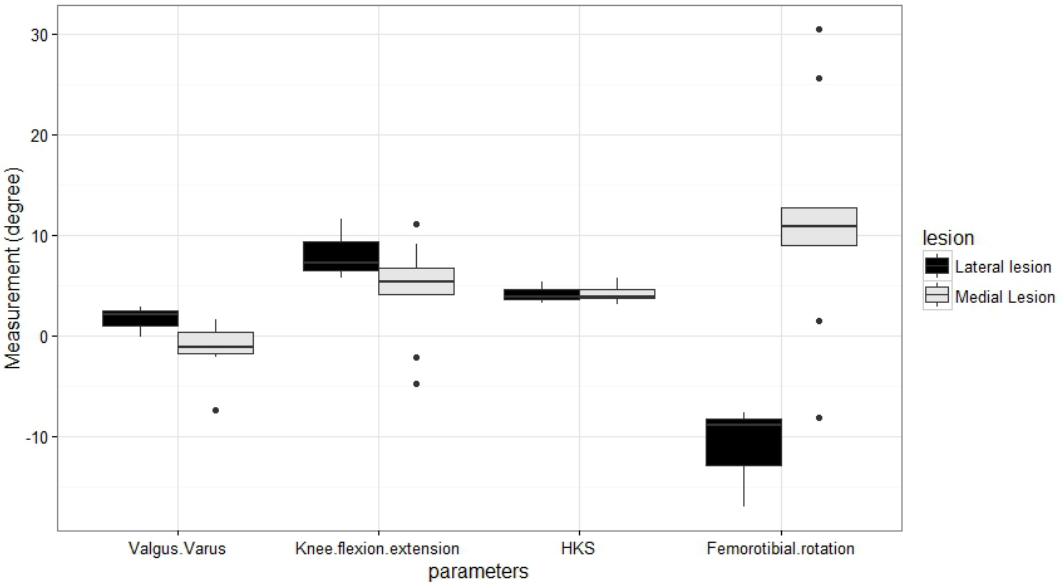
Purpose: Juvenile osteochondritis dissecans (JOCD) is an idiopathic multifactorial condition. Previous 2D measurements of the femorotibial alignment have alluded to biomechanical factors associated with abnormal retropatellar or tibial spine loading and development of OCD. The objective of this study was to characterize the 3D femoro-tibial geometrical parameters of JOCD using upright stereoradiography imaging and compare parameters to those measured in an asymptomatic control group.

Methods: A total of 11 patients (12 knees) who presented with JOCD of the knee with no previous surgical intervention were recruited prospectively. MR images were consulted to determine the location of the OCD lesion. 8 unaffected knees were used as the control group. Full biplanar X-ray images of the lower extremities, with the pelvis in weight-bearing standing position, were taken by a low-dose stereoradiography imaging system. The 3D reconstruction of the femur, tibia and pelvis was generated for each set of biplanar images. A total of 21 2D/3D alignment and morphological parameters were measured in the cohort. These parameters were categorized as pelvis (pelvic incidence, sacral slope, sagittal and lateral pelvic tilt, pelvic rotation), femur (femoral heads diameter, femoral offset, neck shaft angle, neck and femur length, femoral mechanical angle, femoral torsion), tibia (tibial length, torsion, and mechanical angle), and knee (valgus/varus angles, flexion/extension angles, HSK angle, femoro-tibial rotation). A Mann Whitney U-test was performed to compare the differences between JOCD cases and controls and patients with medial and lateral femoral condyle OCD lesions.

Results: Knee flexion/extension angle was significantly different between the JOCD and control groups ($p<0.05$). Three of 12 knees had OCD lesions on the lateral femoral condyle and 9 had lesions on the medial femoral condyle. Femoro-tibia rotation was positive in patients with medial torsion and negative in patients with lateral torsion with significantly different average values ($p<0.05$). Femoro-tibia rotation was only significantly different between the patients with a medial lesion and controls ($p<0.05$) (Figure 1). A greater difference between the femur and tibia torsion was observed in the JOCD group with a lateral lesion ($p<0.05$).

Conclusion: Differences in 3D parameters of the lower extremities were observed between JOCD subjects and controls as well as between JOCD patients with medial and lateral femoral condyle lesions.

Significance: This novel 3D analysis of the lower limbs of OCD patients suggests an underlying mechanical factor associated with development of OCD of the knee. The characterization of these differences has the potential to improve classification and treatment of JOCD.


30
20
10
0
-10
Measurement (degree)
Valgus.Varus
Knee.flexion.extension
HKS
Femorotibial.rotation
parameters
lesion
Lateral lesion
Medial Lesion

Anterior Cruciate Ligament Reconstruction in Pediatric and Adolescent Patients: Quadriceps Tendon Patellar Autograft versus Hamstring Tendon Autograft

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Purpose: Quadriceps tendon patellar bone autograft (QPA) survival following primary anterior cruciate ligament reconstruction in adolescents has not been well characterized. The purpose of this study was to retrospectively compare graft failure risk in a cohort of adolescents that underwent QPA reconstruction to a cohort of subjects that underwent hamstring autograft (HA) reconstruction.

Methods: All adolescent subjects (<19 years of age) who underwent primary ACL reconstruction between 2005 and 2015 were identified. Only subjects with a minimum of 12 months follow-up after primary ACL reconstruction were included in the study. Demographics (age and gender), medial meniscus procedure(s) performed during primary surgery, and occurrence of graft failure were collected from subjects' charts. Graft failure was defined as needing revision surgery or MRI-confirmed graft failure. A multi-variable cox proportional hazards regression analysis was used to compare risk of graft failure in the two groups. Age, gender, and medial meniscus procedure were controlled for as potential confounding variables. Only failures that occurred within 24 months of initial ACL reconstruction were considered in the primary analysis.

Results: Age at surgery (15.3 years ±2.0 vs. 15.6 years ±1.5), sex (54% female vs. 41% male), and medial meniscus procedures performed (11% vs. 7%) was similar in the QPA (n=72) compared to the HA (n=44) group. Mean duration of follow-up was 1.5 years (range: 1-3.1 years) in the QPA group compared to 3.8 years (range: 1-6.0 years) in the HA group. In the first 24 months following surgery, there were 3 (3/72) graft failures in QPA group compared to 6 (6/44) graft failures in the HA group. The adjusted risk or hazard of graft failure in the QPA group was 0.38 [95% CI: 0.09 to 1.6, p = 0.1850] times the risk of graft failure in the HA group. Graft survival at 12 months was 99% in the QPA compared to 91% in HA group. At 24 months, graft survival was also higher in the QPA group (94%) compared to the HA group (86%).

Conclusion: Graft survival in both cohorts was greater than 85% during the first 24 months following surgery, a time period associated with high risk of graft failure. The overall hazard of graft failure trended higher in the HA group compared to the QPA group. Additional follow-up is needed to compare long term outcomes in the two graft groups.

Significance: This study provides direction for further investigation to determine the optimal graft for adolescent ACL reconstruction.

Optimal Fluoroscopic Angulation to Determine Intercondylar Notch Violation During Pediatric Medial Patellofemoral Ligament Reconstruction

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Purpose: Previous anatomic data has suggested that during pediatric medial patellofemoral ligament (MPFL) reconstruction the femoral tunnel must be angled distally and anteriorly to avoid damage to the physis. In doing so, intercondylar notch violation is possible, and intraoperative radiographic evaluation is important to determine if violation of the intercondylar notch has occurred. The purpose of this study was to determine the optimal degree of fluoroscopic angulation necessary to determine the presence of intercondylar notch violation radiographically.

Methods: Fourteen adult cadaveric human femora were disarticulated and all tissue removed from the femoral condylar and intercondylar notch. Under fluoroscopic guidance, Schottle's point was identified on the medial aspect of the distal femur. A 0.62mm Kirschner wire was then drilled through the condyle, directed anteriorly and distally at an angle to create a minimal notch violation. The femur was then placed on a level radiolucent table and coronal plane radiographs angled from -15° to 60° were obtained in 5° increments. Images were assessed to determine the angle of the pin versus the joint line, and the radiographic angle in which reviewers could most clearly visualize violation of the intercondylar notch. Notch violation was graded by two investigators and averaged.

Results: ICC value for all measurements was .970. Mean angling of the drill at 27°± 7° resulted in gross visualization of the pin in the intercondylar notch. (Figure 1) Radiographic examination showed that violation of the notch was appreciated at a mean angle of 37°± 13° (range, 15 to 55°) from neutral.

Conclusion: During pediatric MPFL reconstruction, drilling of the femoral tunnel carries the risk of intercondylar notch breech. Results from this study demonstrate that radiographs angled an average of 37° from neutral are optimal to provide radiographic confirmation of violation intra-operatively, and emphasize the importance of angling the beam in order to obtain a proper view of the intercondylar notch.

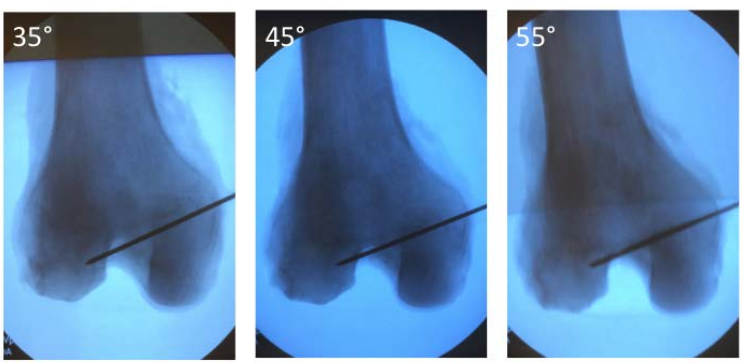

Figure 1: Consecutive radiographs of the left distal femur at 35°, 45° and 55° of angulation with evidence of intercondylar notch violation at 45°.

Significance: Radiographs obtained between 35° to 40° from neutral provide optimal radiographic confirmation of intercondylar notch violation intra-operatively during pediatric MPFL reconstruction.

Increased Glenoid Index is a Risk Factor for Pediatric Anterior Glenohumeral Dislocation: An MRI-Based Case-Control Study

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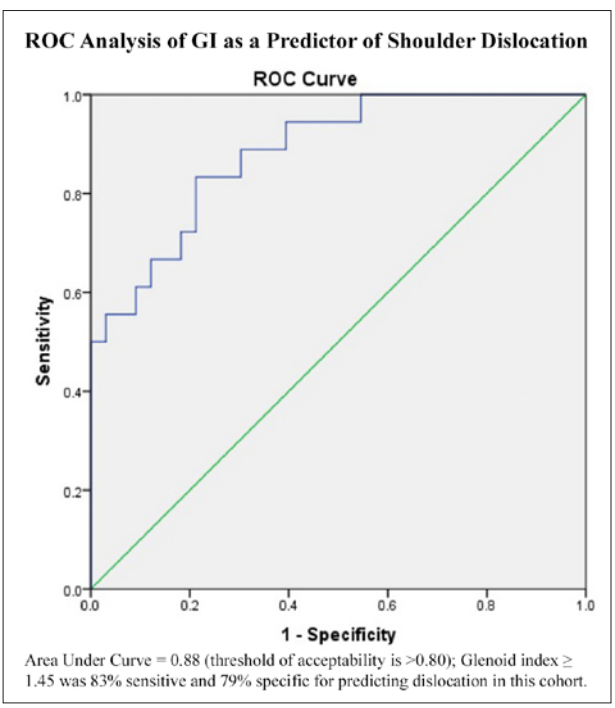
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States

Purpose: In the adult population, anterior glenohumeral instability has been associated with a tall and narrow glenoid morphology, assessed using glenoid index (GI). This morphological association has not been assessed in children and adolescents. This study was designed to examine the association of GI with anterior glenohumeral dislocation in patients 19 years old and younger using a case-control study design.

Methods: An institutional radiology database was queried over a 10-year period to identify patients 19 years old and younger who underwent glenohumeral MRI arthrography and were diagnosed with anterior shoulder dislocation (cases) and those without dislocation and normal shoulder arthrogram studies (controls). Those with bony Bankart lesions were excluded. Glenoid index (glenoid height-to-width ratio) was measured by an attending pediatric musculoskeletal radiologist and a fellowship-trained attending orthopedic surgeon. Comparative analysis between the two groups was performed using Student's t-test for each variable, followed by receiver-operating-characteristic (ROC) analysis to determine discriminative ability when statistically significant.

Results: Thirty-three males and 22 females (mean age: 15.4±2.1 years old) meeting inclusion and exclusion criteria were identified. Mean glenoid index in the dislocator group was significantly greater than the control group (1.55±0.14 vs. 1.38±0.08, P<0.001). ROC analysis revealed adequate discrimination of glenoid index in predicting glenohumeral dislocation (area under the curve [AUC] = 0.88). A glenoid index ≥1.45 was 83% sensitive and 79% specific for predicting dislocation in the study cohort (Figure 1).



Conclusion: Patients with anterior glenohumeral dislocation were noted to have increased glenoid index (taller and narrower glenoid morphology) than controls. Glenoid index may help identify patients at risk for primary or recurrent anterior glenohumeral instability events, and can help guide treatment and anticipatory guidance.

Significance: This is the first study to report MRI-measured glenohumeral morphological differences between patients who suffered anterior shoulder dislocation and

controls in the pediatric patient population. Given the high incidence of anterior shoulder dislocations and the consequences of recurrence, early identification of at-risk patients is of great importance in the pediatric population. Glenoid index may help identify at-risk patients and guide prognostic recommendations.

Treatment of Patellar Instability in Children by Pediatric Medial Patellofemoral Ligament Reconstruction

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Purpose: The reconstruction of the medial patello-femoral ligament (MPFL) is the gold standard in the treatment of patellar instability of proximal origin. In children, the femoral insertion point is located close to the femoral physis, and tunneling involves risks. The aim is to present the results of the reconstruction of the MPFL by anchoring (modified Chassaing technique) soft tissue in children and adolescents.

Methods: Prospective cohort of 50 knees (40 patients) diagnosed with patellar subluxation (28 cases), recurrent dislocation (16) or habitual dislocation (6), mean age 13.5 years (6-18), treated with this technique, and mean follow-up 48 months (24-84).
The surgical technique consisted of a plasty of MPFL (semitendinosus or gracilis) with soft tissue anchor (in the original insertion MPFL in the femur) and subperiosteal in patella.
The pre and post-operative clinical evaluation were done by Lisholm and Tegner scales. The anterior pain, tracking, patella laxity and Smilie sign were recorded.
The radiological study in pre and post-operative included the Caton-Deschamps index and the CT-scan patellar tilt, tibial tubercle trochlear groove (TT-TG) and the degree of trochlear dysplasia.
Clinical evaluation was measured using the Lysholm and Tegner scales.
In our technique, the gracilis tendon autograft is taken and an arthroscopic section of the external retinaculum is done.

Results: The pain was reduced from 32 to 10% of patients, and instability from 100% to 7.1%. The Smilie test was reduced from 100% to 28% of patients ($p < 0.05$).
The Caton-Deschamps average went from 1.34 to 1.23, and the tilt from 27.8 to 13.5 (3-30) ($p < 0.07$).
46 patients had trochlear dysplasia (18 type A, 18 type B and 10 type C), of which 6 cases lost one degree (2 type C to B, 2 type A and 2 B to Type A normalized).
Lysholm scale went from 60 to 91.6 points on average, and Tegner 3.2 to 4.3 ($p < 0.025$).
91% of patients were satisfied.
There were two recurrences: 1 case in which the TT-TG (22mm) was not corrected and one case in wich neither the TT-TG nor the high patella were corrected (Caton-Deschamps 1.5).

Conclusion: MPFL reconstruction based on Chassaing technique is effective and can reshape the trochlea. Other important points are the anatomy, isometrics and plasty tension, and the need to involve associated surgical procedures.

Significance: In the treatment of femoral-patellar instability in children, bone procedures are contraindicated. The modified Chassaing technique provides excellent results using soft tissue reconstruction.

Preoperative Imaging Characteristics of Gartland Type IV Supracondylar Fractures

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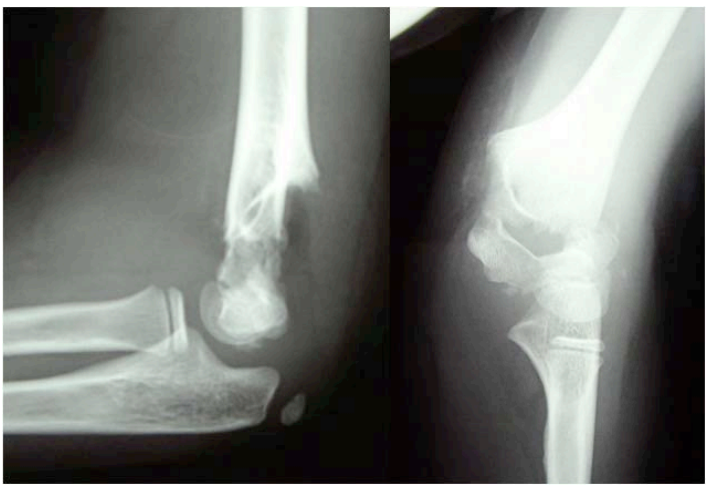
Hospital Sant Joan de Deu, Barcelona, Spain

Purpose: Gartland type IV supracondylar fractures (GIV SCF) are defined by intraoperative instability in both flexion and extension. We hypothesize that this instability is caused by near-complete disruption of the periosteum at the fracture site, with an intact on the medial or lateral side only. This study aims to characterize the preoperative imaging findings of these globally unstable fractures.

Methods: Seventeen GIV SCF fractures were identified through retrospective review of operative reports. Fractures were confirmed as type IV if they were documented as unstable in flexion and extension intraoperatively. Mean subject age was 6.6 yo (range 3-10 years). We retrospectively reviewed all injury radiographs as well as the specific reduction techniques used intraoperatively, when available.

Results: Preoperative AP radiographs demonstrated varus angulation in 5 cases and valgus angulation in 12 cases. Preoperative lateral radiographs demonstrated disruption of both anterior and posterior cortices. The distal fragment was often rotated but always vertically aligned with the proximal fragment (Figure 1). For those fractures in which specific reduction techniques were mentioned, pinning in semi-extension was favored, with valgus fracture reduction achieved via supination and varus fracture reduction obtained in pronation.



Conclusion: In this series, GIV SCF showed a constant radiological pattern on injury radiographs. Our hypothesis is that GIV SCF are produced by a trauma vector in the coronal plane (either varus or valgus) leading to a near-circumferential periosteal rupture in which either a medial or lateral hinge remains.

Significance: GIV SCF can be identified on injury radiographs based on the above imaging characteristics. This information will help with surgical planning of this challenging fracture type.

Results of Pollicisation in very young children In Radial Club Hand – A Comparative Functional Analysis

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Purpose: The purpose of this series is to evaluate the results of pollicisation in very young radial hemimelia patients with and without anomalies of the index to be pollicised i.e. camptodactyly or symphallangism. This paper is a retrospective analysis of prospectively gathered data that documents results of early pollicisation.

Methods: Twenty children with 24 hands (4 bilateral) group A underwent pollicisation at mean age of fifteen months (range 9-36 months). They were analysed clinically by using the angle of the first web, rotation, pinch strength using a bulb sphygmomanometer(developed ingeniously)and interphalangeal movement .Functional analysis was done by using modified Percival, Sykes and Chandraprakasam score, at a mean follow-up of four years (range 3- 7 years) . The modification of the Percival score was done by reducing the tally from a total of 30 points 24 points by eliminating the two point discrimination sensory testing since the children were too young to be able to test this accurately.
All the assessment results were compared with a control group(B) of 25 age- and sex-matched normal children.

Results: In the post-op group A the mean angle of the first web was 58^{o} (range 52-64^{o}) and controls B mean - 53.2^{o} (range-45-60), the mean rotation of the first web Group A was 113^{o} (range 108-120^{o}) controls B- 126^{o}(range- 120-135), the pinch strength group A was 32 mm Hg (range 12-45 mm Hg) controls B- 65mm hg (range- 45-82) i.e. significantly reduced but needs re-testing in later childhood while interphalangeal joint motion group A was 20^{o} (range 10-40^{o}) controls B 90^{o}. The angle of the first web and rotation of the first web was not statistically different in the two groups while the pinch strength and the interphalangeal joint motion were found statistically different. The operated patients functionally fared well (75%) probably due to better angles of fist web and greater oppositional rotation. The detailed Percival scores being excellent in seven patients, good in eight, fair in three and poor in two. The patients who had fair or poor results were pollicised at a later age.

Conclusion: This study thus showed that early pollicisation, even in cases of anomalous digits, resulted in good hand function and reasonable objective parameters of thumb function.

Significance: Literature is sparse about the results of pollicisation in radial club hands in any objective way especially with anomalous digits. No other similar study was found documenting a functional score in very young children.

The Shriners Hospital for Children Upper Extremity Evaluation: Evaluation of Measurement Reliability and Effect of Different Treatment Modalities

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Schneider Children's Medical Center of Israel, Petach Tikva, Israel

Purpose: The Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) is a video-based tool for the assessment of upper extremity function in children with cerebral palsy. This tool includes *spontaneous functional analysis* (SFA) and *dynamic positional analysis* (DPA) and assesses the ability to perform grasp and release. The purpose of the present study was to assess its inter-rater reliability among our rehabilitation team, to identify difficulties in assessment and to evaluate outcomes of treatment strategies in pediatric Cerebral Palsy (CP) upper extremity patients.

Methods: 54 SHUEE studies were evaluated for inter-observer reliability. These were analyzed by 3 therapists. Inter-observer reliability was assessed using the intraclass correlation coefficient. Evaluation scores before and after three different treatment methods were measured for patients who were treated with therapy only (N=22 evaluations, in 17 children), with botulinum injections (N=10) or with surgery (N= 14). The paired student *t* test was used to assess changes within each group.

Results: Inter-observer reliability was found to be excellent for the SFA ($r = 0.88$), *good* for the DPA ($r = 0.75$), and *fair to good* for grasp ($r=0.56$) and release ($r=0.47$). Stratification of the dynamic positional analysis according to anatomical segments showed lower correlations at the fingers level, with higher scores in the wrist assessment. The SHUEE score improved for all subjects who underwent surgery with significant increases in their *SFA* scores ($p<0.01$) as well as in their thumb and wrist *DPA* ($p<0.05$) which correlates well with the type of surgical procedures performed. The assessment before and after botulinum treatment failed to show any statistically significant changes. Evaluation of the therapy only group showed tendency towards improvement in their SHUEE scores, which did not reach statistical significance.

Conclusion: The present study reestablishes the clinical reliability of the SHUEE for assessment of upper extremity function in children with cerebral palsy. It also proves meaningful improvements in SFA as well as in DPA for patients who underwent surgery. Therapy alone is shown to have some positive influence on functional and positional improvements, but these did not reach statistical significance. The SHUEE might have a floor effect limit for assessment of botulinum treatments, or - the effectiveness of botulinum treatments in these patients merits further investigation.

Significance: SHUEE is a reliable measurement tool for evaluation of treatment outcomes.

The Use of the Semi-Sterile Technique for Closed Reduction and Percutaneous Pinning (CRPP) of Pediatric Upper Extremity Fractures

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Purpose: Closed reduction and percutaneous pinning (CRPP) is traditionally performed following full surgical prep and draping. The semi-sterile technique, which has been shown to be safe for supracondylar humerus fractures, utilizes only chlorhexidine paint followed by the use of sterile gloves and towels. The purpose of this study was to assess the use of the semi-sterile technique for CRPP of all pediatric upper extremity fractures.

Methods: A retrospective review was performed of all pediatric patients who underwent CRPP of an upper extremity fracture over a four-year period when there was a transition from a full prep to the semi-sterile technique. Demographic data, fracture type/location, and type of prep technique were recorded. Qualities of intraoperative care were assessed including room set-up, procedure, and room cleaning times. Postoperative care parameters were compared including time to pin removal and complication rates. Data were compared between the technique groups using two-tailed fisher's exact and two-tailed t-tests and deemed significant if $p < 0.05$.

Results: 219 patient records were reviewed including 160 in the semi-sterile group and 59 in the full prep group. When comparing intraoperative parameters between the full prep and semi-sterile techniques, the average room set-up time (20.8 vs. 18.8 mins, $p = 0.42$), procedure time (33.0 vs. 27.1 mins, $p = 0.02$), and room clean times (19.0 vs. 17.0 mins, $p = 0.56$) were shorter in the semi-sterile group.

There were no statistical differences in complication rates between prep groups ($p = 0.57$). Two patients in the full prep group had a pin site infection versus none using the semi-sterile technique.

Conclusion: The semi-sterile technique is a safe and cost effective alternative that should be used when performing CRPP of all pediatric upper extremity fractures.

Significance: The full prep technique increases operating room time and medical waste, thus increasing healthcare costs. A full prep should no longer be utilized when a CRPP procedure is planned for a pediatric upper extremity fracture.

Are there Patient Characteristics Associated with an Increased Risk for Open Reduction in the Treatment of Supracondylar Humerus Fractures?

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Purpose: Current recommendations for treating supracondylar humerus (SCH) fractures include closed reduction and percutaneous pinning. However, if difficulties with closed reduction arise, open reduction may be utilized. The purpose of this study is to identify the patient and treatment characteristics more commonly associated with open versus closed reduction of SCH fractures.

Methods: A retrospective chart review of patients treated for SCH fractures from 2010 to 2014 at two tertiary care children's hospital was performed. Patients were excluded for type I or II SCH fractures. There were 540 patients who met inclusion criteria with 78.3% classified as type III SCH fractures and 21.7% as type IV. Mean age at admission was 5.6 years (range 0.15-13.0).

Results: A total of 94.1% closed and 5.9% open reductions had complete records that could be studied. A number of different physical exam and fracture characteristics were found to positively correlate with open reduction. Patients requiring open reduction were significantly older than those who did not (6.7 $\pm$2.2 vs 5.6 $\pm$2.3, p=0.007). Gartland classification type IV fractures were more likely to require open reductions than type III fractures (closed=19.9%, open=50.0%) (p<0.001).
Skin puckering was found in 5.1% of closed reductions and 27.6% of open (p<0.001). Correlated vascular exam findings included no palpable pulse (closed=9.3%, open=54.8%) (p<0.001), and greater than two second capillary refill (closed=1.6%, open=12.5%) (p=0.004). Exam correlations also included findings of nerve palsy (closed=18.8%, open=62.5%) (p<0.001) as well as the specific palsy types median (p<0.001), radial (p=0.008) and AIN (p<0.001). There was no significant difference found in the time to OR for closed (mean=15.4±18.1 hrs) versus open (mean=19.3±25.5 hrs) reduction (p=0.398), though there were a significantly higher percentage of transfers requiring open reduction (7.5%) compared to those who were admitted from the emergency room (3.7%) (p=0.047).

Conclusion: Need for open reduction was associated with older patient age, Gartland type IV fracture, and higher severity of physical exam findings such as skin puckering, compromised vascular supply, and nerve palsies.

Significance: Predictors of open reduction for pediatric supracondylar humerus fracture include older age of patient, Gartland type IV fracture, and higher severity of physical exam findings.

Differences in Clinical Presentation of Osteochondritis Dissecans of the Capitellum in Males and Females

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Purpose: The purpose of this investigation was to compare clinical features, radiographic findings, and initial treatment of capitellar osteochondritis dissecans (OCD) in males versus females.

Methods: 88 patients who presented to a tertiary children's hospital with capitellar OCD were enrolled in a prospective registry. There were 45 males with 48 affected elbows, and 43 females with 45 affected elbows. Elements of historical and clinical features and operative rates were compared between males and females. Pre-operative imaging was used to analyze Nelson grades and Sauvegrain bone ages. Functional outcomes were assessed using the Timmerman score.

Results: Mean age at presentation was 15.1 years for males and 13.6 years for females ($p<0.001$). Mean skeletal age was 11.6 years for girls and 14.2 years for boys ($p<0.001$). OCD affected the non-dominant elbow in 20% of males versus 43% of females ($p=0.036$). 58% of males played baseball, of which 74% were pitchers. 73% of females were competitive gymnasts. More males (70%) were multisport athletes compared to females (37%) ($p= 0.003$).

There was no difference in the mean duration of elbow symptoms in males (8.9 months, sd=1.3) compared to females (4.7 months, sd=6.0) ($p = 0.122$). Baseball players had greater average glenohumeral internal rotation deficits (GIRD) (30.4°, sd = 21.3°) than non-baseball players (6.2°, sd =12.1°)($p = 0.002$). There were no differences in elbow flexion ($p = 0.933$) or extension ($p =0.982$) between genders, nor was there a significant difference in Timmerman scores in patients with dominant (68.8, sd=21.7) versus non-dominant (47.3, sd=15.1) elbow involvement.

Radiographically, 69.2% of males had Nelson grade 3 or 4 lesions compared to 48.5% of females ($p = 0.094$). 83% of males and 80% of females had contained lesions ($p = 0.779$).

71% of males and 81% of females were treated with simple debridement, drilling, fixation, or osteochondral grafting ($p =0.328$). There were no differences between males and females in the number or types of surgeries performed.

Conclusion: Elbow OCD presented with equal frequency in male and female adolescent athletes. While the majority of males were baseball players, females with capitellar OCD tended to be competitive gymnasts who presented at a younger age and with more non-dominant elbow involvement.

Significance: This analysis of 88 patients provides insight into the presentation of elbow OCD. Further efforts are needed to develop screening and prevention strategies in young female athletes and to identify differences in treatment outcomes, if any, between male and female patients.

Obese Children Are More Likely to Require Surgery for Both Bone Forearm Fractures

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Purpose: Pediatric patients with forearm fractures are usually successfully treated with closed reduction and casting. Loss of reduction and open fractures commonly require surgical intervention. Too many layers of padding are thought to contribute to inability of the splint or cast to hold reduction of forearm fractures. Excess adipose tissue may be a functional equivalent of too much padding in a splint. Other fractures in obese children have been demonstrated to have poorer outcomes when compared to children with normal BMI. The purpose of this study was to investigate the outcomes of both-bone forearm fractures in obese children.

Methods: 181 pediatric patients who presented to a Pediatric Level I trauma center between January 2009 and December 2015 with both-bone forearm fractures were identified by an IRB approved retrospective chart review. One hundred and forty patients met inclusion criteria of open physes and both a radius and ulna fracture. Exclusion criteria included patients treated at an outside facility, patients with closed physes, and isolated ulna or radius fractures. Data collected included fracture type, mechanism of injury, age, gender, cast adequacy, and BMI. Statistical analysis was performed with t-tests, Chi-squared analysis, or non-parametric equivalents with significance set at a=0.05.

Results: Twenty fractures were open (14.3%) and 120 (85.7%) were closed. There was no significant difference between obese and non-obese patients for whether the fracture was open ($p=0.161$) or closed. Obese patients were significantly more likely to require surgery, whether the fracture was open ($p<0.001$) or closed ($p<0.001$). The mean BMI of patients with closed fractures who had a loss of reduction requiring surgery was 21 versus 17 for those successfully treated with closed reduction and casting ($p<0.001$). Boys were more likely to require surgery than girls ($p=0.039$). Older children (mean age 11) were more likely to lose reduction requiring surgery than younger children (mean age 7) ($p<0.001$).

Conclusion: Obese pediatric patients with forearm fractures are more likely to require surgical treatment than normal weight children. This information can help surgeons set appropriate expectations for patients and families. Surgeons should be aware that overweight and obese children should be closely followed for loss of reduction after initial reduction and casting.

Significance: Obese pediatric patients with forearm fractures are more likely to lose reduction of the fracture and to require surgical treatment than normal weight children.

Ossification of the Proximal and Middle Phalangeal Condyles: Radiographic Aid in Phalangeal Neck Fracture Reduction

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Purpose: Phalangeal neck fractures are most often dorsally displaced and angulated. Surgical treatment is often necessary to restore the retrocondylar recess. The purpose of this study was to determine if radiographic landmarks can serve as a reference tool for assessing phalangeal neck fracture alignment based on age and sex.

Methods: 1,061 lateral finger radiographs that were interpreted as 'normal' by pediatric radiologists in children aged 1 to 18 years were retrospectively reviewed. The proximal and middle phalanges of each digit had a line drawn along the volar cortex (defined as the volar phalangeal line (VPL)) and a second perpendicular line was drawn at the level of the phalangeal condyle. A ratio of the anterior to posterior aspects of the phalangeal condyle was determined at the intersection of these lines. Gender of the patients was noted to determine if sex influenced the temporal course of ossification. A linear regression model was utilized to determine the average annual coefficient of growth for the phalangeal condyles.

Results: The average coefficient of growth for the proximal and middle phalangeal condyles is summarized in Table 1. As children increase in age, the VPL will intersect the phalangeal condyle more dorsally due to the eccentric ossification. No significant difference exists between the ratios of the proximal and middle phalanges. Gender did not significantly affect the linear regression model. The 8-9 year old interval had the largest change in size.

Table 1: The effect of age on the ratio measure for the proximal and middle digits

	N	B	95% CI	P-Value
2nd Proximal	726	0.021	0.020 – 0.022	<0.0001
2nd Middle	724	0.018	0.017 – 0.020	<0.0001
3rd Proximal	739	0.019	0.018 – 0.020	<0.0001
3rd Middle	671	0.018	0.017 – 0.020	<0.0001
4th Proximal	692	0.020	0.018 – 0.021	<0.0001
4th Middle	654	0.018	0.017 – 0.019	<0.0001
5th Proximal	633	0.021	0.020 – 0.022	<0.0001
5th Middle	579	0.017	0.016 – 0.018	<0.0001

Conclusion: The phalangeal condyles ossify in an eccentric manner with a rapid growth phase between 8 and 9 years of age. The VPL will intersect the phalangeal condyle more dorsally with increasing age. There is no difference in the time course of development between the proximal and middle phalanges and gender does not influence growth patterns.

Significance: The volar phalangeal line (VPL) and knowledge of where it should intersect the phalangeal condyle can be used as a reference guide for evaluating the reduction of proximal and middle phalangeal neck fractures in children.

Pronation Osteotomy of the Forearm for Brachial Plexus Palsy with Supination Deformity

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Purpose: Klumpke's palsy often leads to deteriorating upper extremity function and cosmetic concerns in children affected by this condition. The aim was to evaluate the results on forearm function and cosmesis following forearm pronation osteotomy for patients with a supination deformity of the forearm secondary to Klumpke's palsy.

Methods: A retrospective study was conducted on 17 consecutive children with Klumpke's palsy and active wrist and finger extension who underwent a pronation osteotomy of the ulna and radius between 2001 and 2014. 17 children with complete records and a minimum follow-up of 2 years were included for evaluation. Age at surgery ranged from 3.7 to 17 years (average 8.5). Resting position and passive and/or active (if age permits) range of motion for forearm pronation and supination were determined preoperatively and at last follow-up.

Results: All patients had a resting preoperative position of -90° (full supination). The average follow-up was 55 months (24 - 100 months). At last follow-up, the mean resting position was 4 degrees of supination, the mean active range of motion was 36 degrees of supination to 23 degrees of pronation and the mean passive range of motion was 80 degrees of supination to 75 degrees of pronation. Almost all patients noted subjective partial improvement of quality of life, function and appearance of the concerned upper limb.

Conclusion: Pronation Osteotomy of the forearm for klumpke's palsy with an active wrist and finger extension is a simple, effective and reproducible technique in improving function and appearance of the upper limb (especially grasping).

Significance: Pronation osteotomy can be considered as an effective treatment for children with supination deformity of the forearm secondary to Klumpke's palsy.

Proximal Forearm Shaft Fractures Fail Non-Operative Treatment up to 70% of the Time

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Purpose: Forearm shaft fractures are the third most common fracture in children, and fracture malunion is associated with significant functional impairment. The purpose of this study was compare the early (within 4 wks of injury) radiographic malalignment rate of proximal forearm shaft fractures to more distal shaft fractures.

Methods: Radiographs of males <18 years of age and females <17 years of age treated between 2007 and 2015 with closed reduction and casting of complete radial shaft forearm fractures were evaluated using age and sex specific criteria. Post-reduction fracture angulation was assessed in terms of both THIRDS and HALVES. Fisher's exact test was used for statistical analysis.

Results: A total of 309 patients met our inclusion criteria: forearm shaft fracture undergoing non-operative treatment. The average age was 8.7 years and the majority of the cohort was male (64%). 100% of patients had a complete radial fracture and 86% had complete ulnas. Significant differences were noted in malalignment rates. In term of THIRDS [p<0.0001], the proximal third fractures failed 70% (32/46) of the time as compared to middle + distal third fractures failing 33% (87/263) of the time. In terms of HALVES [p=0.0003], the proximal half fractures failed at a 50% (55/111) rate while distal half fractures failed 29% (57/198) of the time. The odds of a proximal third fracture failing were 4.6 times higher [95% CI 2.3, 9.1] as compared to more distal fractures. The odds of a proximal half fracture failing were 2.4 times higher [95% CI 1.5, 3.9] than distal half fractures.

	Distal 1/3	Middle 1/3	Proximal 1/3
Males < 10 Females < 8	< 20°	< 15°	< 10°
Males ≥ 10 Females ≥ 8	< 10°	< 10°	< 10°

	Distal 1/2	Proximal 1/2
Males < 10 Females < 8	< 20°	< 15°
Males ≥ 10 Females ≥ 8	< 10°	< 10°

Conclusion: We found that proximal forearm shaft fractures were significantly more likely to exceed angulation criteria as compared to more distal fractures. Proximal third fractures had the highest failure rate of 70% and a 4.6 times higher odds of failure.

Significance: Many forearm shaft fractures exceed angulation criteria during the first four weeks following injury. Proximal fractures have a significantly higher risk than more distal fractures and deserve special attention by the treating orthopaedist.

Variation Amongst Pediatric Hand Orthopaedic Surgeons When Diagnosing and Treating Distal Radius Fractures

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Purpose: Distal radius fractures are the most common injury in the pediatric population, however radiographic examination and subsequent classification is not standardized. A recent study found poor agreement amongst pediatric orthopaedic surgeons when diagnosing and treating these fractures. The purpose of this study was to determine whether or not substantial variation exists amongst pediatric hand surgeons when diagnosing and treating distal radius fractures.

Methods: Ten pediatric hand surgeons who commonly treat pediatric distal radius fractures at different institutions reviewed 100 sets of posteroanterior (PA) and lateral pediatric wrist radiographs. The surgeons were asked to complete a questionnaire describing the fractures, the type of treatment they would recommend and the recommended length of immobilization. Additionally, the surgeons were asked when the next follow-up visit would be scheduled for, and whether or not they would obtain new radiographs at the subsequent and final follow-up visits.

Kappa statistics were performed to assess the agreement amongst examiners with the chance agreement removed. Strength of agreement was determined based on guidelines outlined by Landis and Koch. Kappa values of <0.00 were considered poor agreement, 0.00 to 0.20 slight agreement, 0.21 to 0.40 fair agreement, 0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement, and 0.81 to 1.00 almost perfect agreement.

Results: Fair agreement was present when diagnosing and classifying the distal radius fractures (K = 0.312). Diagnoses included torus, greenstick, Salter-Harris II, and extra-physeal fractures. There was fair agreement regarding the type of treatment that would be recommended (K = .242). There was Slight agreement regarding the length of immobilization (K = .187).

Slight agreement was also present regarding when the first follow-up visit should occur (K = .188). Additionally, there was fair agreement whether or not new radiographs should be obtained at the first follow-up visit (K = .396), and if radiographs were necessary at the final follow-up visit (K = .368). Surgeons had slight agreement regarding stability of the fracture (K = .139).

Conclusion: The inter-reliability amongst pediatric hand surgeons of diagnosing pediatric distal radius fractures showed only fair agreement. Both pediatric orthopaedic surgeons and hand surgeons have wide variability in their treatment of pediatric distal radius fractures.

Significance: Better classification systems of pediatric distal radius fractures are needed that standardize the treatment of these injuries in order to provide the best health outcomes with the least patient morbidity.

How Accurate Are Preoperative Neurovascular Exams in Children with Elbow Fractures? A Prospective Analysis

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Purpose: A detailed pre-operative examination of a child's neurovascular status following pediatric elbow fractures is critical to the assessment of these injuries. Without proper documentation of the preoperative exam, apparent postoperative changes in the neurovascular examination may be difficult to determine, and may dictate different treatment strategies. The reported incidence of neurologic (11%) and vascular (0.3-4.6%) injury associated with supracondylar fractures underscores the importance of the preoperative exam. The purpose of this prospective study was to determine how frequently a complete neurovascular exam could be completed in children with elbow fractures.

Methods: A detailed, specific elbow fracture History and Physical form was developed for prospective use on all pediatric elbow fractures in a tertiary care pediatric trauma hospital from 2013 through 2014. Specific neurovascular exam criteria were documented in an easily used checklist form. IRB approval for the project was obtained. Patients older than 18 years of age were excluded. Demographic data collected included age, BMI, mechanism of injury, fracture type, comorbidities, pre-operative pain management, and the operative procedure performed. Data was analyzed using descriptive statistics, t-tests, and chi-square methods for group comparisons. Statistical significance is defined as $p < 0.05$.

Results: There were 163 patients meeting the inclusion criteria. A complete neurovascular (NV) exam form was completed in 146 of these patients (89.6%). A clinically reliable, complete NV exam was possible in 104 patients (71.2%). In the remainder of the children, the clinician could not determine at least one aspect of the neurovascular exam. A significant correlation was found between age of the subject and ability to obtain a complete exam, with younger children less than age 5 being more likely to have incomplete information on the NV exam ($p<0.000001$). Gender, BMI, fracture type, pre-assessment pain control, and potential language barriers had no effect on whether or not the exam was complete.

Conclusion: Although a complete and detailed neurovascular examination is considered necessary when evaluating pediatric elbow fractures, over a fourth of our patients (29%) were unable to reliably participate in a full preoperative neurovascular exam. Younger children (less than 5 years of age) were less likely to participate in a complete neurovascular assessment.

Significance: Neurovascular examinations in the setting of elbow fractures in children less than five years of age were unreliable and incomplete.

Low Functioning Patients with Brachial Plexus Birth Palsy Have Ineffective Compensatory Upper Extremity Movement Patterns

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Purpose: Maladaptive upper extremity movement patterns occur in many congenital neuromuscular conditions. For patients who experience deficits after the initial recovery phase of chronic brachial plexus birth palsy (BPBP), secondary procedures to prevent contracture and improve active motion may be performed. Electromyography (EMG) can be used to determine whether there are underlying compensatory mechanisms which may adversely affect the results of secondary treatment.

Methods: Eight BPBP patients, mean age 11.2 years (range 7.6 to 18.1 years), with various secondary surgery histories were evaluated with simultaneous 3-dimensional upper extremity motion analysis, 16-channel surface EMG, and video monitoring. Five upper extremity movements were performed on both the affected and unaffected sides: shoulder flexion, shoulder abduction, elbow flexion, forearm pronation, and forearm supination. Maximum end range motion was recorded as the number of degrees at the highest point. EMG sensors placed on the biceps brachii (BIC), triceps (TRI), pronator teres (PT), upper trapezius (UT), and lower trapezius (LT) captured muscle activation patterns that were evaluated with principal components analysis.

Results: Subjects in the high functioning group were able to surpass 90^{o} during both shoulder flexion and abduction, while subjects in the low functioning group were unable to achieve this angle. The difference between the high and low functioning groups may be attributed to BIC function, which had diminished activation during four out of five movements in the low functioning group. During shoulder flexion, the TRI and UT attempted to compensate, but could not (120.3^{o} ±18.7^{o} vs. 68.3^{o} ±21.4^{o}). During shoulder abduction, the TRI attempted to compensate, but could not (120.6^{o} ±21.4^{o} vs. 63.0^{o} ±22.5^{o}). During pronation and supination, the LT attempted to compensate (39.5^{o} ±14.8^{o} vs. 26.5^{o} ± 21.3^{o} and -14.4^{o} ± 22.8^{o} vs. -5.5^{o} ± 26.4^{o}, respectively). The only motion which was conserved across high and low functioning patients was active elbow flexion (143.3^{o} ± 6.7^{o} vs. 148.7^{o} ± 16.6^{o}), for which low functioning patients were able to successfully recruit BIC activity.

Conclusion: Low-functioning patients with chronic brachial plexus birth palsy differed from high-functioning patients by relying more on the triceps, upper trapezius, and lower trapezius than on the biceps brachii for shoulder and forearm motions. They were only effective in recruiting the biceps brachii during active elbow flexion.

Significance: Decreased utilization of the biceps brachii may be a contributor to low functioning shoulder and forearm motion in patients with chronic brachial plexus birth palsy.

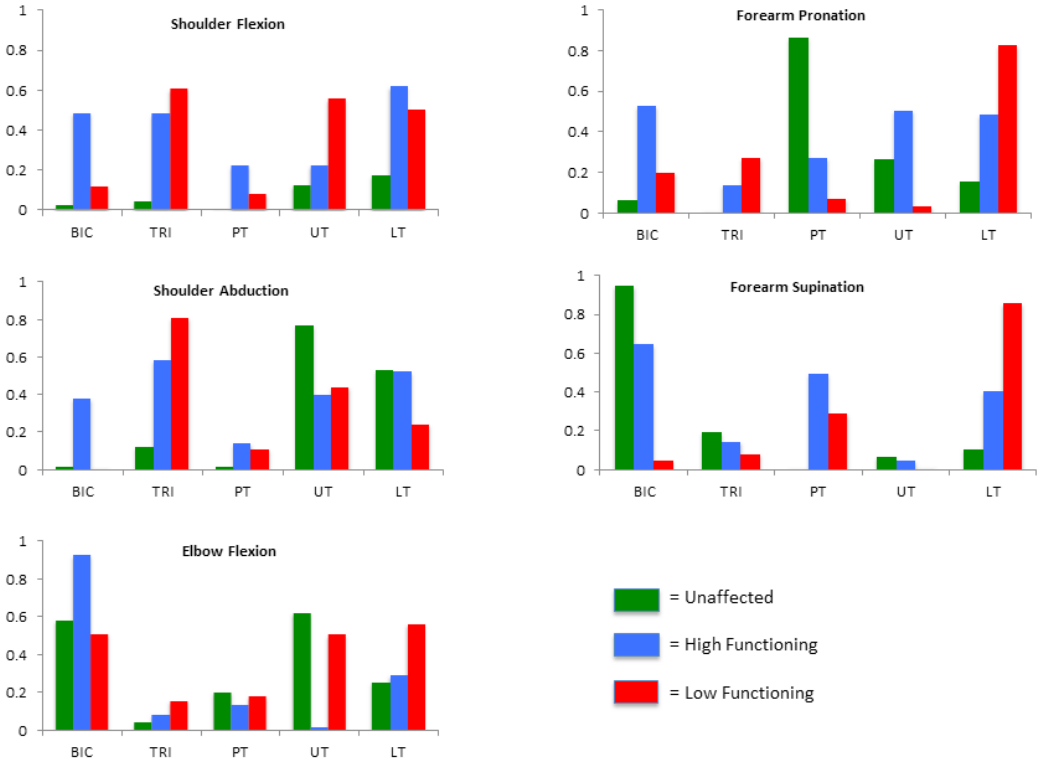

Figure 1. Electromyography muscle activation pattern of biceps brachii (BIC), triceps (TRI), pronator teres (PT), upper trapezius (UT), and lower trapezius (LT) during five upper extremity movements evaluated with principal components analysis.

Longitudinal Analysis of Distal Radius Alignment Parameters in a Cohort of Serial Radiographs

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Purpose: An understanding of the normal alignment of the immature pediatric distal radius is important for determining the adequacy of reductions in fracture management. However, no study has rigorously examined longitudinal pediatric distal radius alignment during growth. The purpose of this study was to assess for trends in four radiographic measurements of the distal radius using serial radiographs in subjects aged between 6 and 14 years of age.

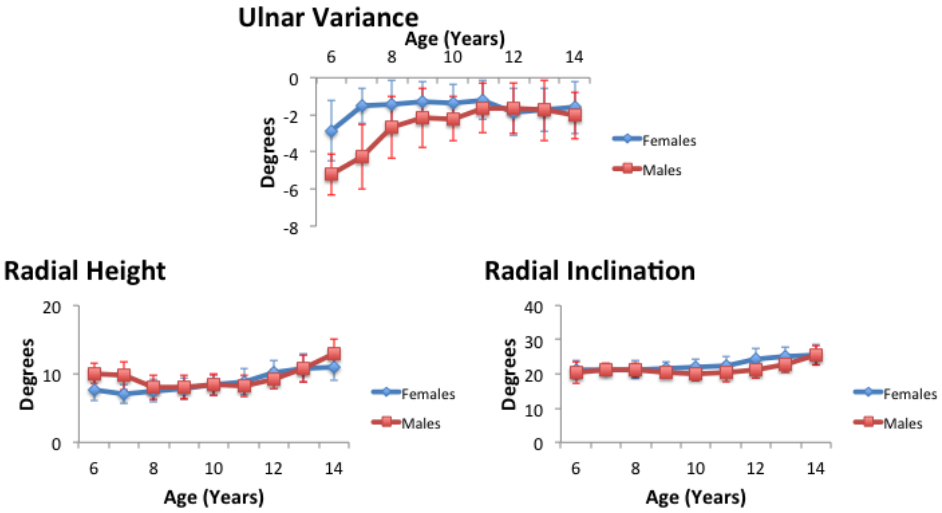
Methods: Annual radiographs from 68 healthy children (n=34 males, 34 females) growing up in Cleveland, Ohio from 1929 to 1942 were analyzed. This radiographic database, known as the Bolton-Brush Collection, is the same historical collection used to establish the Greulich and Pyle bone age atlas. Children with a minimum of three annual radiographs between the ages of 6 and 14 years of age were included. The total number of radiographs between male and females subjects is detailed in Table 1. A mean of 6.5±2.0 radiographs were obtained for each subject, with only 16% (n=8 males, n=3 females) of subjects having a total number of radiographs less than one standard deviation below the overall mean. Measurements of radial height, radial inclination and ulnar variance were performed in each available radiograph. Measurements were tested for intraclass correlation coefficient in 18 radiographs by two authors. The mean values and standard deviation for each measurement between males and females were recorded. Repeated measures analysis of variance (ANOVA) was performed to measure the association between alignment values and subject age.

Results: Intraclass correlation coefficient was 0.892 for all measurements, demonstrating excellent inter-relator reliability. Measurements were performed on a total of 436 images in 68 subjects. Mean measurements in males and females from ages 6 to 14 are shown in Figure 1. Repeat measures ANOVA demonstrated that all variables changed with age ($P<0.001$). Of the parameters measured, ulnar variance demonstrated the most variability with negative ulnar variance in younger children, with the trend towards a more neutral ulnar variance by approximately 7 years of age in females and 11 years of age in males.

Conclusion: Distal radius alignment changes significantly with age in pediatric patients based on analysis of longitudinally collected radiographs examining ulnar variance, radial height, and radial inclination.

Significance: This is the first investigation examining serial changes to commonly performed distal radius alignment parameters using a longitudinal cohort of children. These results may assist clinicians in better understanding and assessing malalignment after fracture treatment.

Figure 1: Mean Alignment Measurements for Males and Females with Standard Deviation



Dual-port Endoscopic Surgery for Intraosseous Lesions Around the Physis

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Purpose: Since 2002, we have treated intraosseous lesions extending across the physis using an endoscopic technique (ESDOP; endoscopic surgery with drilled dual opposing insertion paths around the physis). The purpose of this study is to verify efficacy and safety of this procedure.

Methods: From 2002, forty-one ESDOP operations were performed for 35 intraosseous lesions such as physeal bar, osteomyelitis and tumor, in 29 patients. Diagnosis, operative site, age at operation, complications in perioperative period, follow-up term, and clinical results were reviewed retrospectively.

Results: Mean age at operations was 8.9 years old (range; 1.8-17.3) and mean follow-up term was 3.3 years. There were fourteen lesions of physeal bar including nine distal femurs, four proximal tibiae, two proximal humeri, and one distal tibia. One patient had endoscopic physeal bar resection for three different lesions. Apparent growth recovery was observed in seven lesions under the age of ten, while growth recovery was insufficient in five of nine lesions over the age of ten. There were twelve patients with osteomyelitis involving physis of the proximal tibia in six patients, distal femur in two, distal tibia in one, distal fibula in one, distal radius in one, and the 1st metatarsal bone in one. In ten of twelve cases, osteomyelitis was clinically resolved in a short period after operation and neither growth disturbance nor angular deformity of affected bone was identified postoperatively, except one case with widely destroyed physis preoperatively. In remaining two cases, additional ESDOP operations for recurrence of osteomyelitis followed by physeal bar formation were required due to inappropriate choice of antibiotics or insufficient resection of the sequestrum. Three patients with chondroblastoma in the femoral heads, one with enchondroma in four different lesions, one with bone cyst in the femoral head, and one with Langerhans cell histiocytosis in the distal femur were successfully treated with this technique. As surgical complications, partial sensory deficit in the lateral femoral cutaneous nerve area was observed in one case postoperatively and slight skin burn around the endoscopic port was identified in another case.

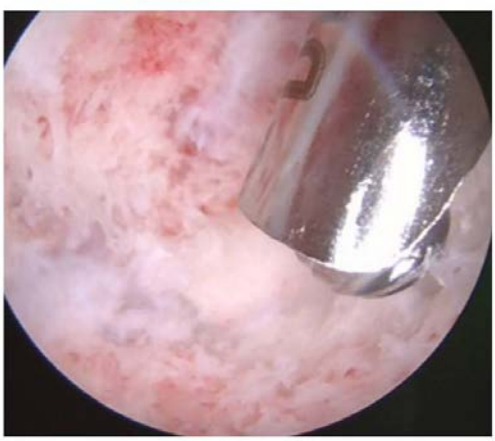

Fig. Physeal bar resection using abrader (10 year-old girl, proximal humerus)

Conclusion: Dual-port endoscopic surgery appears to be safe and useful for the treatment of physeal bar under the age of ten, osteomyelitis, and intraosseous tumor extending across the physis. There may be a potential advantage to the use of endoscopic techniques in patients with intraosseous lesion in children.

Significance: Dual-port endoscopic surgery (ESDOP) could be a promising option for the treatment of intraosseous lesions around the physis.

Epiphyseal Changes on MRI in Pediatric Tibial Osteomyelitis: What Does It Mean?

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Starship Children's Hospital, Auckland, New Zealand

Purpose: To determine the frequency of epiphyseal signal changes on MRI scan in Pediatric acute haematogenous osteomyelitis of the tibia, and to establish whether this signal change correlates with septic arthritis of the adjacent joint.

Methods: A retrospective review of cases of pediatric tibial osteomyelitis at Starship Hospital and Kidz First Hospital between 1997 and 2008 was completed. Patients with a relevant MRI scan were analysed for presenting history, examination findings, microbiology results, radiology results and clinical outcomes. The MRI scans were reviewed by a Pediatric Musculoskeletal Radiologist and Pediatric Orthopedic Surgeon assessing for location of infection, involvement of epiphysis, presence of joint effusion, joint fluid enhancement and synovial changes. MRI findings and clinical outcomes were compared.

Results: 51 patients had a suitable MRI scan and were included. Of the 50 patients with metaphyseal signal change 41 (82%) had signal change in both the metaphysis and epiphysis. 38/42 (90%) of patients with epiphyseal signal change did not have septic arthritis in the corresponding joint. Of the 5 cases of septic arthritis identified all had a joint effusion on MRI scan and 4/5 had signal changes in the epiphysis. The presence of epiphyseal signal change was not a prognostic factor in infection severity.

Conclusion: Transphyseal signal change occurs in most cases of acute pediatric tibial osteomyelitis. Presence of epiphyseal signal change on MRI scan does not necessarily represent septic arthritis and does not mandate washout of the adjacent joint.

Significance: This study from the largest series of tibial osteomyelitis patients published in the world shows that MRI signal changes occur in the epiphysis of the tibia in the majority of cases of tibial osteomyelitis. This finding is difficult to explain from a pathophysiological point of view however it does not necessarily represent spread of infection across the growth plate.

The Use of ProDense for the Treatment of UBC/ABC: Experience at Two Institutions

Ting Zhang; Charles Price, MD; James McCarthy, MD; Jie Nguyen; Scott Hetzel, MS; ***Ken Noonan, MD***
University Wisconsin Madison, Madison, Wisconsin, United States

Purpose: Unicameral/aneurysmal bone cysts (UBC/ABC) can lead to pain, fracture and limb deformity. Multiple treatment modalities are available; yet none has proven to be uniformly effective. In this retrospective study, we evaluate the outcome of ProDense (Wright Medical) used in UBC/ABC.

Methods: We evaluated 41 immature patients from two institutions treated with ProDense from 5/9/2007 to 11/1/2014. Medical record review and evaluation of radiographs and CT scans were performed. Patient demographics, characteristics of the cyst and the method of treatment were recorded. We differentiated percentage fill of ABC/UBC with ProDense via percutaneous vs. open method; characterized replacement of ProDense in ABC/UBC by normal bone or recurrent cyst at final follow up; quantitated rate of fractures and complications after treatment. Statistical analysis was done with Fisher's Exact test and Wilcoxon Signed Rank Sum test.

Results: 29 patients were treated in Wisconsin and 12 were treated in Florida with 35 UBC's and 6 ABC's. The average age was 9.3 years at treatment with open (23) or percutaneous injection (18) of ProDense; 9 had internal fixation. Post-operatively, the average radiographic fill was 94% and 9 had some extraosseus ProDense. Average FU was 2.75 years with 27 having more than two years of follow up. At FU, 13 patients had cyst recurrence averaging 17% (-14 to 68%) of the original cyst size. 3 patients had fracture after initial treatment; 2 were treated surgically. 2/9 patients with extra-osseous ProDense had soft tissue swelling and 1 required debridement. 2 other patients had significant limb swelling despite no obvious ProDense in soft tissues. There were no differences in recurrence rate or fracture for cyst type, location, gender, age, use of internal fixation. At two-year follow-up, those cysts with 100% fill had lower rate of recurrence than those with 90% or less fill (p=0.048).

Location of Cyst	Number
Proximal Femur	9
Distal Femur	3
Proximal Humerus	20
Calcaneus	4
Proximal Tibia	2
Distal Tibia	2
Fibula	1

Conclusion: Using ProDense for UBC/ABC treatment, we had a 7% rate of clinical recurrence (3/41 had pain/fracture). Small recurrence was noted in 32% of patients. ProDense appears to be a viable treatment option for UBC/ABC and improved radiographic appearance at follow-up is noted when the cyst is filled completely. ProDense has the potential to be locally inflammatory and thus efforts are needed to keep it within the bone.

Significance: This is the first retrospective evaluation of ProDense as a treatment for UBC/ABC in growing children. There is a low rate of clinical recurrence and small radiographic recurrence without clinical problems is noted in 32%.

The Relationship Between Perfusion Parameters of Femoral Head Blood Supply with Septic Arthritis of Hip in Infancy

Rujuta Mehta, MS*; Alaric Aroojis, MD; Avi Shah*
B J Wadia Hospital for Children, Mumbai - Maharashtra, India

Purpose: To document perfusion values as a predictive parameter in infant septic hips using Doppler ultrasound and compare with normal hips in our country.

Methods: Thirty infants with septic hips (19 male, 11 female; age range,-12 days to 15 months) underwent doppler ultrasound evaluation between May 2011 to September 2015 with a mean follow up 3.2 years (1-4). On power doppler hyperemia was recorded in ascending posterior femoral neck vessels ,and measured by Colour Doppler i.e. the velocity of blood flow (PSV) resistance (RI), Pulsatility (PI) and Systolic: Diastolic (S/D) ratios in one cardiac cycle. On gray-scale ultrasound, the presence/absence of synovial effusion was noted. ALL above measurements were repeated at 3 weeks after arthrotomy. The same perfusion indices were studied in 90 non-affected infants to establish normogram (53 male, 37 female; age range 2 days to 6 months) for comparison.

Results: There were 30 septic hips and 90 controls (1: 3 comparison ratio).
Septic hip group: Males=19, Females=11, Mean age :- age range, 12 days to 15 months (mean 70.5 days)
Normal hip group: Males=53 , Females= 37 Mean age: (2 days to 6 months;) PSV values 5.7 mm/sec +-2SD. Impedence indices 0.56 RI and 1.03 PI, 2.60 S/D ratio were obtained as baseline normogram.
The average P.S.V in septic group was 8.55 mm/sec. High velocity, low resistance blood flow was documented in the septic hip group, with the peak systolic velocity reaching statistical significance in cases compared to control group (p= 0.023); age and gender independent as found in the inter-relationships study by paired T test.
NO statistically significant difference was found in the PSV values between the pre-op and post op values or the impedence values.
Prospective non randomized observational study. Confidence interval (95%). Power = 80%.
Key Word: power Doppler, septic arthritis

Conclusion: Pre operative PSV was consistently high and can help diagnose septic effusion early even within 24 hours . This is the first of its kind study from our country of Normative perfusion values and comparison with septic hips. To predict osteonecrosis a larger sample size is needed.

Significance: Septic arthritis of infancy is often referred late. Grayscale Ultrasound can diagnose an effusion by when damage to articular cartilage may be advanced. Earliest detection of hyperemia and measuring flow tangibly is possible using doppler indices and can help detect onset of septic arthritis before effusion and damaging debri accumulates in the joint, facilitating prompt management preventing sequelae.

Prophylactic Antibiotic Use in Closed Reduction and Percutaneous Pinning of Supracondylar Humerus Fractures: A Survey of POSNA Members

Bradley M. Kruckeberg, BA; Taylor Ridley, MD; ***Deborah Quanbeck, MD***
University of Minnesota, Minneapolis, Minnesota, United States

Purpose: Antibiotic use in the setting of supracondylar humerus (SCH) fractures treated with closed reduction and percutaneous pinning (CRPP) is controversial. Many surgeons prescribe antibiotics, although current literature demonstrates a low rate of infection following CRPP. The purpose of this study was to investigate surgeon preference and experience with antibiotic administration for pediatric SCH fractures treated with CRPP.

Methods: A questionnaire was given to Pediatric Orthopedic Society of North America (POSNA) members via Survey Monkey (Palo Alto, CA). Demographic questions sought to understand a physician's practice setting, while additional questions inquired about experiences and current antibiotic treatment preferences when treating SCH fractures with CRPP.

Results: A total of 290 surveys were collected. Years in practice were 11% < 2 years, 16.2% 2-5 years, 14.8% 6-10 years, 24.1% 11-20 years, and 33.8% >20 years. Most respondents' practices were in an academic setting (60.3%) and 38.3% reported having a practice with over 50% of orthopedic trauma. The vast majority of physicians (91.3%) performed over 10 CRPP per year. Approximately half of correspondents reported having a patient develop an infection after CRPP. The consensus was to routinely administer antibiotics for CRPP of SCH fractures (83.5%), with the two most influential factors in that decision being the concern for infection without evidence-based guidelines and the perception that this practice is the standard of care. For the 9.7% of respondents that rarely or never used antibiotics, the lack of likelihood for infection and perceived standard of care were the most important factors. Most POSNA respondents reported knowledge of a standard hospital policy or recommendation for prophylactic antibiotics for orthopedic surgery (68.6%), but the majority of policies were not known to be specific for CRPP (58.2%). If presented with new evidence that contradicted their current practice, 68.2% would be willing to change their approach to administering antibiotics, with 70.3% preferring an evidence level I or II and 94.2% preferring a strong to moderate level of recommendation.

Conclusion: The routine use of antibiotics in the setting of CRPP of SCH fractures is the current standard for many surgeons. Despite the present trend, most surgeons are open to changing their practice if provided with high levels of evidence that are contrary to their current management.

Significance: To guide surgeons in making well-informed decisions, this survey establishes the need for evidence-based studies investigating the efficacy of antibiotics used for CRPP of SCH fractures in pediatric patients.

Stanford Children's Health

Children's Orthopedic and Sports Medicine Center

Advancing pediatric orthopedic care

Our Children's Orthopedic and Sports Medicine Center brings together an interdisciplinary team of experts to provide innovative treatments for children with orthopedic and musculoskeletal conditions. Our new 6,000 square foot Pediatric **Motion and Sports Performance Lab** enables clinicians, athletes and researchers to better understand the science of movements in young people. The lab diagnoses and treats conditions, enhances performance and allows for safe return to play.

Stanford MEDICINE

Learn more at **ortho.stanfordchildrens.org**

INDUSTRY SYMPOSIA

WEDNESDAY, MAY 3
12:45 PM – 1:45 PM

BioMarin Sala F

BIOMARIN®

ACHONDROPLASIA (ACH) AND MUCOPOLYSACCHARIDOSIS (MPS): CLINICAL MANIFESTATIONS, SURGICAL MANAGEMENT AND EMERGING TRENDS

Chairman – *William G. Mackenzie, MD, Wilmington, DE, USA*

12:45 PM–1:05 PM	Welcome and Goals ACH: CLINICAL MANIFESTATIONS AND SURGICAL MANAGEMENT *William G. Mackenzie, MD, Wilmington, DE, USA*
1:05 PM–1:15 PM	ACH: EMERGING TRENDS *Paul Arundel, MD, Sheffield, UK* **This first part of the symposium - on ACH - concerns a clinical update only**
1:15 PM–1:35 PM	MPS: INTEGRATING MEDICAL AND SURGICAL CARE WITHIN AN EXPERT MULTIDISCIPLINARY TEAM *Klane K. White, MD, Seattle, WA, USA*
1:35 PM–1:45 PM	Discussion based on Questions from the Audience Faculty & Audience

NuVasive Sala J

NUVASIVE®

MAGEC MASTERS ROUNDTABLE: KEY PRINCIPLES FOR CHALLENGING APPLICATIONS

Faculty:	*Michael Vitale, MD* *Peter Sturm, MD* *Burt Yaszay, MD* *Jeffrey Sawyer, MD*

INDUSTRY SYMPOSIA

THURSDAY, MAY 4
12:45 PM – 1:45 PM

OrthoPediatrics — Auditorium

OrthoPediatrics™ Leading Innovation in Pediatric Orthopedics

MODERN APPROACHES TO THE TREATMENT OF COMPLEX HIP DISEASE
Moderators: Rudolf Ganger, MD and Pablo Castañeda, MD

12:45 PM–12:52 PM	STATE OF THE ART IN SURGICAL TREATMENT OF DDH AFTER WALKING AGE *Pablo Castañeda, MD*
12:53 PM–12:57 PM	Q&A
12:58 PM–1:05 PM	DIAGNOSTIC APPROACH TO HIP PAIN IN ADOLESCENTS *José Lirola, MD*
1:06 PM–1:10 PM	Q&A
	HOW I PLAN AND EXECUTE SURGERY IN ADOLESCENTS WITH HIP DYSPLASIA *Ira Zaltz, MD*
1:11 PM–1:15 PM	Q&A
1:16 PM–1:23 PM	TREATING COMPLEX HIP DEFORMITY INCLUDING CONGENITAL FEMORAL DEFICIENCY *Rudolf Ganger, MD*
1:24 PM–1:28 PM	Q&A
1:29 PM–1:44 PM	CASE PRESENTATIONS
1:45 PM	Q&A

Orthofix — Sala F

ORTHOFIX®

MANAGEMENT GUIDELINES FOR EMERGENCY TRAUMA IN CHILDREN
Chairman – *Prof. Pierre Lascombes, MD, Switzerland*

Speakers:

- *Joachim Lauen, MD, Germany*
- *Franck Launay, MD, France*
- *Jean-Damien Metaizeau, MD, France*

INDUSTRY SYMPOSIA

THURSDAY, MAY 4
12:45 PM – 1:45 PM

Zimmer Biomet Institute — Sala H1 & H2

ZIMMER BIOMET Institute

WHEN TO TREAT, NOW OR LATER?

SURGERY ON PAEDIATRIC SPINAL DEFORMITIES
Prof. Brice Ilharreborde, MD, France

INJURIES OF THE ANTERIOR CRUCIATE LIGAMENT
Prof. Franck Accadbled, MD, France

Pega Medical — Sala J

Pega Medical

"TO CLOSE OR NOT TO CLOSE: NEW PHILOSOPHIES AND SURGICAL TOOLS FOR THE TREATMENT OF SCFE" (a Pega Medical Symposium)

Faculty:
Francois Fassier, MD (Canada)
Jose Herrera Soto, MD (USA)
David Little, MD (Australia) and other distinguished speakers

INDUSTRY SYMPOSIA

THURSDAY, MAY 4
12:45 PM – 1:45 PM

EOS Imaging Sala A

ADDRESSING THE SPINE CARE PATHWAY WITH LOW DOSE, 3D SOLUTIONS

3D ASSESSMENT OF SPINE DEFORMITY PROGRESSION IN AIS PATIENTS
Vidyadhar Upasani, MD, Rady Children's Hospital, San Diego, CA

3D ALARA ANALYSIS OF PEDIATRIC PATIENTS: EXPERIENCE OF A CENTER OF EXCELLENCE
Prof. Raphael Vialle, MD, Hôpital Armand-Trousseau, Paris, France

3D SURGICAL PLANNING FOR AIS PATIENTS
Prof. Brice Ilharreborde, MD, Hôpital Robert-Debré, Paris, France

EOS IN THE HEART OF THE AIS SCREENING PROGRAM IN HONG KONG
Prof. Jack Cheng, MD, The Chinese University of Hong Kong, HK

Symposium Summary
Discover how the EOS technology is key to supporting the entire pediatric spine care pathway: From pathology analysis for both ambulatory and non-ambulatory patients; through follow-up of brace treatment or spine surgery planning; to the analysis of immediate and long term post-operative results, particularly in the case of deformity progression or PJK. Join us to see how full body, weight bearing EOS images can bring unique 3D value at a low dose.

During the symposium, you will hear presentations from spine treatment experts covering:

- The value of full body, weight-bearing, low dose, 3D imaging in the spine care pathway
- The importance of understanding the complexity of spine deformities in 3D and identifying progression indicators
- The ability to follow AIS patients with ALARA exams
- The benefits of 3D planning with EOS images and spineEOS online software

INDUSTRY SYMPOSIA

THURSDAY, MAY 4
12:45 PM – 1:45 PM

K2M Sala H3

TECHNIQUES TO OPTIMIZE SPINAL BALANCE

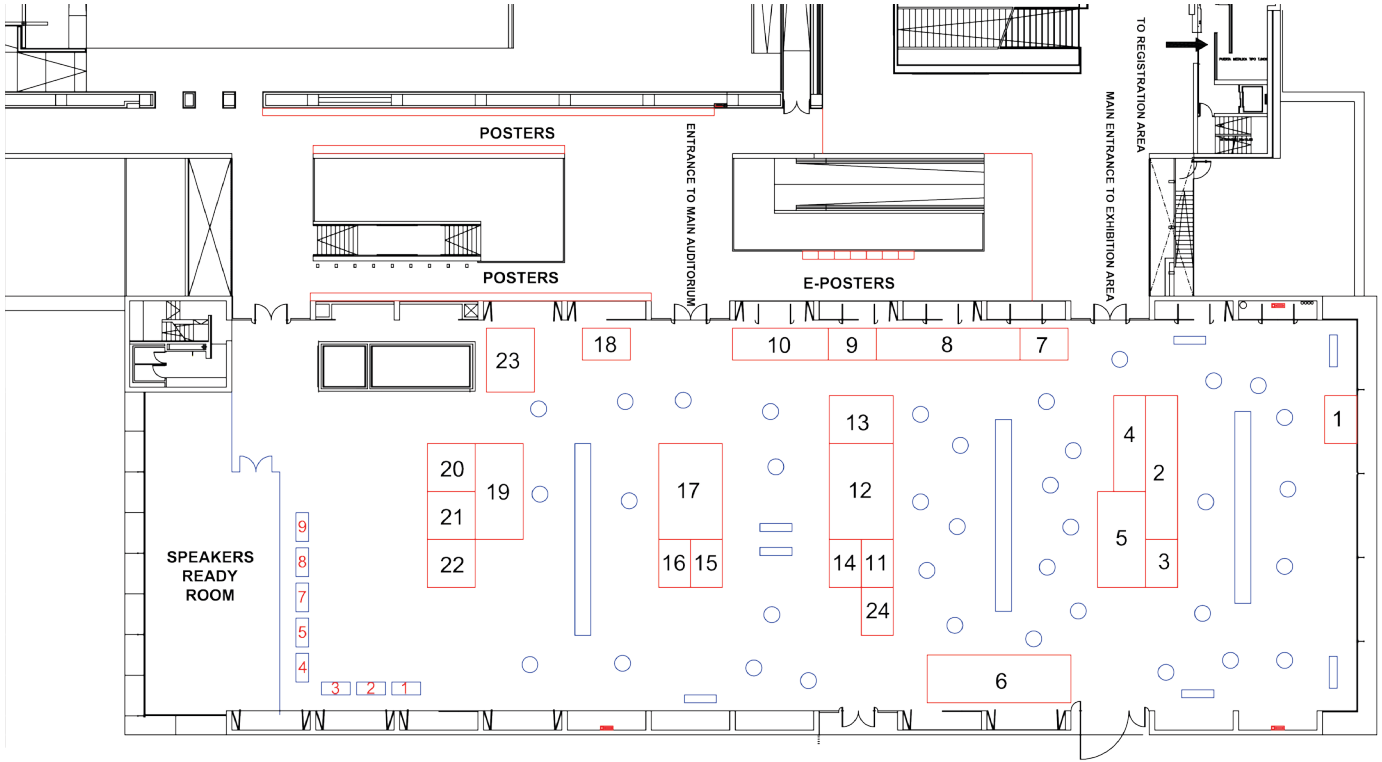
Faculty: *Dennis Devito, MD*

NuVasive Multipurpose Room

SO YOU'RE NOT SURE YOU CAN DO LIMB LENGTHENING

Faculty: *Frank Schiedel, MD*
Christof Radler, MD

EXHIBIT HALL MAP



1. Stryker
2. OrthoPediatrics
3. Smith & Nephew
4. DePuy Synthes
5. EOS Imaging
6. BioMarin
7. Wittenstein Intens GmbH
8. NuVasive
9. TST
10. C-Pro Direct
11. OHK Medical Devices Ltd.
12. Zimmer GmbH
13. K2M
14. Arthrex
15. Semeda Medizinische Instrumente e.k.
16. Wishbone Medical
17. Orthofix SRL
18. Merete GmbH
19. Pega Medical Inc.
20. Shanghai Carefix Medical Instrument Co., Ltd.
21. Int'l Hip Dysplasia Institute (IHDI)
22. BSN Medical GmbH
23. Implanet
24. AquaCast Liner

Table #1 Akron Children's Hospital
Table #2 Clubfoot Solutions
Table #3 CURE International
Table #4 Global Help
Table #5 MHE Research Foundation
Table #7 Rubin Institute
Table #8 Bone & Joint Publishing

EXHIBITOR LISTING

AQUACAST LINER

STAND 24

AquaCast Liner is the most comfortable, waterproof cast liner. Developed by engineers in conjunction with an orthopaedic surgeon and OTCs from across the country, AquaCast Liner has become the choice for hospitals and practices looking to provide the best patient care possible. AquaCast Liners are waterproof, breathable, and washable, minimizing cast-related frustrations. Our liners replace the cotton liners and stockinettes underneath a fiberglass cast, giving patients the freedom to continue their normal daily activities – bathing, showering, and even swimming. AquaCast Liners can be used with any type of fiberglass cast.

AKRON CHILDREN'S HOSPITAL

TABLE 1

Akron Children's Hospital is ranked among the best children's hospitals by U.S. News & World Report. With nearly more than 1 million patient visits in 2016, it has been leading the way to healthier futures for children through quality patient care, education, advocacy, community service and medical discovery since 1890. The system is the largest pediatric provider in northeast Ohio and is comprised of two hospitals, and more than 90 urgent, primary and specialty care locations. The system is proud of its partnerships with other health systems to bring its neonatal and pediatric expertise to patients in their community hospitals, while our home care and school health nurses care for kids in their homes and schools.

ARTHREX

STAND 14

Arthrex has been improving surgical techniques in orthopaedics and traumatology since 1981. With over 6,000 developed products, Arthrex stands for innovation and quality in the field of arthroscopy, sports medicine and orthopaedics. Working with renowned orthopaedists and surgeons, solutions are continuously developed and improved to make even complex procedures evermore simple and safe.

Our product range comprises electronic equipment for arthroscopy, reconstruction instruments and implants for sports medicine and traumatology, joint prosthetics, and orthobiologic products.

Arthrex is an independent, privately held corporation headquartered in Naples, FL, USA, with currently over 1,400 employees in 13 subsidiaries throughout the world.

BIOMARIN PHARMACEUTICAL

STAND 6

BioMarin develops and commercializes innovative biopharmaceuticals for serious diseases and medical conditions. Approved products include the first and only medications for PKU and LEMS, and the first and only enzyme replacement therapies for MPS I, MPS VI and Morquio A syndrome. Visit www.BMRN.com to learn more.

EXHIBITOR LISTING, CONTINUED

BONE & JOINT PUBLISHING

TABLE 8

Bone & Joint Publishing provides a complete and trusted resource for the orthopaedic, trauma and musculoskeletal science communities. The Journal of Children's Orthopaedics (JCO) is an open access journal published by Bone & Joint Publishing, and is the official journal of the European Paediatric Orthopaedic Society (EPOS). JCO publishes high quality, peer-reviewed articles that focus on clinical practice, diagnosis and treatment of disorders unique to paediatric orthopaedics, as well as on basic and applied research. It aims to help physicians stay abreast of the latest and ever-changing developments in the field of paediatric orthopaedics and traumatology.

BSN MEDICAL GmbH

STAND 22

BSN Medical is a global leader in the worldwide healthcare market specialising in the areas of Compression Therapy, Wound Care and Orthopaedics. We are focused on the development of world-class branded products that offer high quality solutions for our caregivers and patients. BSN medical connects its broad portfolio in Wound Care & related Vascular Diseases, Lymphology and non-invasive Orthopaedics with strong technological competencies to meet the market's need for reduced complexity and more efficient treatments. With a continuously developing unique and holistic network of integrated therapy solutions, BSN medical consistently supports a continuum of care.

C-PRO DIRECT

STAND 10

C-Pro Direct exists to support medical professionals, parents and children affected by paediatric orthopaedic conditions of the lower limbs.

C-Pro Direct designs, manufactures and sells various products to help parents and children better manage a variety of conditions affecting the lower limbs, particularly conditions which affect the ability of the foot to abduct and dorsiflex.

CLUBFOOT SOLUTIONS

TABLE 2

Each year 200,000 children are born with congenital clubfoot birth defect and millions of children are left untreated to live with this debilitating birth defect. Fortunately clubfoot is easily corrected with the noninvasive Ponseti Treatment Method that eliminates costly and painful surgeries by utilizing a series of gentle manipulations of the foot (feet), plaster castings and bracing. Clubfoot Solutions is a 501(c)(3) that is responsible for manufacturing and delivering the premier clubfoot brace that is changing lives worldwide. The Iowa Brace was developed at the University of Iowa by a team of doctors lead by Pedeatric Orthopaedic surgeon, Dr. Jose Morcuende.

EXHIBITOR LISTING, CONTINUED

CURE INTERNATIONAL

TABLE 3

CURE International is a network of charitable hospitals and specialty programs, operating in 29 countries with specialties that include orthopedics, neurosurgery, reconstructive surgery, and maternity care. We are dedicated to providing life-changing healing through medical care, training and spiritual ministry. We treat patients in underserved areas whose physical disabilities can be corrected or alleviated through medical intervention, regardless of gender, ethnic background, or religious affiliation.

DEPUY SYNTHES

STAND 4

DePuy Synthes Companies of Johnson & Johnson provides the most comprehensive orthopaedic and neurological solutions in the world. The company offers an unparalleled breadth of products, services, programs and research and development capabilities. DePuy Synthes Companies' solutions in the specialties of joint reconstruction, trauma, neurological, craniomaxillofacial, spinal surgery and sports medicine are designed to advance patient care while delivering clinical and economic value to health care systems worldwide. For more information visit, www.depuysynthes.com.

EOS IMAGING

STAND 5

EOS Imaging is a med-tech company based in Paris, France that designs, develops and markets EOS, an innovative medical imaging system dedicated to orthopedics and osteoarticular pathologies. A low dose or Micro Dose EOS exam provides full body, stereo-radiographic images in weight-bearing positions. The frontal and lateral images are acquired simultaneously in less than 20 seconds without magnification. The accompanying sterEOS workstation enables you to create patient-specific 3D models, calculate over 100 clinical parameters automatically and generate customizable patient reports. EOS also offers online 3D Services and cloud-based, 3D surgical planning software solutions for the spine, hip and knee. The EOS platform connects imaging to care by adding value along the entire patient care pathway from diagnosis to follow-up.

GLOBAL HELP

TABLE 4

Global **HELP** (**H**ealth **E**ducation using **L**ow-cost **P**ublications) Organization (GHO) is a Seattle-based nonprofit that was established 15 years ago to provide free, high-quality, evidence-based, commercial-free medical/healthcare information -- with a primary focus on children's health -- to the underserved throughout the world. The organization's long-term goal is to create sustainable improvement in healthcare by providing people with the information necessary to help them help themselves. GHO is a humanitarian organization that values racial, ethnic, and religious diversity; emphasizes global relevancy; and prioritizes non-commercialism. The organization has 180 publications available on their website in 35 languages that have been dowloaded 19.3 million times in nearly every country in the world. GHO's 200+ videos, available on YouTube, have over 660,000 views.

GLOBUS MEDICAL

STAND 25

Globus Medical, Inc. is a leading musculoskeletal implant company based in Audubon, PA. The company was founded in 2003 by an experienced team of professionals with a shared vision to create products that enable surgeons to promote healing in patients with musculoskeletal disorders.

EXHIBITOR LISTING, CONTINUED

IMPLANET

STAND 23

Implanet is an innovative Band / pedicle-sparing technology company based in Bordeaux and Boston, MA, USA.

For its 10th Anniversary, Implanet is pleased to present its flagship JAZZ™ Platform, comprising 3 new products.

This technological Platform offers the most pioneering and comprehensive range of Band-based solutions available in the market, designed to improve spinal treatments especially in complex indications such as scoliosis, even when bone quality is compromised, thanks to:

- JAZZ™ Band, posterior correction-fixation system compatible with titanium and cobalt-chrome for 3.5 to 6.35mm diameter rods
- JAZZ™ Claw, new exclusive hybrid solution dedicated to top of constructs
- JAZZ™ Frame, allowing to create a very rigid frame for postero-medial translation
- JAZZ™ Lock, new and unique rodless band implant

To create bottom of construct fixation points, the **ISS** product line offers to the surgeons a posterior pedicle system, based on a range of screws, hooks, pre-cut / pre-bent rods and multiple connectors. Implanet solutions are delivered in sterile packaging.

INTERNATIONAL HIP DYSPLASIA INSTITUTE

STAND 21

The International Hip Dysplasia Institute (IHDI) is a not-for-profit effort to improve the health and quality of life for those afflicted with hip dysplasia. The IHDI is supported by the Arnold Palmer Hospital Foundation in Orlando, Florida with major sponsorship from Dan Whitney ("Larry the Cable Guy") and his wife, Cara. With this combined effort, we have joined forces with several noted medical centers around the world to promote prevention, diagnosis, and treatment of hip dysplasia.

K2M

STAND 13

K2M Group Holdings, Inc. is a global medical device company focused on designing, developing and commercializing innovative complex spine and minimally invasive spine technologies and techniques used by spine surgeons to treat some of the most difficult and challenging spinal pathologies. K2M has leveraged these core competencies to bring to market an increasing number of products for patients suffering from degenerative spinal conditions. These technologies and techniques, in combination with a robust product pipeline, enables the company to favorably compete in the global spinal surgery.

MHE RESEARCH FOUNDATION

TABLE 5

The MHE Research Foundation is a nonprofit 501(c) (3) organization dedicated to the support of Researchers, Physicians & Families dealing with Multiple Hereditary Exostoses Syndrome (MHE) Multiple Osteochondroma Syndrome (MO) a rare genetic bone disease.

EXHIBITOR LISTING, CONTINUED

MERETE GmbH

STAND 18

Merete stands for expert orthopaedic and trauma surgery solutions. The market for bone surgical medical products relies upon tested solutions.

By developing simple solutions for difficult problems, Merete has blazed trails that have now become gold standards in medical technology. The story of BioBall® as a simple yet unparalleled system has been continued through other Merete products and solutions. Merete GmbH's impressive product families are sophisticated modular systems that allow optimum results under practically any intraoperative circumstances. With its ever-growing portfolio Merete sets new standards in the field of paediatric orthopaedics, of implants for hip revision and primary hip care, of foot surgery, and of trans-generational care of major bone defects, bone tumours, periprosthetic fractures and trauma. Merete is an owner-managed German company with business operations in more than 33 countries. Thanks to cutting-edge production technologies and an exceptional team of engineers, the company has been developing, manufacturing, and marketing top-quality implants and instruments under one roof for over twenty years now, in the German capital city of Berlin.

NUVASIVE

STAND 8

NuVasive is an innovative company dedicated to the design, development and successful commercialization of non-invasively adjustable, remote controlled implants for a broad spectrum of spinal and orthopedic applications. NuVasive has developed remote controlled distraction systems using magnets which may eliminate the need for additional surgeries for adjustment. The initial products aid in the restoration of proper anatomic position and alignment of the spine and correct limb length discrepancies of the femur and tibia.

OHK MEDICAL DEVICES LTD.

STAND 11

OHK Medical Devices Ltd. is a privately held Medical Devices Company, manufacturing and selling innovative products for orthopedic and vascular surgery and for emergency medicine. Its core patent-protected technology is a line of single-use devices for quick and effective displacement of blood from the limbs and blocking its re-entry.

OHK's surgical products – the **HemaClear®** - are sterile and are widely used to create a bloodless surgical field. Around 1 million procedures have been performed with the **HemaClear®** on all 5 continents with excellent acceptance by users and an impeccable safety track record. **HemaClear®** is endorsed by key opinion leaders in leading adult and pediatric medical centers in North and South America, Europe, and Asia-Pacific.

For additional information see www.HemaClear.com.

ORTHOFIX

STAND 17

Orthofix International N.V. is a diversified, global medical device company focused on improving patients' lives by providing superior reconstructive and regenerative orthopedic and spine solutions to physicians worldwide. The company has four strategic business units that include BioStim, Biologics, Extremity Fixation and Spine Fixation. For more information, please visit www.orthofix.com.

EXHIBITOR LISTING, CONTINUED

ORTHOPEDIATRICS

STAND 2

OrthoPediatrics is helping surgeons improve the lives of children with orthopedic conditions as the only global medical device company focused exclusively on pediatric orthopedics. With innovative surgical systems for Trauma, Limb Deformity, Spine, and Sports Medicine, OrthoPediatrics is dedicated to delivering high quality products and excellent professional education initiatives globally.

PEGA MEDICAL INC.

STAND 19

Pega Medical specializes in the development of medical devices specially conceived for pediatric patients. For the past 15 years, the **Fassier-Duval telescopic IM system** has been the gold standard for the surgical treatment for patients with OI and CTP. The **HINGE Pediatric Plating System** for growth modulation, the **GAP endo-exomedullary system** and the **Free-Gliding SCFE telescopic screw system** have continued the legacy of improving the surgical treatment of children around the world. The newly released **SLIM IM system** completes the family of pediatric products allowing surgeons to treat every patient with the best solution.

RUBIN INSTITUTE FOR ADVANCED ORTHOPEDICS

TABLE 7

Rubin Institute for Advanced Orthopedics (RIAO) is home to some of the world's most renowned orthopedic surgeons and offers state-of-the-art treatment in a variety of orthopedic services for children and adults. The Institute hosts an annual CME-accredited course in limb deformity correction and lengthening. Clinical and research fellowship opportunities are available. The Multiplier and Bone Ninja apps were developed here. The RIAO is located in Baltimore, Maryland, USA.

SEMEDA MEDIZINISCHE INSTRUMENTE

STAND 15

Semeda GmbH - Your partner for high-quality and innovative medicinal products. For over 10 years we have been specialising in accessories for treating clubfoot according to Ponseti. The company Semeda has been specialised in ground-breaking medical devices and accessories for conservative clubfoot therapy for over ten years. The solutions are always particularly practical and user-friendly thanks to our close collaboration with high-calibre partners from every area of the medical and technology sectors.

EXHIBITOR LISTING, CONTINUED

SHANGHAI CAREFIX MEDICAL INSTRUMENT CO., LTD

STAND 20

Shanghai Carefix Medical Instrument Co., Ltd was established in Shanghai in June, 2009, with registered capital of 15 million. Located in Shanghai's Songjiang Economic & Technology Development Zone, an enterprise which is specialized in Research & Development, manufacture, sales and service for orthopedic products with ISO13485 & CE certificate. With new advanced technical equipments. We acquire 8 newly innovated utility patents. We sell well both at home and abroad, enjoying high level reputation from our customers. We also provide OEM project for you. We, as always, are to provide customers with better products and services, eagerly welcome customers around the world to visit our factory, look forward to working with you!

SMITH & NEPHEW

STAND 3

Smith & Nephew is a global medical technology business dedicated to supporting healthcare professionals in their daily efforts to improve the lives of their patients. With leadership positions in Orthopaedic Reconstruction, Advanced Wound Management, Sports Medicine and Trauma & Extremities, Smith & Nephew has more than 15,000 employees and a presence in more than 100 countries. Annual sales in 2016 were almost $4.7 billion. Smith & Nephew is a member of the FTSE100 (LSE:SN, NYSE:SNN).

STRYKER

STAND 1

Stryker is one of the world's leading medical technology companies and, together with our customers, we are driven to make healthcare better. The Company offers a diverse array of innovative products and services in Orthopaedics, Medical and Surgical, and Neurotechnology and Spine that help improve patient and hospital outcomes. Stryker is active in over 100 countries around the world.

TST

STAND 9

TST has a strong place in the market with an extensive production located in Istanbul, Turkey. It's reputation for production and sales excellence has been acquired since 1997, our company started producing high quality orthopedic products and instruments under TST brand for all over the world. TST Medical Devices provides a wide range of innovative products. Furthermore, products are conveniently produced under CE mark and ready to deliver as and when required.

EXHIBITOR LISTING, CONTINUED

WISHBONE MEDICAL

STAND 16

WishBone Medical is a Warsaw, Indiana based pediatric orthopedic company focused on the unmet needs of children suffering from orthopedic issues. We provide anatomically appropriate innovative implants and instruments in sterile-packed, single-use, disposable kits to surgeons for children who are still growing.

Our company is developing a broad product portfolio to address the variety of conditions that pediatric orthopedic surgeons treat on a daily basis.

WishBone Medical has isolated six primary categories for product development:

- Deformity Correction of Long Bone and Hip Disorders
- Sports Related Injuries
- Foot and Ankle Deformities
- Trauma
- Spinal and Thoracic Deformities
- Cerebral Palsy Deformities

WITTENSTEIN

STAND 7

Our main activities are the development, production, sales and marketing of innovative implants for use in orthopedics and traumatology.

FITBONE® is an intramedullary lengthening system intended for limb lengthening of the femur and tibia. With appropriate preoperative planning, it is possible to make axial and torsional corrections as part of limb lengthening in only one surgery. This unique system facilitates an economical treatment concept characterized by a high level of patient comfort as well as short hospitalization and therapy periods.

Contact us via email: info@wittenstein-intens.de or visit our website at www.wittenstein-intens.com
FITBONE® – smarter limb lengthening

ZIMMER BIOMET

STAND 12

Founded in 1927 and headquartered in Warsaw, Indiana, USA, Zimmer Biomet is a global leader in musculoskeletal healthcare. We design, manufacture and market orthopaedic reconstructive products; sports medicine, biologics, extremities and trauma products; spine, bone healing, craniomaxillofacial and thoracic products; dental implants; and related surgical products.

We collaborate with healthcare professionals around the globe to advance the pace of innovation. Our products and solutions help treat patients suffering from disorders of, or injuries to, bones, joints or supporting soft tissues. Together with healthcare professionals, we help millions of people live better lives.

We have operations in more than 25 countries around the world and sell products in more than 100 countries.

POSNA ANTITRUST POLICY

It shall be the policy of the Pediatric Orthopaedic Society of North America (POSNA) to be in strict compliance with all Federal and State Antitrust laws, rules and regulations. Therefore: These policies and procedures apply to all membership, board, committee, and all meetings attended by representatives of the POSNA.

Discussions at POSNA meetings often cover a broad range of topics pertinent to the interests or concerns of orthopaedic surgeons. As a general rule, except as noted below, discussions at POSNA meetings can address topics without raising antitrust concerns if the discussions are kept scrupulously free of even the suggestion of private regulation of the profession. However, a number of topics that might be (and have been) discussed at POSNA meetings may raise significant complex antitrust concerns. These include:

- Membership admissions, rejections, restrictions, and terminations;
- Method of provision and sale of POSNA products and services to non-members;
- Restrictions in the selection and requirements for exhibitors at the POSNA Annual Meeting or in CME activities;
- Collecting and distributing certain orthopaedic practice information, particularly involving practice charges and costs;
- Obtaining and distributing orthopaedic industry price and cost information;
- Professional certification programs;
- Group buying and selling; and
- Inclusions or exclusion of other medical societies in organizational activities or offerings.

When these and related topics are discussed, the convener or members of the POSNA group should seek counsel from its General Counsel.

POSNA urges its Board, committees and members not to participate in discussions that may give the appearance of or constitute an agreement that would violate the antitrust laws. Notwithstanding this reliance, it is the responsibility of each of each POSNA Board or member to avoid raising improper subjects for discussion. This policy has been prepared to ensure that POSNA members and other participants in POSNA meetings are aware of this obligation.

The "Do Not's" and "Do's" presented below highlight only the most basic antitrust principles. POSNA members and others participating in POSNA meetings should consult with the General Counsel in all cases involving specific questions, interpretations or advice regarding antitrust matters.

Do Nots

1. Do not, in fact or appearance, discuss or exchange information regarding:
   a. Individual company prices, price changes, price differentials, mark-ups, discounts, allowances, credit terms, etc. or any other data that may bear on price, such as costs, production, capacity, inventories, sales, etc.
   b. Raising, lowering or "stabilizing" orthopaedic prices or fees;
   c. What constitutes a fair profit or margin level;
   d. The availability of products or services; or
   e. The allocation of markets, territories or patients.
2. Do not suggest or imply that POSNA members should or should not deal with certain other persons or companies.
3. Do not foster unfair practices regarding advertising, standardization, certification or accreditation.
4. Do not discuss or exchange information regarding the above matters during social gatherings, incidental to POSNA-sponsored meetings.
5. Do not make oral or written statements on important issues on behalf of POSNA without appropriate authority to do so.

POSNA ANTITRUST POLICY, cont'd

Do

1. Do adhere to prepared agenda for all POSNA meetings. It is generally permissible for agendas to include discussions of such varied topics as professional economic trends, advances and problems in relevant technology or research, various aspects of the science and art of management, and relationships with local, state or federal governments.
2. Do object whenever meeting summaries do not accurately reflect the matters that occurred.
3. Do consult with General Counsel on all antitrust questions relating to discussions at POSNA meetings.
4. Do object to and do not participate in any discussions or meeting activities that you believe violate the antitrust laws; dissociate yourself from any such discussions or activities and leave any meeting in which they continue.

Special Guidelines for Collecting and Distributing Information

The collection and distribution of information regarding business practices is a traditional function of associations and is well-recognized under the law as appropriate, legal and consistent with the antitrust laws. However, if conducted improperly, such information gathering and distributing activities might be viewed as facilitating an express or implied agreement among association members to adhere to the same business practices. For this reason, special general guidelines have developed over time regarding association's reporting on information collected from and disseminated to members. Any exceptions to these general guidelines should be made only after discussion with General Counsel. These general guidelines include:

1. Member participation in a statistical reporting program is voluntary. A statistical reporting program should be conducted without coercion or penalty. Non-members should be allowed to participate in a statistical reporting program if eligible; however, if a fee is involved, non-members may be charged a reasonably higher fee than members.
2. Information should be collected via a written instrument that clearly sets forth what is being requested.
3. The data that is collected should be about past transactions or activities; particularly if the survey deals with prices and price terms (including charges, costs, wages, benefits, discounts, etc,), it should be historic, i.e., more than three months old.
4. The data should be collected by either POSNA or an independent third party not connected with any one member.
5. Data on individual orthopaedic surgeons should be kept confidential.
6. There should be a sufficient number of participants to prevent specific responses or data from being attributable to any one respondent. As a general rule, there should be at least five respondents reporting data upon which any statistic or item is based, and no individual's data should represent more than 25% on a weighted average of that statistic or item.
7. Composite/aggregate data should be available to all participants – both members and non-members. The data may be categorized, e.g., geographically, and ranges and averages may be used. No member should be given access to the raw data. Disclosure of individual data could serve to promote uniformity and reduce competition.
8. As a general rule, there should be no discussion or agreement as to how members and non-members should adjust, plan or carry out their practices based on the results of the survey. Each member should analyze the data and make business decisions independently.

JuniOrtho™
paediatrics powered by ORTHOFIX

At first glance, many children don't look like heroes; but to their families, friends and people they meet, they are.

JuniOrtho by Orthofix is dedicated to helping surgeons give children with bone traumas and deformities the best option at achieving their potential.

JuniOrtho brings together decades of expertise and leading-edge products to give medical professionals and families alike the ultimate in orthopaedic solutions.

You can't always see the hero inside.

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Booth 17

Not an actual patient

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EPOS

European Paediatric Orthopaedic Society

FUTURE MEETINGS

- The 5th EPOS-EFFORT BAT Instructional Course Trilogy:
  - Basic I 18-20 October 2017, Speising Hospital, Vienna, Austria
  - Trauma 14-16 March 2018, Speising Hospital, Vienna, Austria
  - Basic II 10-12 October 2018, Speising Hospital, Vienna, Austria
- EPOS Advanced Course: Fundamentals of Pediatric Spine Deformities: Children's Spine is Not a Miniature of Adults' Ones!
  24-25 November 2017, Speising Hospital, Vienna, Austria
- The 37th EPOS Annual Meeting
  11-14 April 2018, Oslo, Norway

POSNA

PEDIATRIC ORTHOPAEDIC SOCIETY OF NORTH AMERICA

FUTURE ANNUAL MEETINGS

May 9 – May 12, 2018
Austin, Texas

May 15 – May 18, 2019
Charlotte, North Carolina

May 13 – May 16, 2020
San Diego, California

FUTURE IPOS MEETINGS

November 28 - December 2, 2017
Orlando, Florida

November 27 - December 1, 2018
Orlando, Florida

December 10 - 14, 2019
Lake Buena Vista, Florida

December 8 - 12, 2020
Lake Buena Vista, Florida

Thank you for attending

2017 COMBINED EPOS /POSNA EPOSNA ANNUAL MEETING