

2021

POSNA

ANNUAL MEETING

DALLAS, TX | MAY 12-15, 2021

HILTON ANATOLE



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ABSTRACT BOOK



POSNA

PEDIATRIC ORTHOPAEDIC SOCIETY
OF NORTH AMERICA

LEVELS OF EVIDENCE FOR PRIMARY RESEARCH QUESTIONS

THE JOURNAL OF BONE & JOINT SURGERY · JBJS.ORG
VOLUME 97-A · NUMBER 1 · JANUARY 7, 2015

UPDATING THE ASSIGNMENT OF LEVELS OF EVIDENCE

Levels of Evidence for Primary Research Question^{1,2}

Study Type	Question	Level I	Level II	Level III	Level IV	Level V
Diagnostic— Investigating a diagnostic test	Is this (early detection) test worthwhile?	<ul style="list-style-type: none"> Randomized controlled trial 	<ul style="list-style-type: none"> Prospective³ cohort⁴ study 	<ul style="list-style-type: none"> Retrospective⁵ cohort⁴ study Case-control⁶ study 	<ul style="list-style-type: none"> Case series 	<ul style="list-style-type: none"> Mechanism-based reasoning
	Is this diagnostic or monitoring test accurate?	<ul style="list-style-type: none"> Testing of previously developed diagnostic criteria (consecutive patients with consistently applied reference standard and blinding) 	<ul style="list-style-type: none"> Development of diagnostic criteria (consecutive patients with consistently applied reference standard and blinding) 	<ul style="list-style-type: none"> Nonconsecutive patients No consistently applied reference standard 	<ul style="list-style-type: none"> Poor or nonindependent reference standard 	<ul style="list-style-type: none"> Mechanism-based reasoning
Prognostic— Investigating the effect of a patient characteristic on the outcome of a disease	What is the natural history of the condition?	<ul style="list-style-type: none"> Inception³ cohort study (all patients enrolled at an early, uniform point in the course of their disease) 	<ul style="list-style-type: none"> Prospective³ cohort⁴ study (patients enrolled at different points in their disease) Control arm of randomized trial 	<ul style="list-style-type: none"> Retrospective⁵ cohort⁴ study Case-control⁶ study 	<ul style="list-style-type: none"> Case series 	<ul style="list-style-type: none"> Mechanism-based reasoning
Therapeutic— Investigating the results of a treatment	Does this treatment help? What are the harms? ⁷	<ul style="list-style-type: none"> Randomized controlled trial 	<ul style="list-style-type: none"> Prospective³ cohort⁴ study Observational study with dramatic effect 	<ul style="list-style-type: none"> Retrospective⁵ cohort⁴ study Case-control⁶ study 	<ul style="list-style-type: none"> Case series Historically controlled study 	<ul style="list-style-type: none"> Mechanism-based reasoning
Economic	Does the intervention offer good value for dollars spent?	Computer simulation model (Monte Carlo simulation, Markov model) with inputs derived from Level-I studies, lifetime time duration, outcomes expressed in dollars per quality-adjusted life years (QALYs) and uncertainty examined using probabilistic sensitivity analyses	Computer simulation model (Monte Carlo simulation, Markov model) with inputs derived from Level-II studies, lifetime time duration, outcomes expressed in dollars per QALYs and uncertainty examined using probabilistic sensitivity analyses	Computer simulation model (Markov model) with inputs derived from Level-II studies, relevant time horizon, less than lifetime, outcomes expressed in dollars per QALYs and stochastic multilevel sensitivity analyses	Decision tree over the short time horizon with input data from original Level-II and III studies and uncertainty is examined by univariate sensitivity analyses	Decision tree over the short time horizon with input data informed by prior economic evaluation and uncertainty is examined by univariate sensitivity analyses

1. This chart was adapted from OCEBM Levels of Evidence Working Group, "The Oxford 2011 Levels of Evidence," Oxford Centre for Evidence-Based Medicine, <http://www.cebm.net/ocebml-levels-of-evidence/>. A glossary of terms can be found here: <http://www.cebm.net/glossary/>.
2. Level-I through IV studies may be graded downward on the basis of study quality, imprecision, indirectness, or inconsistency between studies or because the effect size is very small; these studies may be graded upward if there is a dramatic effect size. For example, a high-quality randomized controlled trial (RCT) should have ≥80% follow-up, blinding, and proper randomization. The Level of Evidence assigned to systematic reviews reflects the ranking of studies included in the review (i.e., a systematic review of Level-II studies is Level II). A complete assessment of the quality of individual studies requires critical appraisal of all aspects of study design.
3. Investigators formulated the study question before the first patient was enrolled.
4. In these studies, "cohort" refers to a nonrandomized comparative study. For therapeutic studies, patients treated one way (e.g., cemented hip prosthesis) are compared with those treated differently (e.g., cementless hip prosthesis).
5. Investigators formulated the study question after the first patient was enrolled.
6. 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., successful total hip arthroplasty), called "controls."
7. Sufficient numbers are required to rule out a common harm (affects >20% of participants). For long-term harms, follow-up duration must be sufficient.

References

1. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ*. 1996 Jan 13;312(7023):71-2.
2. Wright JG, Swiontkowski MF, Heckman JD. Introducing levels of evidence to the journal. *J Bone Joint Surg Am*. 2003 Jan;85(1):1-3.
3. OCEBM Working Group. The Oxford 2011 Levels of Evidence. Oxford Centre for Evidence-Based Medicine. 2011. <http://www.cebm.net/ocebml-levels-of-evidence/>. Accessed 2014 Oct 23.
4. Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, Moschetti I, Phillips B, Thornton H. Explanation of the 2011 Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence (Background Document). Oxford Centre for Evidence-Based Medicine. <http://www.cebm.net/wp-content/uploads/2014/06/OCEBM-Levels-of-Evidence-Background-Document-2.1.pdf>. Accessed 2014 Oct 23.
5. Edwards TB. What is the value of a systematic review? *J Shoulder Elbow Surg*. 2014 Jan;23(1):1-2. Epub 2013 Nov 4.
6. Wright JG, Swiontkowski MF, Tolo VT. Meta-Analyses and Systematic Reviews: New Guidelines for JBJS. *J Bone Joint Surg Am*. 2012 Sep 5;94(17):1537.
7. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB. Recommendations of the Panel on Cost-effectiveness in Health and Medicine. *JAMA*. 1996 Oct 16;276(15):1253-8.
8. Caro JJ, Briggs AH, Siebert U, Kuntz KM; ISPOR-SMDM Modeling Good Research Practices Task Force. Modeling good research practices—overview: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force—1. *Value Health*. 2012 Sep-Oct;15(6):796-803.

SCIENTIFIC PROGRAM

WEDNESDAY, MAY 12

GENERAL SESSION: HIP/INFECTION

Moderator: *Alexandre Arkader, MD*

Co-Moderator: *Jonathan Schoenecker, MD*

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1:36 PM–1:40 PM

Long-term Patient Reported Outcomes and Satisfaction with Surgery Deteriorate Significantly with Time After In Situ Epiphysiodesis for Slipped Capital Femoral Epiphysis
Patrick Whitlock, MD; Nicholas Auteri; Molly Uchtman
Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

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1:41 PM–1:45 PM

Proximal Femoral Changes Related to Obesity: An analysis of SCFE Pathoanatomy
Travis Winston, MD; Andrew Landau; Pooya Hosseinzadeh, MD
Washington University School of Medicine, Saint Louis, Missouri

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1:46 PM–1:50 PM



Femoral Neck Growth and Remodeling with Free-Gliding Screw Fixation of Slipped Capital Femoral Epiphysis

Kevin Morash; Benjamin Orlik; Ron El-Hawary, MD;
Luke Gauthier, MD; Karl Logan, MBChB
IWK Health Centre, Halifax, N.S., Canada

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2:00 PM–2:04 PM

Is there a benefit to weaning Pavlik Harness treatment in infantile DDH?

Wudbhav Sankar, MD; Joshua Bram; Shivani Gohel;
Pablo Castaneda, MD
Children's Hospital of Philadelphia, Philadelphia, PA

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2:05 PM–2:09 PM

Comparison of Acetabular Morphology Changes in Pediatric Pelvic Osteotomies using Patient-Specific 3-D Models

Vidyadhar Upasani, MD; Samuel Baird; Jason Caffrey;
Harsha Bandaralage; James Bomar, MPH;
Christine Farnsworth, MS
Rady Children's Hospital - San Diego, San Diego, CA



SCIENTIFIC PROGRAM

WEDNESDAY, MAY 12 CONTINUED

6

2:10 PM–2:14 PM

Outpatient Bryant's Overhead Traction Does Not Affect the Rate of Open Reduction or Avascular Necrosis in Developmental Dislocation of the Hip

*John Birch, MD; Emily Elerson; William Pierce;
Sean Hinds; Benjamin Martin, MD; Ryan Muchow, MD
Texas Scottish Rite Hospital for Children, Dallas, Texas*

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2:24 PM–2:28 PM

Rate of Concomitant Cellulitis and Osteoarticular Infections in a Pediatric Population

*Claire Ryan; Christopher Souder, MD; Matthew Ellington, MD
University of Texas at Austin Dell Medical School, Austin, Texas*

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2:29 PM–2:33 PM

Practice Variation in the Surgical Management of Children with Non-Abscess Forming Acute Osteomyelitis: Policy or Clinical Judgement

*Vidyadhar Upasani, MD; Jessica Burns, MD; Tracey Bastrom, MA;
Keith Baldwin, MD; Jonathan Schoenecker MD, PhD;
Benjamin Shore, MD, MPH, FRCSC; CORTICES Study Group
Rady Children's Hospital, San Diego, San Diego, California*

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2:34 PM–2:38 PM

The Utility of Routine Radiographic Monitoring in Pediatric Osteoarticular Infections

*Christopher Gajewski; Nicholas Gajewski; Alexander Upfill-Brown;
Rachel Thompson, MD; Mauricio Silva, MD
University of California, Los Angeles, Los Angeles, CA*

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2:48 PM–2:52 PM

The Use of Biomarkers in Early Diagnosis of Septic Arthritis and Osteomyelitis

*Michelle Mo, MD; Farshid Guilak; Alexis Elward; Kim Quayle;
Dominic Thompson; Kirsten Brouillet; Scott Luhmann, MD
St. Louis Children's Hospital, Saint Louis, MO*

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2:53 PM–2:57 PM

Outcome of Surgical Excision in Patients with Fibro-Adipose Vascular Anomaly

*Samantha Spencer, MD; Jirawat Saengsin;
Kemble Wang, MD; Patricia Miller, MS; Nicholas Sullivan;
Blair Stewig; Megan Anderson, MD
Department of Orthopaedic Surgery, Boston Children's Hospital,
Harvard Medical School, Boston, MA*

SCIENTIFIC PROGRAM

WEDNESDAY, MAY 12 CONTINUED

12

2:58 PM–3:02 PM

Spinal Involvement and Vertebral Deformity in patients with Chronic Recurrent Multifocal Osteomyelitis

*Nathan Donaldson, DO; Nathan Rogers, MPH; Jennifer Soep
Children's Hospital Colorado, Aurora, CO*

GENERAL SESSION: TRAUMA

Moderator: Charles Mehlman, DO, MPH

Co-Moderator: Christine Ho, MD

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3:48 PM–3:52 PM



Surgical Technique: Medial Pinning in Pediatric Supracondylar Humerus Fractures via the Mini-Open Technique—Safer Than We Thought?

*Andrew Rees; Jacob Schultz; Lucas Wollenman;
Stephanie Moore-Lotridge, PhD; Jonathan Schoenecker MD, PhD;
Gregory Mencio, MD
Vanderbilt University Medical Center, Nashville, Tennessee*

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3:53 PM–3:57 PM



Intraoperative Internal Rotation Stress Test in Displaced Pediatric Supracondylar Humerus Fractures Improves Outcomes

*Andrew Rees; Jacob Schultz; Lucas Wollenman;
Stephanie Moore-Lotridge PhD; Jeffrey Martus, MD;
Gregory Mencio, MD; Jonathan Schoenecker MD, PhD
Monroe Carell Jr. Children's Hospital at Vanderbilt University
Medical Center, Nashville, Tennessee*

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3:58 PM–4:02 PM



Functional Outcomes of Operative vs Non-operative Treatment of Displaced Proximal Humerus Fractures in Adolescents: Early Results from a Multicenter Prospective Study

*Pooya Hosseinzadeh, MD; Andrew Landau; Rachel Goldstein, MD;
Julia Sanders, MD; Jaime Denning, MD; Vidyadhar Upasani, MD;
Keith Baldwin, MD
Washington University School of Medicine, Saint Louis, Missouri*



SCIENTIFIC PROGRAM

WEDNESDAY, MAY 12 CONTINUED

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4:12 PM–4:16 PM



Operative Versus Non-operative Treatment of Z-Type Comminuted Clavicle Fractures in Adolescents: A Sub-stratified Cohort Analysis

Coleen Sabatini, MD, MPH; Eric Edmonds, MD; Elizabeth Liotta; Katelyn Hergott; Donald Bae, MD; Michael Busch, MD; Henry Ellis, MD; Mininder Kocher, MD, MPH; G Li, MD; Jeffrey Nepple, MD; Nirav Pandya, MD; Andrew Pennock, MD; Crystal Perkins, MD; David Spence, MD; David Williams PhD; Samuel Willimon, MD; Philip Wilson, MD; Benton Heyworth, MD
Children's Hospital Boston, Boston, MA

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4:17 PM–4:21 PM



Comparative Effectiveness of Non-operative Versus Operative Treatment for Completely Displaced Clavicle Shaft Fractures in Children

Charles Mehlman, DO; Shital Parikh, MD
Cincinnati Children's Hospital Medical Center, Cincinnati, OH

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4:22 PM–4:26 PM



Changes in Superior Displacement, Angulation, and Shortening in the Early Phase of Healing for Completely Displaced Midshaft Clavicle Fractures in Adolescents: Results from a Prospective, Multicenter Study

Jeffrey Nepple, MD; Andrew Pennock, MD; Benton Heyworth, MD; Tracey Bastrom MA; Donald Bae, MD; Michael Busch, MD; Eric Edmonds, MD; Henry Ellis, MD; Mininder Kocher, MD, MPH; G Li, MD; Elizabeth Liotta; Nirav Pandya, MD; Crystal Perkins, MD; Coleen Sabatini, MD, MPH; David Spence, MD; Samuel Willimon, MD; David Williams, PhD; Philip Wilson, MD
Rady Children's Hospital, San Diego, CA

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4:36 PM–4:40 PM



Management of Syndesmotic Injuries in Children and Adolescents: Results of a Cross-Sectional Survey

Caroline Williams; Benjamin Shore, MD, MPH, FRCSC; Nicholas Sullivan; Blair Stewig; Dennis Kramer, MD; Yi-Meng Yen, MD; Collin May, MD; CORTICES Study Group
Boston Children's Hospital, Boston, MA

SCIENTIFIC PROGRAM

WEDNESDAY, MAY 12 CONTINUED

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4:41 PM–4:45 PM



Suture-button versus Screw Fixation of the Tibiofibular Syndesmosis in Adolescent Ankle Injuries

Benjamin Lurie; Conner Paez; Shayna Howitt;

Andrew Pennock, MD

Rady Children's Hospital, San Diego, San Diego, California

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4:46 PM–4:50 PM



Incidence and Risk Factors for Acute Compartment Syndrome in Pediatric Tibia Fractures

Mitchel Obey; Maksim Shlykov; Margaret Smythe; Katelin Nickel;

Matt Keller; Pooya Hosseinzadeh, MD

Washington University School of Medicine, Saint Louis, Missouri

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5:00 PM–5:04 PM



Clinical Scaphoid Fractures in Children: A prospective radiological study

Sasha Carsen, MD; Kevin Smit, MD; Holly Livock; Zoe Rubin;

Ken Tang; Kerri Highmore; Khaldoun Koujok; Kevin Cheung

CHEO, Ottawa, Ontario, Canada

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5:05 PM–5:09 PM



Use of well-leg traction in the treatment of displaced femoral neck fractures in the pediatric population provides a practical alternative to the peroneal post

Courtney Selberg, MD; Nathan Donaldson, DO;

Rachael Martino, BA; Nathan Rogers, MPH

Children's Hospital Colorado,

Aurora, Colorado

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5:10 PM–5:14 PM



Evaluation and Treatment of Pediatric Pelvic Ring Injuries

Elizabeth Davis; Shiraz Younas, MD

McGovern Medical School, Houston, Texas



Long-term Patient Reported Outcomes and Satisfaction with Surgery Deteriorate Significantly with Time After In Situ Epiphysiodesis for Slipped Capital Femoral Epiphysis

*Patrick William Whitlock MD; Nicholas Auteri; Molly Uchtman
Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio*

LOE-Therapeutic-Level IV

Purpose: Despite concerns regarding future effects of femoroacetabular impingement (FAI), in-situ epiphysiodesis of the proximal femoral physis remains the most common treatment of stable slipped capital femoral epiphysis (SCFE). However, little exists comparing patient perceived satisfaction following this intervention to validated patient reported outcomes (PROs). We hypothesized that PROs for the young hip would correlate with reported patient satisfaction but that both would decline with time since surgery.

Methods: An IRB approved, retrospective review of patients treated with in situ epiphysiodesis for stable SCFE was performed from 2003 to 2018. Patients who developed avascular necrosis, underwent subsequent surgery, or whose postoperative follow-up were not available were excluded. 30 patients (22 males, 8 females) completed the following PROs: patient satisfaction with surgery, Hip dysfunction and Osteoarthritis Outcome Score (HOOS), international Hip Outcome Tool (iHOT), and Nonarthritic Hip Score (NAHS). Clinical, demographic, and radiographic data were recorded. Mean BMI at surgery was 30.1 ± 8.0 . Mean age at surgery was 12.33 ± 1.35 years. Average follow-up of 83.2 ± 61.2 months at the time of survey. Mean alpha angle was $72.0 \pm 8.8^\circ$. Patient satisfaction with surgery, time since surgery and PROs were compared using Spearman's correlations.

Results: A positive correlation between reported patient satisfaction with surgery and the following PROs was observed: iHOT, correlation coefficient = 0.90, $p < 0.0001$; NAHS, correlation coefficient = 0.84, $p < 0.0001$; HOOS, correlation coefficient = 0.87, $p < 0.0001$. Patient satisfaction and PROs were not correlated with alpha angle. Patient reported satisfaction and the following PROs had a negative correlation with time from surgery: iHOT, correlation coefficient = -0.45, $p = 0.01$; NAHS, correlation coefficient = -0.56, $p = 0.001$; HOOS, correlation coefficient = -0.49, $p = 0.006$; patient satisfaction, correlation coefficient = -0.46, $p = 0.02$.

Conclusions: Patient reported satisfaction with in situ epiphysiodesis of SCFE correlates well with the HOOS, iHOT33, and NAHS. Increasing time since surgery inversely correlated with PROs and patient perceived satisfaction with surgery.

Significance: PROs and perceived satisfaction with surgery suggest that hips treated with isolated in-situ epiphysiodesis following stable SCFE deteriorate with time. Further study is warranted to determine which hips are at risk for deterioration of PROs and what additional factors play a role in their decline. Long-term patient reported outcomes and satisfaction with surgery deteriorate significantly with time after in situ epiphysiodesis for slipped capital femoral epiphysis (SCFE).

Proximal Femoral Changes Related to Obesity: An analysis of SCFE Pathoanatomy

*Travis Winston MD; Andrew Jacob Landau; Pooya Hosseinzadeh MD
Washington University School of Medicine, Saint Louis, Missouri*

LOE-Prognostic-Level III

Purpose: Recent research has revealed the importance of the femoral epiphyseal tubercle, a projection in the posterosuperior portion of the metaphyseal surface, and cupping height in the stability of the physis and prevention of capital femoral slippage (SCFE). To better understand the connection between the pathogenesis of SCFE, hip anatomy, and obesity, we performed retrospective analysis of proximal femur and acetabular anatomies using pelvic CT scans in normal weight and obese adolescents.

Methods: We measured morphologic characteristics of the proximal femur and acetabulum in developing hips of 31 obese adolescent patients (BMI \geq 95th percentile for age, mean [SD]=31.3 [4.4] kg/m²) between the ages of 10 and 14 years (11.7 [1.5]) and an age- and sex-matched control group with normal BMI (17.6 [2.0] kg/m²) who had pelvic CT scans for any reason besides hip pain. Most CT scans were performed to evaluate abdominal pain or trauma. Patients were excluded if they had any underlying metabolic or functional condition that could affect normal bone development. Measurements included physeal diameter, tubercle height, width, and volume, cupping height, acetabular version and inclination, and subphyseal bone metabolic density (BMD) performed on true coronal and sagittal views through the center of the physis using previously described and validated techniques. To minimize effects of natural changes in tubercle and cupping size with increasing age, we calculated normalized versions of these values by dividing them by the mean physeal diameter. Subphyseal (BMD) was measured in Hounsfield units (HU).

Results: The epiphyseal tubercle volume, average cupping size, and acetabular version were similar between groups (absolute and normalized) [Table 1]. Acetabular inclination and subphyseal BMD were significantly different between cohorts ($p < 0.049$ and $p < 0.028$, respectively). Normal weight patients had slightly more lateral coverage, measured by acetabular inclination (R=48.5 [3.6], L=43.7[4.2] degrees), than obese patients (R=45.1 [5.0], L=47.3[9.1] degrees). Subphyseal BMD was lower among obese patients (417.17 [73.4] HU) than those with normal BMIs (464.7 [75.3] HU), which could suggest increased metabolic activity in the subphyseal bone in obese adolescents.

Conclusions: Obesity does not appear to cause morphologic changes to the capital femoral epiphysis, though it is associated with decreased subphyseal BMD. Metabolic factors associated with obesity, rather than anatomical changes, may be responsible for physeal instability seen in obese adolescents.

Significance: This study demonstrates that obesity and physeal morphology are independently associated with the development of SCFE and that decreased subphyseal BMD is associated with obesity, which may contribute to this population's predisposition to SCFE.

Table 1. Proximal Femoral and Acetabular Measurements

Measure	Obese		Control		P-value	
	R	L	R	L	R	L
Average Physeal Diameter (cm)	3.8 (0.38)	3.8 (0.39)	3.7 (0.34)	3.7 (0.35)	0.29	0.34
Max. Tubercle Height (cm)	0.39 (0.06)	0.39 (0.07)	0.40 (0.10)	0.39 (0.06)	0.51	0.69
Tubercle Volume – Absolute (cm ³)	1.5 (0.67)	1.5 (0.64)	1.5 (0.66)	1.5 (0.64)	0.94	0.72
Tubercle Volume – Normalized (cm ³)	0.41 (0.18)	0.39 (0.16)	0.41 (0.18)	0.41 (0.17)	0.89	0.55
Average Cupping – Absolute (cm)	0.83 (0.18)	0.68 (0.14)	0.85 (0.19)	0.65 (0.14)	0.79	0.56
Average Cupping – Normalized (cm)	0.22 (0.04)	0.18 (0.03)	0.23 (0.04)	0.18 (0.03)	0.33	0.83
Acetabular Inclination (degrees)	45.1 (5.0)	43.7 (9.1)	48.6 (3.8)	47.3 (4.2)	0.003*	0.049*
Subphyseal Bone Density (HU)	414.4 (67.9)	419.9 (78.9)	467.2 (82.1)	462.2 (68.5)	0.008*	0.028*
Acetabular Version (degrees)	15.1 (4.9)	14.8 (3.9)	13.0 (4.2)	13.1 (5.0)	0.067	0.12

* Indicates statistically significant difference

Femoral Neck Growth and Remodeling with Free-Gliding Screw Fixation of Slipped Capital Femoral Epiphysis

Kevin Morash; Benjamin Orlik; Ron El-Hawary MD; Luke Gauthier MD; Karl J. Logan MBChB
IWK Health Centre, Halifax, N.S. Canada

LOE-Therapeutic-Level III

Purpose: Treatment of stable slipped capital femoral epiphysis (SCFE) most commonly involves in situ fixation with a standard cannulated screw, leading to physeal arrest. Recently, Pega Medical (Laval, Canada) introduced the Free-Gliding (FG) SCFE Screw, which employs a growth-friendly, telescopic design. This study examines femoral neck growth and remodeling over the first 2 postoperative years in stable SCFE treated with FG versus standard screws.

Methods: We retrospectively reviewed 32 hips (19 SCFE, 13 prophylactic) in 16 patients treated with FG screws for stable SCFE. We also reviewed 102 hips (63 SCFE, 19 prophylactic, 20 controls) in 55 patients treated with standard screws. Immediate postoperative radiographs were compared to 1- and 2-year follow-up images.

Results: For the overall study cohort, mean age at surgery was 12.2 ± 1.9 years, with a mean slip angle of $26.9 \pm 18.0^\circ$. In FG SCFE hips, the alpha angle remodeled $12.9 \pm 19.2^\circ$ in the first postoperative year ($P=0.018$) and articulo-trochanteric distance (ATD) decreased by 4.2 ± 4.6 mm at 2 years ($P=0.018$). In Standard SCFE hips, the alpha angle remodeled $4.3 \pm 11.3^\circ$ at 1 year ($P=0.014$), while ATD decreased by 4.5 ± 3.2 mm at 2 years ($P<0.001$). FG Prophylactic hips maintained an unchanged ATD over 2-year follow-up, while Standard Prophylactic hips demonstrated decreased ATD by 5.1 ± 2.5 mm at 2 years ($P<0.001$). By 2 years, FG screws lengthened more in prophylactic (4.8 ± 3.4 mm) than SCFE hips (1.7 ± 1.8 mm, $P=0.027$).

Conclusions: Greater remodeling of femoral neck cam deformity occurs when treating SCFE using an FG screw. Additionally, FG screws allow ongoing normal growth of prophylactically treated hips, while standard screws promote coxa breva.

Significance: In early follow-up, FG screws improve remodeling of the alpha angle while allowing femoral neck growth, particularly in mild slips. Further research is required to measure the impact of this finding on femoro-acetabular impingement and degenerative arthritis.

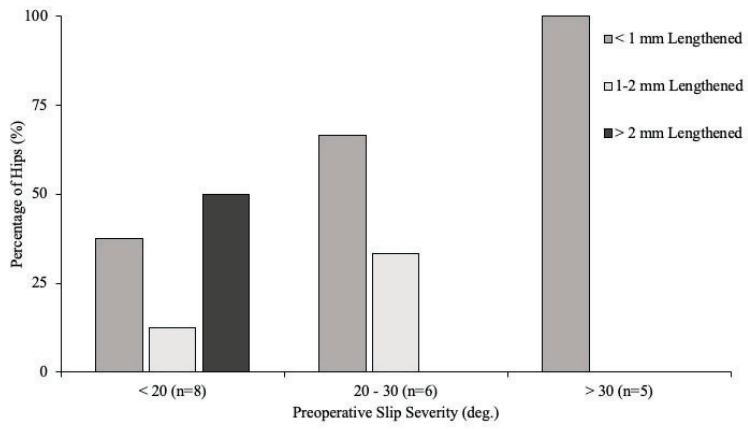


FIGURE 1. Maximum telescoping of Free-Gliding screws used for slipped capital femoral epiphysis, grouped by preoperative slip severity.

Is there a benefit to weaning Pavlik Harness treatment in infantile DDH?

*Wudbhav N. Sankar MD; Joshua Bram; Shivani Gohel; Pablo Castaneda MD
Children's Hospital of Philadelphia, Philadelphia, PA*

LOE-Therapeutic-Level III

Purpose: Following successful treatment of developmental hip dysplasia (DDH) with a Pavlik harness, controversy exists about whether it's better to continue harness use for an additional "weaning" period beyond ultrasonographic normalization or simply terminate treatment. The purpose of this study was to directly compare the one-year radiographic outcomes of two cohorts of infants with DDH treated with Pavlik harness, one with a weaning protocol and one without.

Methods: This was a retrospective comparative review of patients with dislocated/reducible hips and stable dysplasia from two centers. All patients had pre-treatment ultrasounds, and all started harness treatment prior to three months of age. Patients in whom the harness failed, requiring rigid bracing or surgery, were excluded. Powered to detect a 3° difference in acetabular index (based on reported intra-observer error rates for AI), a sufficient cohort of hips were matched according to clinical exam, age at initiation, initial alpha angle (AA), and initial percent femoral head coverage (FHC). Patients from institution W were weaned from the harness over 4-6 weeks following ultrasonographic normalization, while those from institution NW (not weaned) immediately ceased treatment. The primary outcome was AI at one year of age.

Results: Sixteen dislocated/reducible (i.e. Ortolani positive) and 16 stable dysplastic hips were matched at each center (64 total hips in 53 patients). Initial AA and FHC were not significantly different between W and NW cohorts for either disease category ($p=0.59-0.81$). As expected, weaned hips were treated for significantly longer in both the stable dysplasia (1540.4 ± 150.1 vs 1066.3 ± 146.4 hours, $p<0.01$), and dislocated/reducible cohorts (1596.6 ± 230.0 vs 1362.5 ± 263.8 hours, $p=0.01$). Despite this, we found no significant difference in AI at one year in either cohort ($22.8 \pm 3.2^\circ$ vs $23.1 \pm 2.2^\circ$, $p=0.84$ for stable dysplasia; $23.9 \pm 2.7^\circ$ vs $24.8 \pm 2.6^\circ$, $p=0.32$ for Ortolani positive).

Conclusions: Despite greater total time in harness, infants treated with an additional weaning period did not demonstrate significantly different radiographic results at one year of age compared to those who were not weaned.

Significance: Our study—the first to directly compare weaned vs. not weaned infants using objective radiographic outcomes and strict matching criteria—does not demonstrate a benefit to harness weaning over immediate cessation. However, differences in follow-up protocols between centers support the need for a more rigorous randomized controlled trial.

Comparison of Acetabular Morphology Changes in Pediatric Pelvic Osteotomies using Patient-Specific 3-D Models

Vidyadhar S V Upasani MD; Samuel Baird; Jason Patrick Caffrey; Harsha Bandaralage; James David Bomar MPH; Christine L. Farnsworth MS
Rady Children's Hospital-San Diego, San Diego, CA

LOE-Not Applicable-

Purpose: Evaluate differences in change of acetabular coverage angles and volume between Pemberton, Dega, San Diego and Salter osteotomies using 3-D printing technology.

Methods: Preoperative computed tomography (CT) scans from patients with acetabular dysplasia were studied. CT scans were rendered into a 3-D printable format and four mock pelvises from each patient were printed utilizing a rigid material to simulate bone and a flexible material to simulate the tri-radiate cartilage and pubic symphysis. Mock Salter (Figure 1A), Pemberton, Dega, and San Diego osteotomies were performed on the quadruplicate sets of 3-D prints by a fellowship trained pediatric orthopaedic surgeon. CT scans were taken of the pre- and postoperative 3-D printed hips. Custom software measured acetabular volume as a hemisphere of the fitted sphere (Figure 1B). Acetabuli were divided into equal octants and coverage angles were calculated for the five weight-bearing octants (Figure 1C).

Results: Fourteen hips in 14 patients were included; 1 male, 13 female; mean age 5.4 ± 1.3 years (range: 3 to 7 years). Acetabular volume decreased significantly ($p < 0.05$ all comparisons) from the preoperative volume in all cases: Pemberton ($-1375.2 \pm 1329.9 \text{ mm}^3$, -14% difference), Dega ($-1816.3 \pm 1328.1 \text{ mm}^3$, -19% difference), San Diego ($-1876.7 \pm 1238 \text{ mm}^3$, -19% difference) and Salter ($-537.3 \pm 934.2 \text{ mm}^3$, -6% difference). Acetabular volume change for the Salter was significantly ($p < 0.05$ all comparisons) less than each other osteotomy. The change in acetabular volume for the Pemberton, Dega and San Diego were not significantly different from each other. Compared to preoperative mean coverage angles, the postoperative mean coverage angles were different across several regions ($p < 0.05$ all comparisons). The San Diego had greater coverage in the P ($75.4^\circ \pm 8.8^\circ$ to $79^\circ \pm 7.4^\circ$), SP ($81.9^\circ \pm 9.5^\circ$ to $92.6^\circ \pm 9.3^\circ$), and S ($98.6^\circ \pm 9.2^\circ$ to $111.1^\circ \pm 12.8^\circ$) regions. The Salter had greater coverage in the S region ($98.6^\circ \pm 9.2^\circ$ to $102.6^\circ \pm 7.3^\circ$). The Pemberton increased in S ($98.6^\circ \pm 9.2^\circ$ to $106.6^\circ \pm 9.7^\circ$), SA ($74^\circ \pm 12.1^\circ$ to $91^\circ \pm 16.7^\circ$), and A ($45.8^\circ \pm 8.9^\circ$ to $50.7^\circ \pm 11.7^\circ$) regions. The Dega increased in S ($98.6^\circ \pm 9.2^\circ$ to $106.9^\circ \pm 12.7^\circ$), SA ($74^\circ \pm 12.1^\circ$ to $97.3^\circ \pm 13.6^\circ$), and A ($45.8^\circ \pm 8.9^\circ$ to $53.4^\circ \pm 11.3^\circ$) regions.

Conclusions: Acetabular volume decreases found in this study support the conventional belief that redirection osteotomies such as the Salter are more volume neutral than incomplete osteotomies such as the Pemberton, Dega and San Diego. However, this study shows that even the Salter decreases acetabular volume. Additionally, this study re-demonstrated that each osteotomy used for correction of acetabular dysplasia uniquely changes acetabular coverage in different regions.

Significance: Differences in volume changes and acetabular coverage between osteotomies should influence surgical planning to optimize treatment of patient-specific dysplasia.

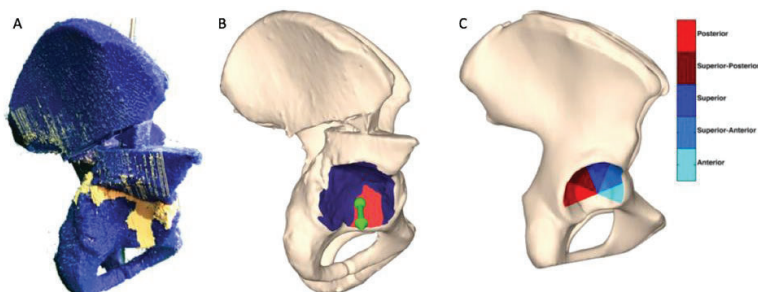


Figure 1. A) 3-D printed hip post-Salter osteotomy. B) CT scan of 3-D printed hip post-Salter osteotomy. C) Weight-bearing octant coverage angles.

Outpatient Bryant's Overhead Traction Does Not Affect the Rate of Open Reduction or Avascular Necrosis in Developmental Dislocation of the Hip

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LOE-Therapeutic-Level IV

Purpose: The efficacy of preliminary traction in the management of late-presenting developmental dislocation of the hip (DDH) to increase the likelihood of closed reduction and/or decrease the incidence of avascular necrosis (AVN) is controversial. We sought to document compliance with and effectiveness of Bryant's outpatient traction in late-presenting patients with idiopathic DDH.

Methods: Patients presenting between 6-24 months of age with previously unoperated, idiopathic fixed DDH were prospectively enrolled in this IRB-approved study. Treatment was determined by participating surgeons' preference and parents' expressed willingness to comply to the use of preliminary traction. Outpatient traction, parental education, and clinical monitoring was instituted by one nurse during an outpatient visit. Parents were advised to use traction as long as possible (at least 14 hours/day) daily for 4 weeks. Hours of traction were documented using a validated monitor; parents were additionally asked to report average daily usage. Rate of successful closed reduction; secondary procedures six or more months after index reduction; and evidence of proximal femoral epiphyseal growth disturbance one and two years post-reduction were documented.

Results: 90 patients with 108 affected hips (24 right, 48 left, 18 bilateral) were enrolled in the study. There were 7 males and 8 females. 33 patients prescribed preliminary traction had adequate traction hour data for review. Defining compliance as 14 hours/day average use, 15 patients (45.5%) were compliant, 6 (18.2%) admitted non-compliance, while 12 (36.4%) claimed compliance, but were not. Overall, 65/108 hips (60.2%) were closed reduced. Age at treatment was the only demographic characteristic associated with an increased incidence of closed reduction (11.7 vs. 14.6 months, $p < 0.01$). Comparing traction-compliant patients to non-traction and least compliant patients, the incidence of closed reduction was 19/31 (61.3%) and 46/77 (59.7%) respectively; irregular ossific nucleus development at one year was 7/31 (22.6%) and 23/77 (29.9%) respectively, and distorted proximal femoral epiphysis at two years (21-35 months post-reduction) 4/29 (13.8%) and 9/60 (15%) respectively; none of these differences was statistically significant. 20/31 (64.5%) hips in traction-compliant patients required secondary procedures post-reduction, compared to 9/77 (11.7%) hips in the non-traction cohort ($p < 0.01$).

Conclusions: Parent-reported use of outpatient traction is unreliable. We did not document a significant increased rate of closed reduction or decreased rate of AVN in compliant traction patients compared to those not receiving preliminary traction.

Significance: Four weeks of outpatient overhead Bryant's traction does not appreciably affect the rate of closed reduction or AVN in the treatment of late-presenting DDH.

Table 1. Outcomes in 90 patients with 108 affected hips.

Variable		Traction Compliant	No Traction/Non-Compliant	Overall	p-value
		#/total (%)	#/total (%)	#/total (%)	
Type of reduction	Closed	19/31 (61.3%)	46/77 (59.7%)	65/108 (60.2%)	0.88
Disturbed ossific nucleus development @ 1 year	Yes	7/31 (22.6%)	23/54 (29.9%)	30/108 (27.8%)	0.44
Distorted capital epiphysis @ 2 years post-reduction	Yes	4/29 (13.8%)	9/60 (15.0%)	13/89 (14.6%)	>0.99
Secondary surgery >6 months post-reduction	Yes	20/31 (64.5%)	9/77 (11.7%)	29/108 (26.9%)	<0.01

Rate of Concomitant Cellulitis and Osteoarticular Infections in a Pediatric Population

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LOE-Prognostic-Level III

Purpose: Concern for infection is a common presentation in pediatric emergency departments. Two of the most common occurrences are cellulitis and osteoarticular infections. The work up and treatment for these two entities differ greatly with advanced imaging prior to surgical intervention being utilized frequently in cases of deep infections but rarely indicated in cellulitis. Within our institution, we have noted that clinical signs consistent with cellulitis often lead to a work up for deep musculoskeletal infections despite a lack of evidence to suggest that the two entities commonly co-exist. The aim of this study is to identify the rate of concomitant cellulitis with osteomyelitis or septic arthritis.

Methods: A retrospective study was performed at a single, tertiary care institution of 482 patients undergoing MRI to evaluate for deep infection from January 2008 to December 2018. Charts were reviewed for clinical signs of cellulitis as documented in the admission history and physical exam. MRI reports were then examined and findings of cellulitis and/or deep musculoskeletal infections were recorded. The data was analyzed to determine the incidence of concomitant cellulitis with deep infection.

Results: Of the 482 patients undergoing MRI, 238 had documented signs of cellulitis. Of these, 52 cases (10.8%) demonstrated both cellulitis upon clinical presentation and an associated deep musculoskeletal infection on MRI. On the basis of location, 92.3% were found to be involving the hand and wrist or the foot and ankle (GROUP 1). Group 1 consisted of 116 cases with 48 cases (41.4%) of concomitant cellulitis and deep infection. The remaining skeletal sites (Group 2) consisted of 122 cases with 4 cases (3.3%) of concurrent cellulitis and musculoskeletal involvement. A significant difference in the rate of concomitant cellulitis and deep osteoarticular infections were found based on location ($p < 0.0001$).

Conclusions: When cellulitis is seen in the areas of the hand and wrist as well as the foot and ankle, there was a greater than 40% chance of a deep musculoskeletal infection. This is compared to the remaining skeletal sites in which a rate of just over 3% of concomitant cellulitis and deep osteoarticular infection was found.

Significance: The index of suspicion for additional deep musculoskeletal involvement should be high when cellulitis is seen in the distal extremities. Yet, when found on the other areas of the body, a low likelihood of deep infection is present and advanced imaging may not be indicated at initial presentation.

Practice Variation in the Surgical Management of Children with Non-Abscess Forming Acute Osteomyelitis: Policy or Clinical Judgement

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LOE-Not Applicable-

Purpose: Children's hospitals have adopted clinical practice guidelines for the diagnosis and management of pediatric acute osteomyelitis (OM). However, surgical intervention for pediatric OM remains controversial in the absence of an associated septic arthritis or subperiosteal abscess. While there is some consensus that surgery can be used to identify the causative organism or to debride and irrigate the bone to reduce disease burden, the objective criteria for when to go to surgery are not well defined. The purpose of this study was to identify practice variation and factors that lead to this variation in surgical management of non-abscess forming OM (NA-OM).

Methods: Children with NA-OM were retrospectively analyzed between January 1, 2010 and December 31, 2016 from 18 pediatric medical centers throughout the United States. Demographics, clinical assessments, and culture and sensitivity results were reviewed. Multivariate regression and classification and regression tree (CART) analyses were performed to determine variables that predicted surgical management.

Results: 745 children with NA-OM were included with an average age of 8.1 ± 4.6 years. 386 (51.8%) children were treated surgically. Multivariate analysis revealed institution, ambulatory status, disseminated disease, elevated C-reactive protein (CRP), and elevated platelet count to be significant predictors of surgery ($p < 0.01$). In the CART analysis, three distinct patterns of surgical intervention (Figure 1) were identified based on institution. A cohort of 4 institutions operated on the majority (86%) of patients regardless of clinical factors. A second tier of 5 institutions operated on 62% of patients, especially if they were non-ambulatory or if they had negative blood cultures. And a third tier of 9 institutions operated on 33% of their patients, increasing to 70% if they had disseminated disease or a high C-Reactive Protein (>15.9 mg/dL).

Conclusions: This study identified significant differences in the rates of surgical management (33% to 86%) and variables driving the decision to operate on NA-OM across the United States. Drivers of surgery fell into broad categories of either 'policy' or 'clinical judgement'. At centers using 'clinical judgement' the main variables driving surgery were negative blood cultures or disease severity (non-ambulatory or disseminated disease with CRP above 15.9 mg/dL).

Significance: This is the first study to objectively identify significant variability in the surgical management of NA-OM across 18 major children's hospitals. As a result of these findings, it is essential for future studies to determine if surgical indications based on 'policy' or 'clinical judgement' provide the best care for children with NA-OM.

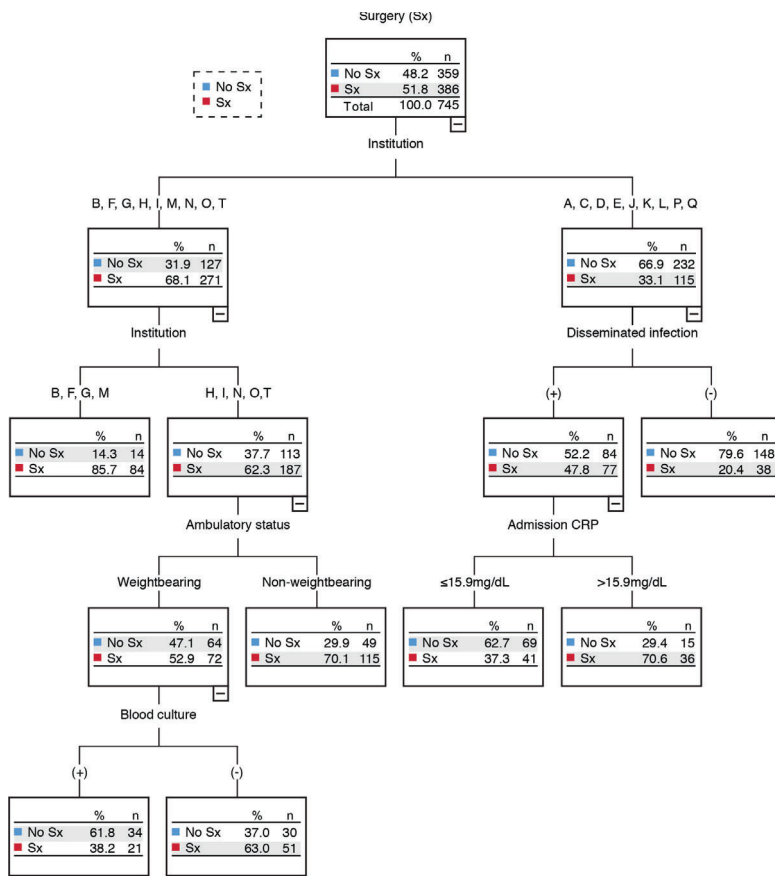


Figure 1: CART Analysis for Variables Associated with Surgical Management of Children with Non-Abscess Forming Acute Osteomyelitis

The Utility of Routine Radiographic Monitoring in Pediatric Osteoarticular Infections

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LOE-Diagnostic-Level II

Purpose: Pediatric musculoskeletal (MSK) infections broadly include isolated osteomyelitis (OM), septic arthritis (SA) and combined infections (OM+SA). The significant burden of these diagnoses often prompts monitoring with serum inflammatory markers and serial radiographs to evaluate for negative sequelae, including recurrent infection, pathologic fracture and growth disturbance or arrest, despite limited data supporting this practice. The purpose of this study is to evaluate the utility of obtaining routine, serial radiographic follow-up for pediatric osteoarticular infections.

Methods: An IRB-approved retrospective review was completed. Children <18 years admitted to a single institution with a culture/biopsy-proven diagnosis of OM, SA or OM+SA between 2012-2018 were included. All post-discharge radiographs were reviewed and retrospectively categorized as either routine (scheduled) or reactive. Routine radiographs were obtained regardless of clinical presentation. Reactive radiographs were obtained in patients presenting with persistent or recurrent pain, injury, fever, swelling, limb deformity or elevation of inflammatory markers. Negative sequelae, defined as growth arrest/disturbance, pathologic fracture, recurrent MSK infection, and underlying neoplastic process, were recorded and tracked. Descriptive statistics were used to summarize demographic and outcome variables. Number needed to screen (NNS) was defined as the inverse of the incidence of negative sequelae detected.

Results: 130 patients were included for analysis, with a mean age of 11.9 years. 90 (69%) patients were diagnosed and treated for OM, 25 (19%) for SA and 15 (12%) for combined infections. A total of 269 radiographs were obtained following discharge. 61 (47%) patients had one follow-up radiograph, 32 (25%) had two, 16 (12%) had three and 21 (16%) had four or more. Of those obtained, 242 (90%) were routine, resulting in the detection of three (1%) negative sequelae and a resultant NNS of 81 (95% CI: 27-250). The remaining 27 were reactive radiographs, resulting in the detection of three (11%) negative sequelae with a NNS of 9 (95% CI: 3-28).

Conclusions: While radiographs remain a widely utilized tool to monitor response to treatment in osteoarticular infections, they rarely alter management in the absence of other signs or symptoms of negative sequelae while significantly increasing radiation burden in this pediatric population. In addition, all patients with radiographically-detected negative sequelae had signs and/or symptoms consistent with an altered course, negating the need for routine radiographic surveillance.

Significance: Treating orthopaedic surgeons are encouraged to shift from a routine to a reactive radiographic protocol following osteoarticular pediatric infections.

The Use of Biomarkers in Early Diagnosis of Septic Arthritis and Osteomyelitis

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LOE-Diagnostic-Level II

Purpose: The diagnosis of septic arthritis (SA) and osteomyelitis (OM) has remained challenging in the pediatric population, oftentimes delaying early diagnosis and requiring invasive interventions. The purpose of this pilot study was to identify a novel panel of biomarkers that can accurately diagnose SA and OM at initial presentation using serum alone.

Methods: 20 patients < 18 years old and whose working diagnosis included SA (n=10) and OM (n=10), were identified. Serum was collected at initial evaluation. Diagnosis was based on laboratory tests and clinical outcomes. Each sample underwent seven ELISA (C1-C2, COMP, CS-846, hyaluronan, procalcitonin, PIIANP, CTX-II) and 65-plex cytokine panels. Lasso regression analysis was performed to identify a limited set of predictive biomarkers.

Results: Average age of SA patients was 4.7 years (0-10); 80% were male and 20% female. Average age of OM patients was 9.5 years (0-15); 50% were female and 50% male. 50% of SA patients presented within 24 hours of symptom onset, compared to 0% of OM patients (p=0.033). However, despite presenting earlier, 30% of SA patients were discharged home with an incorrect diagnosis and re-presented to the ED days later. At time of presentation: temperature $\geq 38.5F$ was present in 10% of SA and 40% of OM patients (p=0.12), mean ESR (mm/hr) was 51.6 in SA and 44.9 in OM patients (p=0.63), mean CRP (mg/dl) was 55.8 in SA and 71.8 in OM patients (p=0.53), and mean WBC (K/mm³) was 12.5 in SA and 10.4 in OM patients (p=0.34). 90% of SA patients presented with 2 or less of the Kocher criteria, with 100% of SA and 40% of OM patients undergoing surgery. 70% of SA cultures were culture negative, 10% MSSA, 10% Kingella, and 10% Strep pyogenes. This was compared to 40% of OM cultures that were culture negative, 50% MSSA, and 10% MRSA. 6 biomarkers (CTX-II, TGF- α , IL-3, IL-8, TPO, and TRAIL) were identified that were able to classify 19 out of the 20 cases correctly (100% OM, 90% of SA) with a sensitivity and specificity of 90% [Figure 1].

Conclusions: This study identified a panel of novel biomarkers that can differentiate between SA and OM at initial presentation with a sensitivity and specificity of 90%. Further study is needed to evaluate the applicability of these biomarkers in the work-up of musculoskeletal infections.

Significance: A novel panel of 6 biomarkers were identified that can differentiate between septic arthritis and osteomyelitis at initial presentation using serum alone.

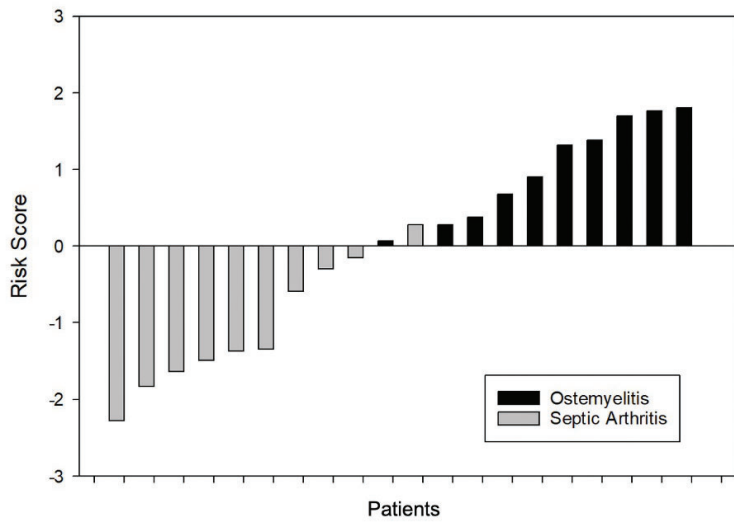


Figure 1: 19 of 20 cases correctly classified (100% OM, 90% SA) with a specificity and sensitivity of 90%, using the following 6 biomarkers – CTx-II, TFG-a, IL-3, IL-8, TPO, TRAIL.

Outcome of Surgical Excision in Patients with Fibro-Adipose Vascular Anomaly

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LOE-Therapeutic-Level IV

Purpose: Fibro-Adipose Vascular Anomaly (FAVA) is a recently-defined subtype of vascular anomaly that usually presents in childhood. Management of this condition is challenging and requires a multi-disciplinary team approach. There is no established therapy or treatment paradigm. We report on outcomes of FAVA patients treated by Orthopaedic surgical excision at our institution.

Methods: All patients with known FAVA that underwent surgical excision by our department were retrospectively reviewed. Between 2003 and 2019, 79 patients had a confirmed diagnosis of FAVA based on clinical, radiological, and histological criteria and were for the analysis utilizing a combination of medical records, radiologic findings, and telemedicine reviews.

Results: Mean age at presentation was 12 years. Females form the majority of patients (68%). Average years between presentation and surgery was 4.9 years. The most common location of lesion was in the thigh (36.1%), followed by the calf (33.3%). The most common involved muscle was the quadriceps (33.3%), followed by the gastrocnemius (27.8%). There were significant improvements in pain outcomes following surgery (Table 1). Sixty-four of 72 patients (88.9%) reported improvement in pain following surgery. Thirty-three (45.8%) patients reported some form of persistent pain at latest follow-up. Twenty-one patients (29.2%) had symptomatic residual disease or recurrence of FAVA requiring further intervention. Nine patients (12.5%) required further surgery and eight patients (11.1%) required further interventional radiology procedures. Four patients (5.6%) required eventual amputations for intractable pain and loss of function. Lesions involving multiple compartments are associated with symptomatic residual or recurrent disease requiring further intervention ($p=0.02$). Older age at time of surgery was associated with presence of persistent pain ($p=0.033$). Lesions with direct nerve involvement were associated with presence of persistent pain ($p=0.02$) and neuropathic symptoms at latest follow-up ($p=0.04$) as well as symptomatic residual disease and/or recurrence requiring further treatment ($p=0.001$). Forty-two patients (58.3%) had preoperative joint contractures, of which 39 of these (92.9%) had sustained improvement at latest follow-up. Size of FAVA lesion was not associated with intraoperative bleeding requiring transfusion ($p=0.74$).

Conclusions: Surgical excision of FAVA results in improvement in symptoms for the majority of patients. However, symptomatic residual disease and/or recurrence are not uncommon. Diffuse lesions and direct nerve involvement are associated with a worse outcome.

Significance: Traditionally, vascular malformations have been managed with non-surgical modalities and interventional radiological procedures. Our findings suggest that in carefully selected patients, surgery is a useful management option that can reliably lead to sustained improvements in pain and joint contracture.

Table 1. Pain Outcomes Following Surgery

Parameters	n (%)		p-value
	Before Surgery (n=72)	After Surgery (n=72)	
Pain at rest	48 (66.7)	16 (22.2)	<0.001
Pain with activity	71 (98.6)	38 (52.8)	<0.001
NSAID requirement	55 (76.4)	19 (24.4)	<0.001
Narcotic requirement	15 (20.8)	5 (6.9)	0.03
10-point pain score (mean \pm SD)	5.2 \pm 2.6	1.5 (2.5)	<0.001
Reported improvement in overall pain with surgery		64 (88.9)	

Spinal Involvement and Vertebral Deformity in patients with Chronic Recurrent Multifocal Osteomyelitis

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LOE-Prognostic-Level III

Purpose: Chronic Recurrent Multifocal Osteomyelitis (CRMO) is an inflammatory disorder of bone, typically arising adjacent to the physes of long bones but also seen throughout the skeleton. For patients with involvement of the spine, CRMO lesions can cause compression deformities with a range of severity from minimal anterior wedging to circumferential height loss known as vertebra plana. This study aims to examine a large cohort of CRMO patients to determine the prevalence of spine involvement and any associated deformity.

Methods: This is a retrospective review of all patients with a diagnosis of CRMO seen at our institution between January 2003 and September 2020. These patients were identified through a prospectively maintained database of all CRMO patients seen at the institution. A retrospective review was then undertaken to identify all patients with spinal involvement and determine the prevalence of CRMO in the spine and its effects on vertebral height and deformity.

Results: Of the 198 patients diagnosed with CRMO at our institution, 53 (26.8%) were found to have spinal involvement. Among the patients with spinal involvement, vertebral body lesions were identified in 32 of these 53 patients (60.4%). The remaining lesions were located in the sacrum or posterior elements. Radiographic evidence of the vertebral body deformity was noted in 27 of these 32 patients.

Conclusions: This large cohort of CRMO patients demonstrates that a significant portion have spinal involvement. Furthermore, approximately 84% of the patients with vertebral body involvement have some degree of deformity.

Significance: While the ideal treatment modality for spinal CRMO and its resultant deformity has yet to be determined, imaging studies, including Whole Body MRI, spine-specific MRI, and spine radiographs are useful in identifying vertebral lesions and early spinal deformity. This study demonstrates that 26.8% of patients diagnosed with CRMO have spinal involvement. As the disorder becomes more commonly recognized and diagnosed, the need for spinal surveillance has increased. Identification and monitoring of these lesions is important as the disease has a relapsing and remitting course with a highly variable progression to significant deformity. Delayed detection may lead to greater deformity and worse outcomes.



Surgical Technique: Medial Pinning in Pediatric Supracondylar Humerus Fractures via the Mini-Open Technique—Safer Than We Thought?

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LOE-Therapeutic-Level IV

Purpose: Displaced pediatric supracondylar humerus fractures (SCHFs) are most commonly stabilized after reduction by percutaneous pinning. Although SCHF's are often biomechanically stable after lateral-only entry pinning (lateral pinning), some argue that the addition of a medial entry pin (cross pinning) confers superior stabilization and many surgeons continue to use it. One of the most consistent arguments against medial entry pinning is the risk of iatrogenic ulnar nerve injury. The true risk of iatrogenic ulnar nerve injury is difficult to discern, as many small cohort studies use different surgical techniques and vary widely in their reported rates of injury. This study aimed to use a large, single-center, single-technique (mini-open) retrospective case series to better determine the rate of iatrogenic ulnar nerve injury as well as describe the technique used.

Methods: Retrospective review all patients undergoing percutaneous pinning for SCHFs was used to identify patients who underwent cross pinning between 2007 and 2017 at a large tertiary pediatric hospital. All patients undergoing cross pinning had the medial pin placed via the mini-open technique. Retrospective chart review was completed to record injury characteristics, operative variables, fixation strategy, long-term follow up on complications such as iatrogenic ulnar nerve injury. Intraoperative images and cadaveric dissection images were taken to better illustrate the described technique.

Results: A total of 698 patients were identified that underwent cross pinning during the study period. Iatrogenic ulnar nerve injury was reported in 3 cases (0.43%). In 2 out of the 3 cases of iatrogenic nerve injury, the ulnar nerve symptoms resolved at mean follow up of 17 weeks.

Conclusions: Here, in the largest single-center study of cross pinning for SCHFs, the iatrogenic ulnar nerve injury rate of 0.43% was nearly 10x lower than generally accepted rate. Only one patient in this study had ulnar nerve deficits as a result of iatrogenic injury at last follow up.

Significance: Previous studies have not adequately accounted for variation in technique when reporting rates of iatrogenic ulnar nerve injury in cross pinning of pediatric SCHFs. Estimates of the true rate draw on many studies in which a closed approach was used. This large case series suggests that cross pinning via the mini-open technique can be used safely by the experienced surgeon when needed.

Intraoperative Internal Rotation Stress Test in Displaced Pediatric Supracondylar Humerus Fractures Improves Outcomes

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LOE-Diagnostic-Level III

Purpose: Stabilization of the medial column is vital in preventing loss of fixation and malunion in displaced pediatric supracondylar humerus fractures (SCHFs). The preferred percutaneous pin configuration for medial column fixation remains controversial between medial pinning (cross pinning) and additional lateral-based pinning. The use of an intraoperative internal rotation stress test (IRST) to objectively evaluate adequacy of fixation has been proposed as a more reliable means to determine the optimal fixation strategy for each unique fracture. This study aimed to evaluate the effectiveness of implementing the IRST at reducing institution-wide complications in pediatric patients treated operatively for SCHFs. For patients in whom the IRST indicated instability, and thus the need for additional fixation, this study also compared outcomes between pin configurations.

Methods: Pediatric patients undergoing percutaneous pinning for SCHFs between 2007 and 2017 at a single center were retrospectively reviewed. The IRST was made a universal institutional practice during 2013. Patients were divided into two groups for analysis: 1) pre-2013 patients (non-IRST) and 2) post-2013 patients (IRST). Pin configuration was determined by intraoperative surgeon decision with or without the IRST. Subgroup analysis was completed for IRST patients who needed additional fixation in the form of either 1) cross pinning or 2) three lateral-based pins. Multiple Fischer Exact Tests were applied to compare initial injury characteristics and outcomes between groups.

Results: 820 non-IRST and 636 IRST patients were included. After IRST implementation, the rate of loss of fixation ($p=0.003$) and reoperation ($p<0.001$) decreased significantly. No cases resulted in loss of fixation after adoption of the IRST. Complication rates between cross pinning and 3 lateral-based pins were not significantly ($p>0.05$) different in patients with an initially unstable IRSTs.

Conclusions: This large retrospective cohort analysis demonstrates significant improvement in outcomes after institution-wide implementation of the IRST for treating pediatric SCHFs. Furthermore, there does not appear to be a significant difference in outcomes between the use of a 3rd lateral pin and cross pinning when the IRST indicates need for additional fixation.

Significance: As one of the most common pediatric orthopedic trauma injuries, reducing complications in displaced pediatric SCHFs is a priority of pediatric orthopedists. The IRST is a free and simple maneuver that is proven to be associated with fewer complications like loss of fixation in this study. Our results suggest that a change in practice that includes use of the intraoperative IRST as the standard of care in operative pediatric SCHFs could improve outcomes.

Table 1. Non-IRST versus IRST Complications

Total Cases	Non-IRST		IRST		P-Value
	820		636		
	n	(%)	n	(%)	
Compartment Syndrome	3	0.4	0	0.0	0.262
Loss of Fixation	10	1.2	0	0.0	*0.003
Avascular Necrosis	1	0.1	1	0.2	0.999
Malunion	0	0.0	0	0.0	-
Pin Tract Infection	20	2.4	8	1.3	1251
Deep Infection	5	0.6	3	0.5	0.999
All-Cause Reoperation	27	3.3	1	0.2	***<0.001
Vokmann's Contracture	0	0.0	0	0.0	-

*, $p<0.05$, ***, $p<0.001$

Functional Outcomes of Operative vs Non operative Treatment of Displaced Proximal Humerus Fractures in Adolescents: Early Results from a Multicenter Prospective Study

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LOE-Therapeutic-Level II

Purpose: Displaced proximal humerus fractures are uncommon injuries in the pediatric population. These fractures are treated non-operatively in young children due to great remodeling potential. The remodeling potential of significantly displaced proximal humerus fractures in adolescents are not well understood and the optimal treatment of these fractures is controversial. We prospectively studied functional outcomes of these patients treated operatively and non-operatively at six major level 1 trauma centers using general upper extremity and shoulder-specific outcome measures.

Methods: Adolescents 11-16 years of age with displaced proximal humerus fractures (>30 degrees of angulation or 50% displacement on AP or Lateral shoulder radiographs) treated at six level 1 pediatric trauma centers were enrolled in the study. Type of treatment was chosen by the treating physician. Patient Reported Outcome Measurement Instrument (PROMIS) upper extremity and pain scores, qDASH, Shoulder Pain and Disability Index (SPADI) scores were measured at 3 and 6 months post-injury. Descriptive statistics were used to report mean and SD for continuous variables and frequencies of categorical variables. Independent t-test was used to compare outcome scores between operatively treated and non-operatively treated groups. Alpha level was set at 0.05.

Results: 44 patients (average 12.7 years) have enrolled so far in this prospective study. 25 were male (56%) and 20 patients (45%) were treated operatively. 29 fractures were at the metaphysis and 15 were at the physal level. The group treated operatively was older (mean age 13.7 vs. 12.6, $p=0.03$). The maximum angulation and translation on radiographs were similar between groups. Functional outcomes at 3 months was available for 23 patients (12 operative). At 3 months after injury, PROMIS pain scores (38.2 non-op group vs. 37.6 operative group), PROMIS upper extremity scores (52.8 non-op vs 51 operative), qDASH (5.6 non-op vs. 6.4 operative), and SPADI scores (3.7 non-op vs. 1 operative) were not significantly different between groups. 6 months data is available for 8 patients (4 operative) with no significant difference in PROMIS (pain and upper extremity), qDASH, or SPADI scores between groups ($p>0.05$).

Conclusions: We report early findings of the only prospective multicenter study of displaced proximal humerus fractures in adolescents. Both operatively and non-operatively treated patients report excellent functional outcomes at 3 and 6 months after injury. Non-operative treatment of these injuries can result in similar functional outcomes as operative treatment.

Significance: Early findings in the only prospective multicenter study of displaced proximal humerus fractures in adolescents provide support for non-operative treatment of these injuries.

Operative Versus Non-operative Treatment of Z-Type Comminuted Clavicle Fractures in Adolescents: A Substratified Cohort Analysis

Coleen S. Sabatini MD; Eric W. Edmonds MD; Elizabeth Liotta; Katelyn Hergott; Donald S. Bae MD; Michael T. Busch MD; Henry Bone Ellis MD; Mininder S. Kocher MD; G Ying Li MD; Jeffrey Jerome Nepple MD; Nirav Kiritkumar Pandya MD; Andrew Pennock MD; Crystal Perkins MD; David D. Spence MD; David Williams PhD; Samuel Clifton Willimon MD; Philip Wilson MD; Benton E. Heyworth MD; FACTS Children's Hospital Boston, Boston, MA

LOE-Therapeutic-Level II

Purpose: There has been a recent shift towards operative management of mid-shaft clavicle fractures in adults and adolescents. This has been largely based on studies in the adult population that showed reduced rates of non-union, symptomatic mal-union and better short-term functional outcomes. For injuries with a comminuted “Z-type” fracture pattern, characterized by vertical positioning of a segmental fragment, it is commonly accepted to treat surgically due to concerns about healing and bony prominence. The purpose of this study was to assess the clinical, radiographic, and patient-reported outcome measures (PROs) in adolescents with comminuted Z-type mid-shaft clavicle fractures, by comparing an operative and non-operative cohort.

Methods: Patients aged 10 to 18 years treated for a diaphyseal clavicle fracture between August 2013 and February 2016 at 1 of 8 geographically diverse pediatric centers were screened and enrolled at the time of injury. Inclusion criteria were a comminuted Z-type fragment ≥ 1 cm in size, with >35 degrees of angulation relative to the long axis of the clavicle, and $>100\%$ fracture displacement at time of presentation. Clinical course, complications, validated PROs, quality of life metrics, and satisfaction scores were analyzed and compared between the operative (Op) and non-operative (NonOp) cohorts.

Results: 82 patients (37 NonOp, 45 Op) were included, 60 (73%) of whom provided two-year PROs, with similar response rates between treatment cohorts. There were no significant differences in demographics or fracture characteristics in the two cohorts, other than fracture shortening being greater in the operative cohort (mean 29mm) compared to the non-operative cohort (mean 23mm, $p=0.01$). This confounder was controlled for in both regression analysis and propensity score matching. There was no statistically significant difference in the rates of non-union (none), delayed union (Op 2%, NonOp 0%, $p=1.0$), symptomatic malunion (Op 0%, NonOp 3%, $p=0.4$), refracture (Op 4%, NonOp 3%, $p=1.0$), unexpected surgery (Op 11% vs. NonOp 5%, $p=0.45$), or clinically significant complications (Op 16%, NonOp 5%, $p=0.17$) between cohorts. There were no differences in PROs (Table 1), even when controlling for fracture shortening.

Conclusions: Z-type mid-shaft clavicle fractures are one of the most severe fracture patterns seen in adolescent shoulders. Yet, in this comparative investigation of two-year PROs and complications, surgery appears to offer no benefit over non-operative management.

Significance: The comparable natural histories between this study's operative and non-operative cohorts are critical for surgeons and their adolescent patients to understand when deciding appropriate management, particularly when reviewing what are often very concerning appearing initial radiographs.



TABLE 1. Two-Year Patient Reported Outcomes (PROs), by Treatment Group			
Patient Reported Outcome Instrument	Non-Operative (n=26)	Operative (n= 34)	p-value ¹
ASES			
Mean Score (SD)	99.0 (4.8)	97.0 (8.1)	1.00
Patients (%) with Score <90 [†]	1 (4.2%)	2 (5.7%)	
QuickDASH			
Mean (SD)	0.4 (1.8)	2.2 (4.6)	0.50
Patients (%) with Score >10 [†]	0 (0.0%)	2 (5.9%)	
EQ-VAS			
Mean (SD)	94.5 (5.6)	92.6 (7.4)	0.50
Patients (%) with Score <80 [†]	0 (0.0%)	2 (5.9%)	
EQ-5D Score			
Mean (SD)	0.98 (0.1)	0.95 (0.1)	1.00
Patients (%) with Score <0.80 [†]	1 (3.8%)	1 (2.9%)	
General Satisfaction			
Mean (SD)	1.5 (0.8)	1.4 (0.7)	0.39
Patients (%) with Score >2 [†]	4 (15.4%)	2 (5.9%)	
Marx Shoulder Activity			
Mean (SD)	11.8 (5.5)	12.9 (5.8)	0.53
Patients (%) with Score ≤7 [†]	4 (10.9%)	8 (17.8%)	

[†] p-values represent outcomes for bifurcated PRO scores only, e.g. "Patients (%) with score..."

[\[...\]](#)

Comparative Effectiveness of Non-operative Versus Operative Treatment for Completely Displaced Clavicle Shaft Fractures in Children

Charles T. Mehlman DO; Shital N. Parikh MD
Cincinnati Children's Hospital Medical Center, Cincinnati, OH

LOE-Therapeutic-Level III

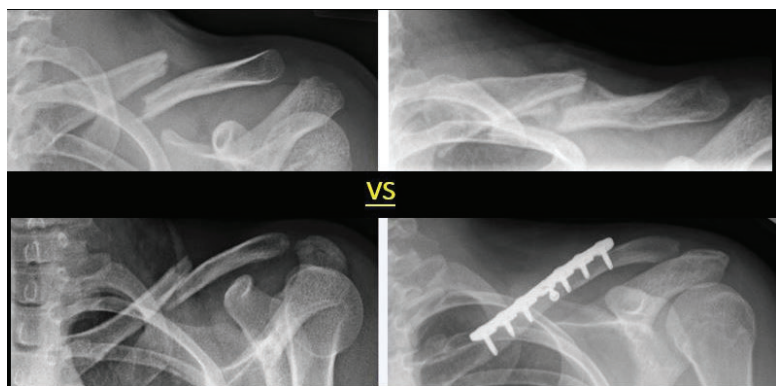
Purpose: Our aim was to compare the outcomes among children treated non-operatively versus operatively for completely displaced clavicle fractures

Methods: A retrospective cohort study of 110 pediatric patients with completely displaced clavicle shaft fractures was undertaken, 55 treated non-operatively and 55 treated operatively (plate and screws). Outcome measures included time to return to activities, complications, and QuickDASH scores. Data was collected via chart review and telemedicine follow-up. Regarding statistical analysis Fisher's exact test was used for categorical variables and Student's two-tailed t-test for continuous variables.

Results: The non-operative group had an average age of 11.6 years (range 8-14 yrs) while the operative group average was 14.3 years (range 9-17 yrs). No significant difference ($p=0.941$) between the groups was identified regarding average time to return to full unrestricted activities (90.4 days for non-operative group and 89.7 days for operative group). Significant ($p=0.031$) differences in refracture rate were detected, 22% (12/55) non-operative patients vs 7% (4/55) operative group. There was a 27% rate (15/55) of plate and screw removal in the operative group. A subset of each group provided QuickDASH data and no significant differences ($p=0.329$) were noted, 77% (17/22) non-operative patients reported no disability vs 88% (22/25) operative group.

Conclusions: Prior comparative studies in this age group have documented a faster return to unrestricted activities. Our study did NOT confirm this. We also found a surprisingly high 22% re-fracture rate in the non-operative group and an annoyingly high 27% rate of plate & screw removal in the operative group.

Significance: These data can help aid in the shared-decision making process with patients and families when deciding on treatment of displaced pediatric clavicle fractures.



Changes in Superior Displacement, Angulation, and Shortening in the Early Phase of Healing for Completely Displaced Midshaft Clavicle Fractures in Adolescents: Results from a Prospective, Multicenter Study

*Jeffrey Jerome Nepple MD; Andrew Pennock MD; Benton E. Heyworth MD; Tracey P. Bastrom MA; Donald S. Bae MD; Michael T. Busch MD; Eric W. Edmonds MD; Henry Bone Ellis MD; Mininder S. Kocher MD; G Ying Li MD; Elizabeth Savika Liotta; Nirav Kiritkumar Pandya MD; Crystal Perkins MD; Coleen S. Sabatini MD; David D. Spence MD; Samuel Clifton Willimon MD; David Williams PhD; Philip Wilson MD; Function after Adolescent Clavicle Trauma and Surgery [FACTS]
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LOE-Not Applicable-Level IV

Purpose: Progressive displacement of diaphyseal clavicle fractures has been observed in adult patients, at times necessitating a change from non-operative to operative treatment. Whether this occurs in adolescent patients has not been well investigated. The purpose of this study was to assess the rate and extent of progressive clavicle fracture displacement in adolescent patients following injury and during the early stages of healing.

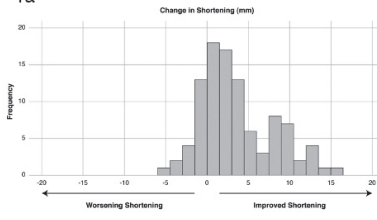
Methods: This was an IRB approved multi-center study evaluating prospective data that had previously been collected as part of a larger study evaluating the functional outcomes of adolescent clavicle fractures. A consecutive series of completely displaced diaphyseal clavicle fractures in patients age 10-18 years treated at one of three tertiary care pediatric trauma centers were included; all of which had standardized imaging within 2 weeks of the date of injury and throughout the course of healing (5-20 weeks post-injury). Measurements of clavicle shortening, superior displacement, and angulation were performed using validated techniques. Progressive displacement and/or interval improvement in fracture alignment were noted, as well as the subsequent need for surgical intervention. Patient demographic and radiographic parameters were assessed as possible risk factors for interval displacement.

Results: One hundred patients met the inclusion criteria. The mean shortening, superior displacement, and angulation at the time of injury were 24 mm, 15 mm, and 7°, respectively. At a mean of 10 weeks post-injury, the fracture alignment improved across all three measurements for the overall cohort, with mean improvements in shortening of 15%, superior displacement of 15%, and angulation of 21% (Figure 1) Using a clinical threshold of a change in shortening or displacement of 10 mm or angulation of 10 degrees, 21% of fractures improved, 4% worsened, and 75% remain unchanged. Patients with more severe fractures were more likely to have improved alignment than less displaced fractures ($p < 0.001$). No patient underwent surgical intervention for progressive displacement.

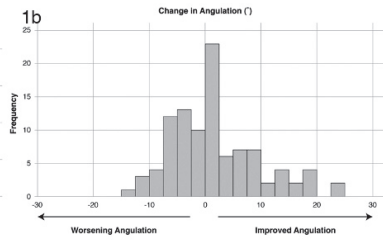
Conclusions: Significant early improvements in fracture alignment were observed in a substantial percentage of adolescent patients with completely displaced clavicle fractures. Among the most severely displaced fractures, a 20% improvement in shortening and 50% improvement in angulation was identified. In 4% of cases, increased displacement was observed, but this tended to be mild, and in no cases did it prompt surgical intervention.

Significance: Fracture settling during the early phases of healing in adolescents may lead to a final clavicle deformity that is less pronounced than that present at the time of injury.

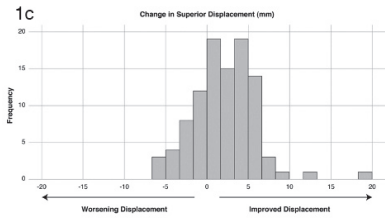
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1b



1c



Management of Syndesmotic Injuries in Children and Adolescents: Results of a Cross-Sectional Survey

Caroline Williams; Benjamin J. Shore MD; Nicholas Sullivan; Blair Stewig; Dennis Kramer MD; Yi-Meng Yen MD; Collin May MD; CORTICES Study Group
Boston Children's Hospital, Boston, MA

LOE-Therapeutic-Level IV

Purpose: Although literature on operative adult syndesmotic injury management has shown improved outcomes of suture-button over screw fixation, this has yet to be characterized in pediatric populations. The aims of this study were to evaluate trends in syndesmotic injury management and identify factors influencing surgeon choice of implant for pediatric and adolescent syndesmotic injuries.

Methods: Retrospective chart review to collect demographic, operative (including implant used) and outcome data was completed for all pediatric patients undergoing syndesmosis fixation using either screw or suture-button implant at our institution between 2003-2019. An electronic questionnaire regarding surgeon demographics and implant preferences was nationally distributed to 30 fellowship-trained pediatric orthopedic surgeons. We analyzed responses to determine surgeons' preferences at different time-points throughout their careers as well as factors influencing these preferences.

Results: Retrospective Chart Review: Between 2003 and 2019, 27 pediatric orthopaedic surgeons meeting inclusion criteria performed 184 pediatric syndesmosis fixations using either screw (n=140, 76.1%) or suture-button (n=44, 23.9%) implants. Per-year analysis showed increased use of suture-button following its introduction to the market in 2008 with a corresponding decreased use of screws (FIGURE 1). Those cases utilizing a screw implant required secondary surgery in 118/140 cases (84.3%) compared to 15/44 cases (34.1%) utilizing suture-button, equating to a 2.47-fold increased risk of secondary surgery. Survey: Suture button preference was reported in 70% (n=21) of survey respondents, with half (n=15) reporting a preference change from screw to suture-button since the start of practice. Respondents cited avoidance of secondary surgery (n=13, 86.7%), extrapolation from adult outcomes (n=11, 73.3%), comfort with procedure (n=4, 26.7%), improved biomechanics (n=3, 20.0%) and anecdotal data (n=1, 6.7%) as primary influences on implant preference.

Conclusions: Implant selection for pediatric syndesmotic injuries is currently variable. Our objective and surgeon-reported data suggest a shift from screw to suture-button fixation in pediatric populations, with avoidance of a secondary operation and extrapolation from adult outcomes as likely primary motivators.

Significance: The data from our study highlights the importance of larger comparative studies of pediatric patients treated with suture-button versus screw implants in order to establish standard of care for these injuries.

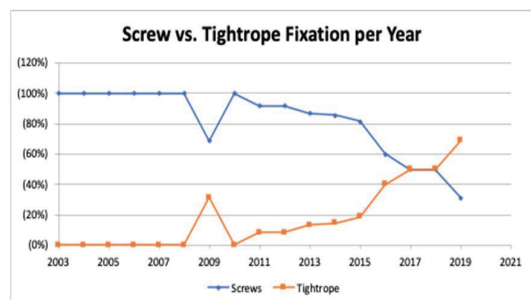


Figure 1. Retrospective chart review of 184 cases of operative syndesmosis repair since 2003 at the senior authors' affiliated Pediatric Hospital, showing percentage contribution of screw and suture-button fixation to total operative cases per year.

Suture-button versus Screw Fixation of the Tibiofibular Syndesmosis in Adolescent Ankle Injuries

Benjamin Lurie; Conner Paez; Shayna Howitt; **Andrew Pennock MD**
Rady Children's Hospital, San Diego, San Diego, California

LOE-Therapeutic-Level IV

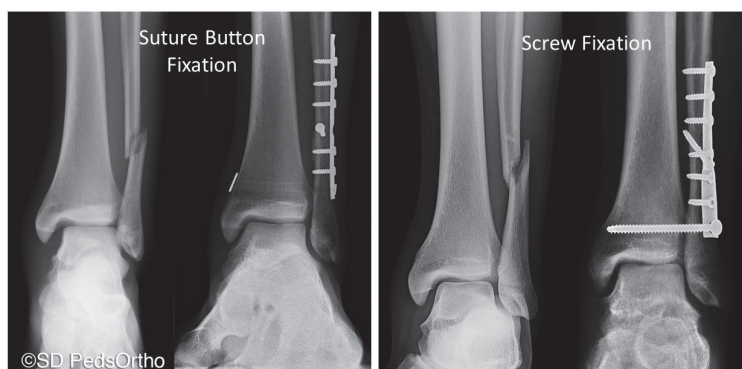
Purpose: Fixation of the tibiofibular syndesmosis is often performed with a trans-syndesmotic screw or suture-button. Suture-button fixation has reportedly lower rates of syndesmotic malreduction and implant removal, though some studies document increased complications due to infection and implant subsidence. The purpose of this study was to compare maintenance of reduction, complications, implant removal and functional outcomes of suture-button versus syndesmotic screw fixation in adolescents.

Methods: A retrospective chart review identified patients who underwent syndesmotic fixation from 2010-2019 at a single institution. Loss of syndesmotic reduction (diastasis) was defined as either a >2 mm increase in tibiofibular clear space or >2 mm decrease in tibiofibular overlap, and corresponding incongruence of the ankle mortise (medial clear space 1 millimeter greater than superior clear space). Functional outcomes were collected at a minimum of 1 year post surgery using the Foot and Ankle Ability Measure (FAAM).

Results: Seventy-seven adolescents (45 syndesmotic screw, 32 suture-button) were included (mean age: 16±1.5 years). (Figure 1) Forty-five patients had Weber C fibula fractures, 27 Weber B fractures, and 5 had isolated syndesmotic injuries or small posterior malleolus fractures only. Fifty-one patients (66%) had functional outcomes available. There was no significant difference in mean FAAM Sports score between the two groups (Suture-button=94.8%, Screw=89.8%) at mean follow-up of 4.0±2.1 years. Syndesmotic implant removal occurred in 36/45 patients (80%) in the screw group compared to 4/32 patients (13%) in the suture-button group (p<0.001). There was one case of syndesmotic diastasis requiring revision surgery in the screw group, and no cases in the suture-button group, including in 9 patients weighing over 100 kilograms. There were 4 superficial infections and 1 deep infection in the screw group, with 1 superficial infection in the suture-button group.

Conclusions: While both suture-button and screw fixation maintained syndesmotic reduction, suture-button fixation led to significantly lower rates of implant removal surgery. Suture-button fixation prevented recurrent diastasis in adolescents weighing over 100 kilograms, and functional outcomes were at least equivalent to screw-fixation at a mean follow-up of 4.0 years.

Significance: Suture button fixation has increasingly become our institution's preferred fixation device for adolescent syndesmosis injuries requiring surgery because of its durable clinical outcomes, low complication rates, and its low likelihood to require subsequent surgery.



Incidence and Risk Factors for Acute Compartment Syndrome in Pediatric Tibia Fractures

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LOE-Therapeutic-Level IV

Purpose: Acute compartment syndrome (ACS) is a rare complication of traumatic injuries in children. Tibia fractures are the most common cause of ACS in the pediatric population and high-risk patients need to be closely monitored for this complication. The goal of this study is to determine the incidence and risk factors of developing ACS in a large cohort of children with tibia fractures.

Methods: Maryland, New York, Vermont, and Wisconsin State Inpatient Databases, State Emergency Department Databases, and State Ambulatory Surgery and Services Databases (SID/SEDD/SASD) from the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality, were used to retrospectively identify patients 1-18 years of age with tibia fractures. The HCUP Nationwide Emergency Department Sample (NEDS) for nationwide data was also queried. Multivariable generalized estimating equations models were used to determine risk factors associated with development of compartment syndrome in all tibia fractures, and among open tibia fractures specifically.

Results: 50,640 patients with tibia fractures were studied and 309 cases of compartment syndrome were identified. The incidence of ACS was 0.6% and 5.5% in the all tibia and open tibia fracture groups, respectively. 23 cases of ACS (7.4% of all ACS) were not diagnosed during the first admission which were more common in teens treated nonoperatively. Predictors of increased ACS risk in the all tibia fracture group included age 13-18 (RR: 4.04, CI 3.03-5.38), open fractures (RR: 3.83, CI: 2.88-5.08), and MVC mechanism (RR: 5.69, CI: 3.82-8.49). Nationwide, open and operatively treated fractures had an increased ACS rate (3.98% and 5.51%, respectively).

Conclusions: Teenagers (age ≥ 13), open fractures and MVC (high energy) mechanism were most strongly associated with ACS in children with tibial fractures. ACS can present in a delayed fashion, as evidenced by post-index cases.

Significance: This study defines the incidence and risk factors of developing ACS in a large cohort of children with tibia fractures, the most common type of fracture associated with ACS. This can inform medical decision making and may help prevent the devastating effects of this complication by allowing the clinician to be aware of patient at elevated risk for developing ACS.

Clinical Scaphoid Fractures in Children: A prospective radiological study

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LOE-Diagnostic-Level II

Purpose: The term “clinical scaphoid” is often used to refer to an injury that is clinically suspicious for a scaphoid fracture, despite negative radiographs. Plain radiographs have low sensitivity in detecting acute scaphoid fractures in children. The clinical scaphoid is a clinical conundrum for physicians as the optimal management of these injuries in children is still unknown. Recent studies in adults have demonstrated that early CT or MRI for scaphoid injury reduces the incidence of ‘missed’ fractures, and prevents unnecessary immobilization and medical visits. No such evidence exists for children, and optimal clinical management is unknown. We prospectively evaluated the role and results of advanced imaging in children presenting to a fracture clinic with a clinical scaphoid and negative radiographic imaging.

Methods: A prospective cohort study was performed over a four month time period at a tertiary care pediatric centre. Patients presenting with findings consistent with a clinical scaphoid fracture, and two sets of normal x-rays, were eligible. All patients underwent CT and MRI. The primary outcome measured was fracture incidence on CT and MRI. Secondary outcomes included indirect costs incurred by the patient and caretakers, as well as functional outcomes and quality of life measures. Indirect costs were recorded via patient diary.

Results: Twenty-five patients were recruited between May and September 2019; 9 patients (36%) were diagnosed with a scaphoid fracture, 7 patients (28%) were found to have a confirmed scaphoid fracture on CT, and 7 patients (28%) were found to have a scaphoid fracture on MRI. An additional two cases were considered equivocal on CT and 6 cases equivocal on MRI. Only five of the nine confirmed scaphoid fractures were seen on both CT and MRI. The diagnostic concordance between CT and MRI was 16 of 25 cases (64%).

Conclusions: A fracture incidence of 36% is significantly higher than previously reported in children with clinical scaphoid injury and serially negative radiographs, which presents an important problem of both injury identification but also definition of clinical importance. Optimal management of clinical scaphoids is still unknown. The discordance between CT and MRI results also requires additional investigation and the development of diagnostic standards.

Significance: There is still very little known about pediatric clinical scaphoid injuries. Advanced imaging for reveals higher fracture incidence than previously reported. Future research should help to better define the clinical importance of clinical scaphoid natural history, and optimal treatment, but advanced imaging will be important to help identify these injuries adequately

Table 1. Demographics

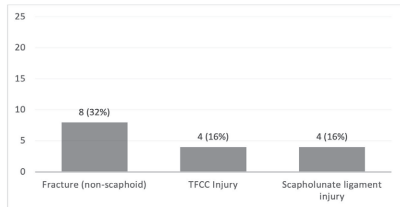
Variable	n	Value
Age (at consent), median (IQR)	25	12.51 (10.84, 14.68)
Gender, freq (%)	25	
Male		15 (60.0)
Female		10 (40.0)
Dominant hand, freq (%)	25	
Right		21 (84.0)
Left		4 (16.0)
Injured Side, freq (%)	25	
Right		12 (48.0)
Left		13 (52.0)
Mechanism of Injury, freq (%)	24	
Fall from non-motorized moving vehicle		12 (48.0)
Fall during activity (e.g. sports)		4 (16.0)
Fall from standing height		2 (8.0)
Direct impact to wrist (no fall)		2 (8.0)
Twisting injury (no fall)		1 (4.0)
Punch		1 (4.0)
FOOSH mechanism, not otherwise specified		2 (8.0)

Table 2. Concordance between CT and MRI

CT (down) / MRI (across), n (%)	YES	NO	EQUIVOCAL
Yes	5 (20.0)	0	2 (8.0)
No	1 (4.0)	11 (44.0)	4 (16.0)
Equivocal	1 (4.0)	1 (4.0)	0

Proportion Agreement (95%CI) = 0.640 (0.425, 0.820)

Graph 1. Other injuries detected on MRI



Use of well-leg traction in the treatment of displaced femoral neck fractures in the pediatric population provides a practical alternative to the peroneal post

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Children's Hospital Colorado, Aurora, Colorado*

LOE-Therapeutic-Level IV

Purpose: Displaced femoral neck fractures (FNF) in the pediatric population are clinically significant because they have high complication rates. Without the use of traction, it's difficult to gain appropriate length at the fracture site, avoid varus femoral neck positioning, and avoid retroversion at the fracture site. The use of well-leg traction on a flat radiolucent table (WLT) is a method to apply traction to the injured leg without the use of the peroneal post. This study compares the ability to restore native hip anatomy and avoid complications between WLT (n=8), a traditional fracture table with a peroneal post (PPT, n=12), and a flat radiolucent table without traction (FRT, n=9).

Methods: A total of 29 patients who were surgically treated for a FNF between 2007-2016 at the study institution were retrospectively reviewed. Pre-, intra-, and post-operative radiographs were analyzed for the injured hip and compared to the contralateral, uninjured hip for neck shaft angle (NSA) and epiphyseal tilt (ET). We defined "satisfactory reduction" as an NSA and ET within 5° of the contralateral side. Complications were also compared between groups.

Results: Patients included were 86.21% male, averaged 12.02 years of age at presentation, and weighed 47.12 kilograms at time of surgery. Satisfactory reduction was achieved in all 29 patients and 58.62% experienced at least one complication. 12.5% of patients in the WLT group experienced a late infection compared to the 33.33% from the PPT group and 22.22% from the FRT group. No patients treated with WLT experienced avascular necrosis, compared to the 16.67% for patients treated with PPT, and 44.44% in the FRT group. 16.67% of patients treated using PPT and 11.11% of patients treated with FRT experienced failure of primary fixation and underwent revision within the first 3 postoperative months. No patient in the WLT group experienced failure of fixation.

Conclusions: The use of WLT in treatment of displaced pediatric FNF is an alternative to either the PPT or FRT, as it can achieve a satisfactory reduction matching the contralateral side. WLT is useful in fixation patients who are too small for a traditional fracture table and may avoid complications associated with use of the PPT and FRT. This approach offers an equivalent direct visualization and an improved ability to visualize the lateral radiograph intraoperatively.

Significance: The use of WLT in the pediatric patient with a displaced FNF may offer a reasonable technique alternative for the smaller, younger patient over the PPT and FRT.

Traction Used	Complications				Demographics	
	Failed Primary Fixation	AVN	Total Hip	Non-Union	Average Weight (kg)	Average Age (years)
Flat Jackson (n=8)	1	2	1	1	45.79 (+/-11)	11.51 (+/-3.06)
Peroneal Post (n=14)	2	2	0	1	58.27 (+/-15.01)	13.74 (+/-2.80)
Well-Leg Traction (n=9)	0	0	0	0	35.69 (+/-17.61)	10.03 (+/-4.68)

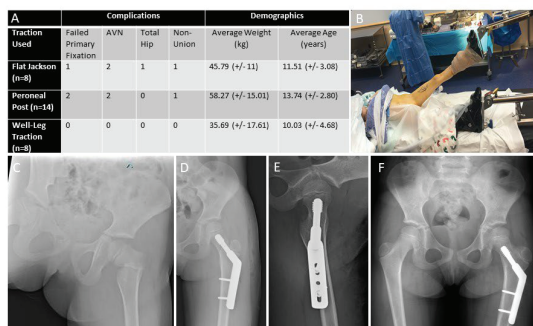


Figure 1: A) Table of complication rates and average demographics. B) Use of well-leg traction for a left displaced femoral neck fracture in a 5-year-old female patient. Patient is on a radiolucent flat top table with the uninjured leg placed in a boot with the fully extended and the foot dorsiflexed. Traction is applied to the injured leg. C) 5-year-old female with displaced femoral neck fracture. D, E) AP and lateral images of 5-year-old female following fixation with a compression hip screw and combined anterior/lateral approaches using well-leg traction. F) AP pelvis at 1-year follow-up prior to hardware removal.

Evaluation and Treatment of Pediatric Pelvic Ring Injuries

Elizabeth Davis; Shiraz A. Younas MD
McGovern Medical School, Houston, Texas

LOE-Prognostic-Level III

Purpose: A variety of systems exist to classify pelvic fractures, but most fail to be practically applied to pediatric pelvic fractures. Pediatric pelvic fractures are rare and treatment varies widely as adult treatment algorithms do not suggest the most appropriate intervention. The purpose of this study is to review the incidence, presentation, treatment, and complications of pediatric patients with pelvic ring injuries at a level I trauma center.

Methods: A retrospective chart review was conducted of all pediatric patients (17 years or less) treated at our institution between October 2013 and June 2018 with pelvic fractures. Demographic data, admission vitals and labs, treatment, associated injuries, and complications were recorded. Plain radiographs and computerized tomography (CT) with surface rendered reconstructions were reviewed to analyze fracture patterns and the triradiate cartilage.

Results: We identified 124 patients with median age of 13 years. Most common mechanisms were motor vehicle collisions, autopedestrian accidents, and fall from height. Associated injuries included lower extremity fractures, traumatic brain injury, and solid organ injury. Eighty-five (69%) were treated non-operatively; 39 (31%) received surgical intervention. Of patients treated non-operatively, 21 (21.4%) received a manipulation under anesthesia (MUA). Of patients treated operatively, 8 (21%) received closed reduction and application of an external pelvic fixation device, 25 (64%) received closed reduction and percutaneous screw fixation (CRPS), and 6 (15%) received open reduction and internal fixation (ORIF). Repeat intervention was required in 2 (5%) cases due to incongruence or loss of fixation. Overall mortality rate was 3% and was due to concomitant injuries, not from the pelvic injury.

Conclusions: Pediatric pelvic fractures can be managed non-operatively in most cases. Certain patterns predict when a MUA should be performed. When surgical intervention is warranted, CRPS and closed reduction with application of an external fixator are the most common procedures. This can be safely done with minimal complications. Mortality is low and usually due to traumatic brain injury or solid organ injury; it is not from hemorrhage after pelvic ring injury. Patients should be closely examined for musculoskeletal lower extremity injuries as they are commonly associated.

Significance: Pediatric pelvic instability should be treated with operative stabilization whether with a distraction frame or internal fixation as this improves reduction and functional outcomes with minimal complications.

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

HAND SUBSPECIALTY DAY

Period 1: 7:50 AM–9:40 AM

Chair: Joshua Abzug, MD

Co-Chair: Mary Claire Manske, MD

Co-Chair: Christine Ho, MD

Co-Chair: Julie Samora, MD

25

7:50 AM–7:54 AM

Long-Term Results for Surgically Treated Radial Polydactyly

Takehiko Takagi, MD

National Center for Child Health and Development, Tokyo, Tokyo, Japan

26

7:55 AM–7:59 AM

A practical algorithm for radial polydactyly

Chia-Hsieh Chang, MD

Chang Gung Memorial Hospital, Taoyuan city, Taiwan

27

8:00 AM–8:04 AM

Reliability of Masada Classification for forearm involvement in patients with Hereditary Multiple Osteochondromas (HMO)

Carley Vuillermin, FRACS;

Maria Canizares; Lindley Wall, MD; Suzanne Steinman, MD; Ann Van Heest

Boston Children's Hospital, Boston, MA

28

8:15 AM–8:19 AM

Outcomes of Biceps Rerouting for Forearm Supination Contractures in Brachial Plexus Birth Injury

Mary Claire Manske, MD; Cory Pham; Michelle James, MD

Shriners Hospital for Children Northern California, Sacramento, California

29

8:20 AM–8:24 AM

Why the Knife? Reasons Children and their Families Choose Surgery for Ganglion Cysts

Jennifer Ty, MD; Joshua Bram; David Falk; Benjamin Chang; Ines Lin; Faris Fazal; Apurva Shah, MD

Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

30

8:25 AM–8:29 AM



The Radiocoronoid line - a novel technique for diagnosing radiocapitellar dislocation

Kenneth Pak Leung Wong; Daniel JiaDong; Ling Hui Tay;

Nicole Lee; Arjandas Mahadev, FRCS

KK Women's and Children's Hospital, Singapore, Singapore

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

FOOT SUBSPECIALTY DAY

Period 2: 10:18 AM – 11:52 AM

Chair: Derek Kelly, MD

Co-Chair: Maryse Bouchard, MD

Co-Chair: Joshua Hyman, MD

31

10:18 AM–10:22 AM **Pediatric Posterior Ankle Impingement- Arthroscopic Management and Outcomes: A Prospective Study**
Indranil Kushare, MD; Ramesh Ghanta; Jorge Gomez; Kristen Kastan; Tracie Stone; Sachin Allahabadi, BA; Scott McKay, MD
Texas Children's Hospital, Houston, Texas

32

10:23 AM–10:27 AM **Does the Stabilization of the Calcaneocuboid Joint With a Steinman Pin in Evans Osteotomy Procedures Affect Its Incidence of Arthritis?**
Brett Heldt; Isaiah Roepe; Elsayed Attia; Vinitha Shenava, MD; Jaclyn Hill, MD
Texas Children's Hospital, Houston, TX

33

10:28 AM–10:32 AM **A Retrospective Analysis of Nonoperative Treatment of Idiopathic Toe Walking: Outcomes and Predictors of Success**
Maryse Bouchard, MD; John Bartoletta; Elaine Tsao, MD
Seattle Children's Hospital, Seattle, WA

34

10:42 AM–10:46 AM **Talectomy for the Treatment of Rigid Non-idiopathic Clubfoot Deformity: Long-Term Follow-Up**
Jill Larson, MD
Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL

35

10:47 AM–10:51 AM **Clubfoot Activity, Recurrence & Exercise (CARES): A Pilot Study** This study investigates whether patient/parent reported outcomes (PROs) and activity levels for children with clubfoot are different in patients treated for relapse. It also proposes a method to assess outcomes remotely.
Steven Frick, MD; Ghida El-Banna; Nicole Segovia
Stanford University, Stanford, CA



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

36

10:52 AM–10:56 AM **The Atypical Clubfoot: Is it doomed from the start?**
Katherine Rosenwasser; Nickolas Nahm, MD;
John Herzenberg, MD
Sinai Hospital of Baltimore/Lifebridge Health, Baltimore, Maryland

HIP SUBSPECIALTY DAY

Period 1: 7:50 AM–9:40 AM

Chair: Rachel Goldstein, MD

Co-Chair: Scott Rosenfeld, MD

37

7:50 AM–7:54 AM **Acetabular Coverage Decreases at the End of Skeletal Growth: a 3D CT Study of Healthy Hips**
Ethan Ruh; April Krivoniak; Michael McClincy, MD
University of Pittsburgh, Pittsburgh, PA

38

7:55 AM–7:59 AM **Patients That Undergo Concomitant Hip Arthroscopy and Periacetabular Osteotomy Obtain Minimal Clinically Important Difference More Than Patients That Undergo Isolated Periacetabular Osteotomy: An analysis of 231 hips**
Anthony Essilfie; Stacy Robustelli, BS; Ernest Sink, MD
The Hospital for Special Surgery, New York, NY

39

8:00 AM–8:04 AM **Intermediate Term Results of Combined Surgical Dislocation and Periacetabular Osteotomy for Complex Perthes Deformities: Can We Save the Hip?**
Serena Freiman; Jeffrey Nepple, MD; Gail Pashos;
Perry Schoenecker, MD; John Clohisy, MD
Washington University School of Medicine, St. Louis Missouri

40

8:15 AM–8:19 AM **Analyzing Impingement Patterns and Planning Corrective Osteotomy Using Patient-specific 3-Dimensional CT Models for Collision Detection in Patients with Severe Slipped Capital Femoral Epiphysis**
Till Lerch; Florian Schmaranzer; Moritz Tannast;
Klaus Siebenrock, MD; Simon Steppacher; Daniel Maranhó, MD;
Young Kim, MD; Eduardo Novais, MD
Boston Childrens Hospital, Boston, MA

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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8:20 AM–8:24 AM

Surgical Hip Dislocation Combined with Femoral Head Osteoplasty and Intertrochanteric Osteotomy as a Delayed Reconstruction of Slipped Capital Femoral Epiphysis (SCFE)-induced femoroacetabular impingement (FAI): a 10-year Experience

*Houssam Bouloussa; Sunny Parekh; Muzaffar Ali; Landon Cluts; Michael McClincy, MD; Patrick Bosch, MD
Children's Hospital of Pittsburgh of UPMC, Pittsburgh, PA*

42

8:25 AM–8:29 AM

Capital Realignment for High Grade Slips Using Anterior Approach and Subcapital Osteotomy

*Sandeep Patwardhan, MD;
Dr. Ashok Shyam; Parag Sancheti
Sancheti Institute for Orthopaedics & Rehabilitation, Pune, India*

HIP SUBSPECIALTY DAY (CONTINUED)

Period 2: 10:18 AM – 11:58 AM

43

10:18 AM–10:22 AM

The Role of the Artery of Ligamentum Teres in Revascularization in Legg-Calve-Perthes Disease

*William Morris, MD; Angel Valencia; Molly McGuire;
Harry Kim, MD
Texas Scottish Rite Hospital for Children, Dallas, TX*

44

10:23 AM–10:27 AM

Hip morphology in early-stage LCPD: Is there an argument for anatomic-specific containment?

*Wudbhav Sankar, MD; Courtney Selberg, MD; Joshua Bram;
Patrick Carry; Rachel Goldstein, MD; Tim Schrader, MD;
Jennifer Laine, MD; Harry Kim, MD
Children's Hospital of Philadelphia, Philadelphia, PA*

45

10:28 AM–10:32 AM

Reliability and Validity of Assessment of Legg-Calve-Perthes Disease Hypoperfusion with Perfusion MRI

*David Chong, MD; Tim Schrader, MD; Jennifer Laine, MD;
Scott Yang, MD; Shawn Gilbert, MD; Harry Kim, MD
International Perthes Study Group, Dallas, TX*



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

46

10:42 AM–10:46 AM **Self-Reported Physical Function Doesn't Correlate with Pain or Functional Limitations in Adolescents Undergoing Hip Preservation Surgery**

*Wilshaw Stevens; Kirsten Tulchin-Francis, PhD;
David Podeszwa, MD
Scottish Rite for Children, Dallas, TX*

47

10:47 AM–10:51 AM **Acetabular development following treatment of developmental hip dysplasia: Does the addition of bony surgery at index procedure decrease risk of secondary surgery?**

*Ernest Sink, MD; Rachael Martino, BA; Aaron Brandt;
Patrick Carry; Courtney Selberg, MD
Children's Hospital Colorado, Aurora, Colorado*

48

10:52 AM–10:56 AM **Quasi-static MRI Motion Analysis to Study Hip Translation and Its Association with Hip Rotation and Morphology**

*Young Jo Kim, MD; Alireza Emami; Shayan Hosseinzadeh;
Eduardo Novais, MD; Ata Kiapour
Boston Children's Hospital, Boston, MA*

NEUROMUSCULAR SUBSPECIALTY DAY

Period 1: 7:50 AM – 9:40 AM

Chair: Andrew Georgiadis, MD

Co-Chair: Benjamin Shore, MD, MPH, FRCSC

Co-Chair: Lane Wimberly, MD

49

7:50 AM–7:54 AM **Severe Hip Subluxation in Non-Ambulatory Cerebral Palsy (CP): What Factors Lead to Lasting Success Of Reduction?**

*Kristen Carroll, MD; Alyssa Thorman; Whitney Moss;
Bruce MacWilliams; Matthew Talmage; Mark McMulkin;
Glen Baird, MD; Alan Stotts, MD
Shriners Hospital for Children- Salt Lake City, Salt Lake City, UT*

50

7:55 AM–7:59 AM **3-D Acetabular Morphology of the Neuromuscular Hip: Implications for Pre-operative Planning**

*Megan Severson, MD; Harsha Bandralage; James Bomar, MPH;
Christine Farnsworth, MS; Vidyadhar Upasani, MD
Rady Children's Hospital-San Diego, San Diego, CA*

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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8:00 AM–8:04 AM

Hip Pain and Scoliosis in Non-Ambulatory Children with SMA

Nickolas Nahm, MD; Rewais Hanna; Melissa Bent, MD;

Karen Patterson; Sarah Sund, BS; Mary Schroth;

Matthew Halanski, MD

University of Wisconsin, Madison, WI

52

8:15 AM–8:19 AM

Bone Deficits in Spina Bifida Accelerate During Puberty

Robert Kay, MD; Nicole Mueske; Susan Rethlefsen, PT;

Alexander Van Speybroeck; Wendy Mack;

Tishya Wren, PhD

Children's Hospital Los Angeles, Los Angeles, CA

53

8:20 AM–8:24 AM

Long and Short Term Kinematic Outcomes of Rectus Femoris Transfers in Ambulatory Children with Cerebral Palsy

Rubini Pathy, MD; Mary Gannotti; Brianna Liquori; George Gorton

Shriners Hospitals for Children, Springfield, MA

54

8:25 AM–8:29 AM

Outcomes of Patellar Tendon Imbrication for Crouch Gait

Lauren Hyer, MD; David Westberry, MD; Prabhav Saraswat; Ashley

Carpenter; Jon Davids, MD

Shriners Hospitals for Children, Greenville, SC

LOWER EXTREMITY SUBSPECIALTY DAY

Period 2: 10:18 AM – 11:58 AM

Chair: Phil McClure, MD

Co-Chair: Megan Young, MD

55

10:18 AM–10:22 AM

The Effects of Lower Extremity Rotational Malalignment on Pediatric Patient-Reported Outcomes Measurement and Information System (PROMIS) Scores

Janan Chandrananth; Richard Hannan; Daniel Bouton, MD;

Ellen Raney, MD; Jeremy Bauer, MD

Shriners Hospital for Children, Portland, OR



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

56

10:23 AM–10:27 AM **Patient reported PROMIS assessment in pediatric patients with tibial deficiency, fibular deficiency, and proximal focal femoral deficiency - A multicenter study**

*Vanna Rocchi; Nina Cung; Jeffrey Fine; Jeffrey Ackman, MD; Sarah Nossov, MD; Janet Walker, MD; David Westberry, MD; Joel Lerman, MD
Shriners Hospitals for Children Northern California, Sacramento, CA*

57

10:28 AM–10:32 AM **◆ Treatment of Congenital Pseudarthrosis of the Tibia: 2-year Minimum Followup**

*Dror Paley, MD, FRCSC; David Feldman, MD; Aaron Huser DO; Claire Shannon, MD; Michelle Coleman; Anna Hell
Paley Institute, West Palm Beach, FL*

58

10:42 AM–10:46 AM **Complications Requiring Readmission Following Lower Limb Lengthening: A 10 Year U.S. Database Study**

*Sanjeev Sabharwal, MD; Ashish Mittal; Sachin Allahabadi, MD; Rishab Jayaram; Matt Callahan
University of California, San Francisco, San Francisco, CA*

59

10:47 AM–10:51 AM **Angular Deformity before and after Temporary Epiphysiodesis for Leg Length Discrepancy**

*Katherine Antoniak; Curtis VandenBerg, MD; Oussama Abousamra, MD
Children's Hospital Los Angeles, Los Angeles, CA*

60

10:52 AM–10:56 AM **Novel Treatment for Improving Knee Range of Motion in Patients with Arthrogyposis and Severe Knee Flexion Deformity**

*David Feldman, MD; Aaron Huser, DO; Dror Paley, MD, FRCSC; Troy Rand; Michael Beck
Paley Institute, West Palm Beach, FL*

◆ 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).

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

SPINE SUBSPECIALTY DAY

Period 1: 7:50 AM – 9:40 AM

Chair: Sumeet Garg, MD

Co-Chair: Craig Eberson, MD

61

7:50 AM–7:54 AM

How low can you go? Evaluation of Implant Density in Growing Construct Conversion to Posterior Spinal Fusion for Early Onset Scoliosis

*Edward Compton; Purnendu Gupta, MD; Jaime Gomez, MD; Kenneth Illingworth, MD; David Skaggs, MD, MMM; Paul Sponseller, MD; Amer Samdani, MD; Steven Hwang; Matthew Oetgen MD, MBA; Jennifer Schottler; George Thompson, MD; Michael Vitale, MD, MPH; John Smith, MD; Lindsay Andras, MD; Pediatric Spine Study Group
Children's Hospital Los Angeles, Los Angeles, CA*

62

7:55 AM–7:59 AM

Superiority of convex first differential rod technique in three-dimensional correction of Lenke 1&2 Adolescent Idiopathic Scoliosis

*Lorena Floccari, MD; Trey Moberly; Todd Ritzman, MD
Akron Children's Hospital, Akron, OH*

63

8:00 AM–8:04 AM

Predictors of Optimal Outcomes of Selective Thoracic Fusion at Five Years

*Amelia Lindgren, MD; Tracey Bastrom MA; Amer Samdani, MD; Suken Shah, MD; Firoz Miyanji, MD; Patrick Cahill, MD; Vidyadhar Upasani, MD; Peter Newton, MD; Burt Yaszay, MD
Rady Children's Hospital, San Diego, CA*

64

8:15 AM–8:19 AM

Scoliosis Surgery Normalizes Cardiac Function in AIS Patients

*Terry Amaral, MD; Vishal Sarwahi, MBBS; Aaron Atlas; Jesse Galina; Sayyida Hasan; Sarika Kalantre
Cohen Children's Medical Center, New Hyde Park, NY*



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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8:20 AM–8:24 AM

Spinal Fusion Effects on Pulmonary Function and Breathing Mechanics in Adolescent Idiopathic Scoliosis

Vincent Prusick, MD; Joel Eastman; Hank White; Sam Augsburger; Vishwas Talwalkar, MD; Ryan Muchow, MD; Henry Iwinski, MD
Shriners Hospitals for Children-Medical Center, Lexington, KY

66

8:25 AM–8:29 AM

Airway Management of Pediatric Cervical Fusions

Daniel Hedequist, MD; Nora O'Neill; Danielle Cook; Sabeena Chacko
Boston Children's Hospital, Boston, MA

SPINE SUBSPECIALTY DAY (CONTINUED)

Period 2: 10:18 AM – 11:58 AM

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10:18 AM–10:22 AM

Transcranial Motor Evoked Potential Monitoring During Scoliosis Surgery in Children with Cerebral Palsy: Is it Feasible?

Wade M. Shrader, MD; Katherine Kenny; Kenneth Rogers, PhD; Sabina DiCindio; Anthony DiNardo; Alier Franco; Suken Shah, MD
Nemours A.I. duPont Hospital for Children, Wilmington, DE

68

10:23 AM–10:27 AM

Breaking the Dogma: Does UIV have to be T2 in CP Patients Undergoing Spinal Fusion for their Neuromuscular Scoliosis?

Jakub Sikora-Klak; Paul Sponseller, MD; Tracey Bastrom, MA; Suken Shah, MD; Patrick Cahill, MD; Mark Abel, MD; Amer Samdani, MD; Peter Newton, MD; Burt Yaszay, MD
Rady Children's Hospital, San Diego, CA

69

10:28 AM–10:32 AM

Ambulatory Neuromuscular Scoliosis Patients have Similar Rates of Infection, Perioperative Complications, and Revision to Adolescent Idiopathic Scoliosis Patients

Vishal Sarwahi, MBBS; Sayyida Hasan; Yungtai Lo; Terry Amaral, MD; Jesse Galina; Aaron Atlas
Cohen Children's Medical Center, New Hyde Park, NY

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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10:42 AM–10:46 AM **Prophylactic Application of Local Vancomycin onto Surgical Field Shows No Decrease of Acute Surgical Site Infection in Adolescent Idiopathic Scoliosis Patients**

De-An Zhang; Marilan Luong;

*Robert Cho, MD; Shriners Spine Study Group; Selina Poon, MD
Shriners for Children Medical Center, Pasadena, CA*

71

10:47 AM–10:51 AM **◆ Multimodal Treatment for Severe Spinal Deformity in Osteogenesis Imperfecta: Rationale, Outcomes and Complications**

Tyler McDonald; Alexander Kuzma; Yushane Shih, MD;

Kenneth Rogers, PhD; Petya Yorgova; Richard Kruse, DO;

Jeanne Franzone, MD; Suken Shah, MD

Nemours/Alfred I. duPont Hospital for Children, Wilmington, DE

72

10:52 AM–10:56 AM **Post-Operative Complications Assessment for Patients with Early-Onset Scoliosis and Baclofen Pump Usage Undergoing Growth-Friendly Spinal Instrumentation Surgeries**

Amy Xu; Majd Marrache; Christina Hardesty, MD; Mari Groves;

Mark Erickson, MD; Robert Murphy, MD; George Thompson, MD;

Paul Sponseller, MD

Johns Hopkins School of Medicine, Baltimore, MD

SPORTS SUBSPECIALTY DAY

Period 1: 7:50 AM – 9:30 AM

Chair: Peter Fabricant, MD

Co-Chair: Jennifer Beck, MD

Co-Chair: Eric Edmonds, MD

73

7:50 AM–7:54 AM **Descriptive Epidemiology from the Research in OsteoChondritis Dissecans of the Knee (ROCK) Prospective Cohort**

Carl Nissen, MD

University of Pennsylvania, Philadelphia, PA

◆ 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).



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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7:55 AM–7:59 AM

Osteochondral Allografting for Unsalvageable Osteochondritis Dissecans in the Skeletally Immature Knee: A Comparative Analysis of Radiographic Healing and Early Clinical Outcomes Between Skeletally Mature and Immature Patients

Breann Tisano; Henry Ellis, MD; Charles Wyatt, NP; Philip Wilson, MD

Scottish Rite for Children, Dallas, Texas

75

8:00 AM–8:04 AM

Predicting Outcomes of Talar Osteochondritis Dissecans Lesions in Children

Kathleen Maguire, MD; Mitchell Johnson; Kunbo Park, MD; Divya Talwar; J Todd Lawrence, MD

Children's Hospital of Philadelphia, Philadelphia, PA

76

8:15 AM–8:19 AM

Activity Specific Differences in Patients Returning to Sports Following Primary Hip Arthroscopy

Whitney Hovater; David Howell; Stephanie Mayer, MD

Children's Hospital Colorado, Aurora, CO

77

8:20 AM–8:24 AM

Clinical Outcomes, Survivorship, and Return to Sports After Arthroscopic Capsular Repair with Suture Anchors for Adolescent Multidirectional Shoulder Instability at Mean Follow-Up of 6 Years

Brendon Mitchell; Matthew Siow; Alyssa Carroll; Andrew Pennock, MD; Eric Edmonds, MD

Rady Children's Hospital, San Diego, San Diego, California

78

8:25 AM–8:29 AM

Utility of MRI Assessment of Healing following Marrow Stimulation of Capitellar OCD

Charles Goldfarb, MD;

Matthew Smith; James Broughton; Mitchel Obey; Travis Hillen
Washington University, Saint Louis, Missouri

SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

SPORTS SUBSPECIALTY DAY (CONTINUED)

Period 2: 10:18 AM – 12:00 PM

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10:18 AM–10:22 AM **Do Continuous Peripheral Nerve Blocks Decrease Home Opioid Use Following Anterior Cruciate Ligament Reconstruction in Children and Adolescents?**

The Envelope Please.

John Schlechter, DO; Bryn Gornick; Benjamin Sherman, DO; Tanner Harrah

Children's Hospital of Orange County, Orange, CA

80

10:23 AM–10:27 AM **Descriptive Epidemiology of Complete Anterior Cruciate Ligament Tears in the Skeletally Immature Population: A Multicenter Investigation of the PLUTO Study Group**

Lauren Hutchinson, MPH;

Melissa Christino, MD; Andrew Pennock, MD;

PLUTO Study Group; Mininder Kocher, MD, MPH

Boston Children's Hospital, Boston, MA

81

10:28 AM–10:32 AM **Anatomic versus Non-anatomic Anterolateral Tenodesis in Combination with Anterior Cruciate Ligament Reconstruction – Sometimes Cheaper is Better**

Samuel Van De Velde; Gregory Schmale, MD; Scott Telfer

University of Washington, Seattle, WA

82

10:42 AM–10:46 AM **Iliotibial Band Autograft Provides The Fastest Recovery Of Knee Extensor Mechanism Function In Pediatric Anterior Cruciate Ligament Reconstruction**

Curtis VandenBerg, MD; Mia Katzel; Veronica Beltran;

Adriana Conrad-Forrest; Tishya Wren, PhD

Children's Hospital Los Angeles, Los Angeles, CA



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13

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10:47 AM–10:51 AM **Functional Recovery After Revision ACL Reconstruction In Adolescents and Young Adults**
Benjamin Wilson, MD; Benton Heyworth, MD; Ryan Coene; Dai Sugimoto; Lyle Micheli, MD; Mininder Kocher, MD, MPH; Melissa Christino, MD
Boston Children's Hospital, Boston, MA

84

10:52 AM–10:56 AM **Risk Factors for Revision Following Anterior Cruciate Ligament Reconstruction in a Pediatric Population: A Prediction Algorithm**
Aristides Cruz, MD; Nicholas Lemme; Daniel Yang; Brooke Barrow; Ryan O'Donnell; Alan Daniels, MD
Brown University Department of Orthopaedics, Providence, RI

TRAUMA SUBSPECIALTY DAY

Period 1: 7:50 AM – 9:40 AM

Chair: Mauricio Silva, MD

Co-Chair: Amy McIntosh, MD


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7:50 AM–7:54 AM  **Acute Cast Immobilization of Pediatric and Adolescent Forearm Fractures – Is It Safe?**
Casey Codd; Danielle Hogarth; Chloe Grzyb; Joshua Abzug, MD
University of Maryland School of Medicine, Baltimore, Maryland

86

7:55 AM–7:59 AM  **Long-leg versus Short-leg Cast Immobilization for Displaced Distal Tibial Physeal Fractures**
Christopher Souder, MD; James Spearman; Lori Thornton, NP; Jessica Treiber; Ainsley Bloomer; Brian Scannell, MD; Christine Ho, MD
Dell Medical School at the University of Texas at Austin, Austin, Texas

87

8:00 AM–8:04 AM  **Conservative Management of Transitional Ankle Fractures in Adolescents: Does Immobilization Type Affect Outcome?**
Kevin Neal, MD; Gary Kiebzak, PhD; Jane Benson
Nemours, Jacksonville, FL

88

8:15 AM–8:19 AM



Titanium Elastic Nails System (TENS) in Adolescent Forearm Fractures: Using Bone Age as an Objective guide to its Limits.

Chin Chuen Tan; Kenneth Pak Leung Wong; John Allen; Arjandas Mahadev, FRCS

KK Women's and Children's Hospital, Singapore, Singapore

89

8:20 AM–8:24 AM



Canal Fill of the Forearm Bones When Placing Intramedullary Nails

Max Hamaker; Casey Codd; Nathan O'Hara; Joshua Abzug, MD
University of Maryland School of Medicine, Baltimore, Maryland

90

8:25 AM–8:29 AM



Re-fractures of the Radius and Ulna in Adolescents: Tumbling and Contact Sports may be at Risk in the First Year

Corey Gill, MD; Ami Kapadia; Charles Wyatt, NP; Gerard Montgomery, MS; Philip Wilson, MD; Henry Ellis, MD
Scottish Rite For Children, Dallas, Texas

TRAUMA SUBSPECIALTY DAY (CONTINUED)

Period 2: 10:18 AM – 11:54 AM

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10:18 AM–10:22 AM



Vitamin D Insufficiency and Metaphyseal Fractures in Children

John Bryan; Rachel Thompson, MD; Benjamin Yu; Carly Strohbach, BA; Lubna Ziauddin; Jamie Burgess, PhD; Joseph Janicki, MD
Lurie Children's Hospital of Chicago, Chicago, IL

92

10:23 AM–10:27 AM



Pediatric Orthopedic All-Terrain Vehicle (ATV) Injury Patterns, Surgeries, and Complications – Appreciating the True Morbidity and Impact

Brien Rabenhorst, MD; Chad Willis; David Bumpass
University of Arkansas-Medical Sciences, Little Rock, AR

93

10:28 AM–10:32 AM



"You're O.K. anesthesia": Closed Reduction of Displaced Pediatric Forearm and Wrist Fractures in the Office Without Anesthesia

Byron Izuka, MD; Joshua Radi PhD; John Livingstone
Kapiolani Medical Center for Women and Children, Honolulu, HI



SUBSPECIALTY DAY PROGRAMS

THURSDAY, MAY 13 CONTINUED

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10:42 AM–10:46 AM



Non-Operative versus Operative Pediatric and Adolescent Medial Epicondyle Fractures: A Comparison of Outcomes Between Pediatric and Non-Pediatric Fellowship Trained Orthopedic Surgeons

Jessica Traver, MD; Layla Haidar; David McClendon; Kailash Panchapakesan; Timothy Borden, MD; Surya Mundluru, MD; Lindsay Crawford, MD; Shiraz Younas, MD; Alfred Mansour, MD
UT-Health at McGovern Medical School, Houston, TX

95

10:47 AM–10:51 AM



AP, Axial, and External Oblique Views Reliably Measure Medial Epicondyle Displacement Using Corresponding Point Methodology but the Measurements Only Moderate Correlate with True Displacement as Measured by CT Scan

J Todd Lawrence, MD; Ryan Guzek; Kathleen Harwood; Divya Talwar; David Isaacs; Donna Pacicca, MD; Michael Saper; Peter Fabricant, MD; Scott McKay, MD; Eric Edmonds, MD; Stephanie Mayer, MD; Matthew Ellington, MD; V Joughin, MD
Children's Hospital of Philadelphia, Philadelphia, PA

96

10:52 AM–10:56 AM



All Epiphyseal vs Trans-epiphyseal screw fixation for Tillaux fractures– Does it matter?

Brett Heldt; Elsayed Attia; Isaiah Roepe; Raymond Guo; Vinitha Shenava, MD; Indranil Kushare, MD
Texas Children's Hospital, Houston, Texas

Long-Term Results for Surgically Treated Radial Polydactyly

Takehiko Takagi MD

National Center for Child Health and Development, Tokyo, Tokyo Japan

LOE-Therapeutic-Level III

Purpose: Although thumb polydactyly is one of the commonest congenital hand differences, postoperative deformities/relapses have been reported so far. We surveyed characteristics of reoperation cases with thumb polydactyly in our long-term series.

Methods: Between 2002 and 2019, we have 458 initial operations for thumb polydactyly. We could follow 280 thumbs (Wassel type I, 6; II, 79; III, 12; IV, 144; V, 22; VI 17) for more than 5 years. There were 166 male and 114 female patients. The average age of the patients at the time of the initial operation was 14 months (range, 4 to 62 months). The average follow-up period was 74 months (range, 60 to 148 months). We assessed re-operation rate, time, and procedure.

Results: Re-operation number was 44 cases (16%) (Wassel type II, 15 (19%); III, 7 (58%); IV, 16 (11%); V, 3 (14%); VI, 3 (18%)). The mean age at the re-operation was 4.4. The procedure of the re-operation was mainly osteotomy at types II, III and IV, and opponensplasty at types V and VI.

Conclusions: Correction loss at/after the initial operation was caused by the original character of the deformity, such as inclination of the joint surface, stability of the joint (ex. loosening of the collateral ligament), deviation of the bone axis, or persistent traction of the flexor and extensor tendons.

Significance: ●Most re-operations were performed within five years after initial surgeries.●Type III has more highly re-operation rate than the other types. The tendon attachment transfers for type III or the opponensplasty with the first web plasty for types V and VI may prevent postoperative deformities at the initial surgeries.●Osteotomies were more performed in types II, III, and IV, while opponensplasties were in types V and VI as re-operations.●We need regular observations for detecting postoperative deformities.

A practical algorithm for radial polydactyly

Chia-Hsieh Chang MD

Chang Gung Memorial Hospital, Taoyuan city Taiwan

LOE-Diagnostic-Level III

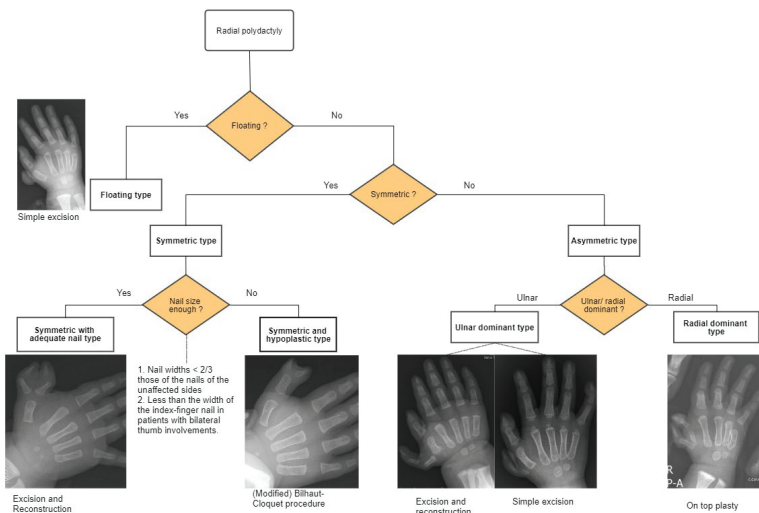
Purpose: Many studies reported surgical techniques and outcomes of radial polydactyly, however preoperative evaluation and surgical guidelines are limited. This study aimed to develop a new classification of radial polydactyly to guide surgical treatment.

Methods: The algorithm was based on 4 items: floating, symmetric, dominant thumb, and nail size. Five hundred patients with 545 affected thumbs at our hospital were reviewed and categorized using the new classification. The relationship between surgical procedures and classification was compared for Wassel’s classification and the new classification system.

Results: According to the new classification, of the 545 polydactylies, 78 were categorized as floating type, 369 as ulnar-dominant type, 8 as radial-dominant type, 70 as symmetric adequate nail type, and 20 as symmetric hypoplastic type (20). Surgical treatments were simple excision, excision with reconstruction, ray amputation or on-top plasty, excision with reconstruction, and the Bilhaut Cloquet procedure, respectively. The distribution of surgical procedures was more related to the new classification than to Wassel’s classification.

Conclusions: The new radial polydactyly classification system offers a clinical algorithm, based on 4 questions about physical findings, to categorize radial polydactyly and recommend surgical procedures. Wassel’s classification is a good conventional nomenclature for radial polydactyly, and the new algorithm is a useful tool for preoperative assessment.

Significance: A new algorithm for preoperative assessment is helpful for young surgeons.



Reliability Masada Classification for forearm involvement in patients with Hereditary Multiple Osteochondromas (HMO)

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LOE-Diagnostic-Level III

Purpose: In patients with Hereditary Multiple Osteochondromatosis (HMO) affecting the upper extremity the most common site with clinically significant deformities is the forearm. Classifications describing lesion characteristics have been used to recommend surgical intervention and stratify outcomes, however there isn't consensus on which classification scheme offers greater reliability. The purpose of this study was to determine the reliability of the Masada classification and newer classifications proposed by Gottschalk and Jo among pediatric hand surgeons.

Methods: 111 patients with HMO between June 2014 and October 2019 were enrolled from the Congenital Upper Limb Differences (CoULD) Registry. There were 101 forearms with preoperative radiographs in 67 patients included. Four pediatric hand surgeons from CoULD undertook an online evaluation. Each rater classified the radiographs according to the Masada classification as used by the CoULD registry. Six weeks later, raters were asked to reclassify the images according to Masada classification and the newer independently proposed classifications by Gottschalk and Jo. Raters received educational materials with a detailed description of each original classification system. Interrater agreement across raters for Masada, Gottschalk and Jo classifications and across rater reported non-classifiability were assessed by estimating Fleiss's kappa along with a 95%CI. Comparisons in Kappa statistics were conducted to assess any significant shift from pre-to post instruction.

Results: Interrater agreement for Masada classification after the first reading was poor (kappa=0.35;95% CI=0.30—0.41) across all raters. Interrater agreement across the four raters decreased for the Masada classification from first to second reading (kappa=0.35 versus 0.21; p<0.001). It was found that the Gottschalk classification yielded significantly better interrater agreement compared to Masada (kappa=0.43 versus 0.21;p<0.001). Similarly, the Jo classification yielded significantly higher interrater agreement (kappa=0.43 versus 0.21;p<0.001). (Table 1)

Conclusions: Despite wide use, the Masada classification was a less reliable way to classify forearm deformities; it may not be as reliable as newer classification systems proposed. The Gottschalk classification offered a better reliability and allowed the classification of more cases, it offered more options for location without the specificity of accompanying deformity but lacked mention of radial head dislocation. The Jo classification similarly had better reliability and offered more location options than Masada and did incorporate radial head dislocation in some patterns.

Significance: A more inclusive classification that considers lesion location, deformity and status of the radial head could help surgeons to have a common language when studying disease and surgical outcomes and thereby a better understanding on what influences a patient's outcome.

Table 1. Reliability Masada Classification for forearm involvement in Hereditary Multiple Osteochondromas (HMO).

Reading 1: Pre-instruction		
CoULD Masada Classification	Freq.	(%)
Interrater agreement	Kappa	(95% CI)
Masada classification	0.35	(0.30, 0.41)
Proportion not classifiable	0.14	(0.06, 0.22)
Reading 2: Post-instruction		
Masada interrater agreement	Kappa	(95% CI)
Masada classification	0.21	(0.15, 0.26)
Proportion not classifiable	0.03	(-0.06, 0.10)
Radius	0.04	(-0.04, 0.12)
Ulna	0.08	(0.00, 0.16)
Does Masada capture deformity?	0.29	(0.22, 0.38)
Gottschalk interrater agreement	Kappa	(95% CI)
Gottschalk classification	0.43	(0.38, 0.47)
Proportion not classifiable	0.08	(0.00, 0.16)
Radius	0.07	(-0.02, 0.14)
Ulna	0.06	(-0.02, 0.14)
Does Gottschalk capture deformity?	0.23	(0.14, 0.30)
Jo interrater agreement	Kappa	(95% CI)
Jo classification	0.43	(0.38, 0.47)
Proportion not classifiable	0.18	(0.10, 0.26)
Radius	0.17	(0.09, 0.25)
Ulna	0.14	(0.06, 0.22)
Does Jo capture deformity?	0.18	(0.09, 0.25)

Outcomes of Biceps Rerouting for Forearm Supination Contractures in Brachial Plexus Birth Injury

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LOE-Therapeutic-Level IV

Purpose: Forearm supination contractures occur in 7% of children with brachial plexus birth injuries (BPBI). Loss of pronation is functionally limiting and aesthetically displeasing. These contractures may progress and require forearm osteotomies to reposition the forearm in neutral or mid-pronation. Biceps rerouting has been proposed when pronation has deteriorated, but is still at least 0° (neutral); the outcomes of this procedure are not well described. The purpose of this investigation is to evaluate long-term outcomes of biceps rerouting for this indication, including magnitude and maintenance of correction, complications, and subsequent need for osteotomy.

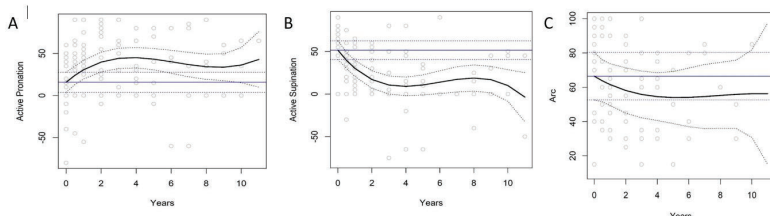
Methods: We conducted a retrospective review of all children with BPBI and forearm supination contractures who were treated with biceps rerouting for the above indications from 1990-2019, and had at least 2 years follow-up. Demographic information (sex, age at surgery), BPBI characteristics (side, severity), surgical details (post-operative complications, subsequent forearm osteotomy) and ranges of motion were obtained from medical records. Pre- and post-operative active pronation (AP) and supination (AS), elbow flexion contracture (EFC), and arc of forearm rotation (Arc) were analyzed for changes over time using linear mixed effect models.

Results: 25 children (13 Females, 13 Left, 15 Global BPBI) underwent biceps rerouting at 7 ± 3 years and followed for 5.7 ± 3 years. Pre-operatively, mean AP and AS were $6\pm 29^\circ$ and $62\pm 27^\circ$, respectively, and mean pre-operative Arc was $69\pm 40^\circ$. At final follow up, mean AP, AS, Arc were $41\pm 37^\circ$, $14\pm 34^\circ$, and $62\pm 42^\circ$. AP was significantly improved from pre-operative at 2 years post-operatively, and remained improved thereafter. Similarly, AS was significantly decreased by 2 years post-operatively and remained stable thereafter. Neither Arc nor EFC showed a significant trend overtime. (Figure 1). 2/25 (8%) children underwent subsequent forearm osteotomy for recurrent contracture. No patient developed post-operative complications.

Conclusions: Biceps rerouting in children with BPBI improves forearm position when pronation is deteriorating, by shifting the arc from supination to pronation without decreasing it, or worsening elbow flexion contractures. These results are maintained over time. When performed before pronation is reduced beyond neutral, this procedure may check the development of a severe supination contracture and reduce the need for forearm osteotomy.

Significance: Biceps rerouting may be considered for treatment of deteriorating loss of pronation in children with BPBI with a low risk of complications and lasting correction, potentially reducing the need for forearm osteotomy.

Figure 1. Predicted and observed changes in (A) active pronation, (B) active supination, and (C) arc of forearm rotation over time. Solid black lines indicate the point estimate at each time point, and dashed black lines show the 95% confidence intervals. The solid blue line shows the estimated value at baseline, and dashed blue lines represent the confidence interval around the baseline. Time points at which the black and blue dashed lines do not overlap indicated a statistically significant change from baseline.



Why the Knife? Reasons Children and their Families Choose Surgery for Ganglion Cysts

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LOE-Therapeutic-Level II

Purpose: Ganglion cysts of the hand/wrist are frequently managed non-operatively, but can be treated with surgical excision if there is pain or dysfunction. No studies have examined the specific factors predictive of the decision to undergo surgical treatment for pediatric patients. We hypothesized that increased pain scores at initial presentation would be predictive of the decision to undergo surgical intervention.

Methods: This was a prospective study of pediatric patients (≤ 18 years) with ganglion cysts of the hand and wrist seen between 2017-2019 at two institutions. Baseline demographic data was collected in addition to cyst characteristics, Wong-Baker pain scores, and PROMIS scores (pain, depression, upper extremity function, anxiety). Patients were cohorted by the decision to undergo surgical intervention versus continued observation at a minimum 6-months follow-up. Multivariable regressions were used to determine the factors predictive of surgical excision.

Results: 153 patients with a mean age of 10.0 ± 5.3 years were included for analysis. 44 (28.8%) underwent surgical excision of their ganglion cyst at a mean 2.2 months after initial visit. Only two patients under the age of 3 were managed surgically. Sex and cyst location were not different between cohorts. Surgical patients were older (11.8 vs 8.7 years, $p=0.005$) and presented to the clinic later after appearance (10.7 vs 5.5 months, $p=0.045$). Surgical patients also had higher pain scores at presentation (3.3 vs 1.4, $p=0.001$). 45.7% of patients choosing surgery had initial pain scores ≥ 4 (moderate/severe pain) compared to 17.7% choosing observation ($p=0.002$). Cysts receiving surgery were larger (79.5% vs 48.1% >1 cm, $p<0.001$) and were more commonly diagnosed using MRI (9.1% vs 0.9%, $p=0.024$). For 102 patients with baseline PROMIS scores, the surgical group had higher pain interference (45.4 vs 40.1, $p=0.007$) and depression (42.2 vs 38.8, $p=0.039$) scores. In multivariable analysis, pain scores ≥ 4 (OR 2.9, $p=0.024$) and cyst size >1 cm (OR 3.2, $p=0.018$) were predictive of surgery for patients ≥ 3 years.

Conclusions: Pediatric patients with ganglion cysts choosing surgical excision were older at presentation and took longer to present to the clinic. Patients choosing surgery also had larger cysts that were more commonly diagnosed with MRI. Children with ganglion cysts who initially present with moderate/severe pain scores and larger cysts are more likely to ultimately choose surgical excision.

Significance: Surgeons may consider earlier surgical intervention in pediatric patients who present with higher pain scores and larger cysts.

Table 1: Cyst History and Location Stratified by Operative vs. Non-Operative Management

Variables	Non-Operative	Operative	P-value
N	109	44	-
Age at presentation (yrs)	8.7 ± 5.5 (0.2-18.0)	11.8 ± 4.2 (1.4-17.6)	0.002
Sex			0.151
Male	51 (46.8)	15 (34.1)	
Female	58 (53.2)	29 (65.9)	
Cyst location	48 (44.0)	24 (54.5)	0.611
Dorsal wrist	32 (29.4)	12 (27.3)	
Volar wrist	23 (21.1)	6 (13.6)	
Retinacular cyst	5 (4.6)	1 (2.3)	
Extensor tendon sheath	1 (0.8)	1 (2.3)	
Other			
Cyst laterality			0.878
Right	56 (51.4)	22 (50.0)	
Left	53 (48.6)	22 (50.0)	
Hand Dominance			0.585
Right	68 (78.2)	34 (87.2)	
Left	10 (11.5)	3 (7.7)	
Ambidextrous	9 (10.3)	2 (5.1)	
Cyst affecting dominant hand	50 (57.5)	21 (53.8)	0.704
Cyst size			<0.001
<1cm	56 (51.9)	9 (20.5)	
>1cm	52 (48.1)	35 (79.5)	
Time to clinic presentation (mos)	5.5 ± 8.3 (0.1-60.0)	10.7 ± 18.1 (0.3-108.0)	0.005
Pain at presentation	1.4 ± 2.4 (0-10)	3.3 ± 3.1 (0-8)	0.001
Total Beighton Score	1.6 ± 2.2 (0-9)	2.1 ± 2.2 (0-8)	0.144
Imaging for Diagnosis			
Ultrasound	26 (23.9)	8 (18.2)	0.445
MRI	1 (0.9)	4 (9.1)	0.024
Time to Surgical Excision (mos)	-	2.2 ± 3.5 (0-15.0)	-
Follow-Up Duration (mos)	21.7 ± 7.2 (6.0-32.7)	19.4 ± 7.3 (6.4-31.8)	0.086

Statistics reported as either mean ± SD (Range) or number (%)

The Radiocoronoid line - a novel technique for diagnosing radiocapitellar dislocation

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LOE-Diagnostic-Level III

Purpose: The radiocapitellar line (RCL) has been widely used to diagnose elbow dislocation. However, there are limitations to the RCL, with the cartilaginous portion of bone making interpretation of radiographs difficult. The study aims to show that a new line, the radiocoronoid line, which connects two points on the medial aspect of the radius proximal to the radial tuberosity is more suited to diagnose elbow dislocations in the anteroposterior projection; as well as to look for factors affecting accuracy of the RCL.

Methods: The radiographs of 50 normal and 17 laterally dislocated elbows were obtained. An unbiased independent reviewer drew the radiocoronoid and radiocapitellar line. 4 other blinded independent reviewers of different levels of training drew the RCL and the radiocoronoid line for 20 radiographs and repeated the process a week later. The accuracy of the RCL was assessed using distance away from bisection point of capitellum, and ratio (distance from point where line crosses capitellum to lateral aspect of capitellum over the total width of capitellum). The relationship of the radiocoronoid line and the lateral aspect of coronoid fossa was assessed, with dislocation being the line lateral to it and normal being medial to it or cutting the lateral edge of fossa

Results: The radiocoronoid line had a higher accuracy (95.5%) compared to RCL (32.8%), higher specificity (94%) compared to RCL (10%), as well as higher positive predictive value (85%) compared to RCL (27.4%). There was no intra or inter-observer variability for the radiocoronoid line. Regarding the radiocapitellar line, skeletal age statistically predicted the ratio for the male population ($p < 0.05$), with the ratio nearing 0.5 (point of bisection) as skeletal age increased.

Conclusions: The radiocoronoid line is a reliable alternative to diagnose elbow dislocation in the anteroposterior projection. Skeletal age influences the accuracy of the RCL for males.

Significance: The radiocoronoid line in future practice would be during the reduction of the radial head under conscious sedation. The traditional radiocapitellar line would cause the radial head to appear dislocated even though they were normal. In contrast, the radiocoronoid line would allow a more accurate diagnosis, avoiding unnecessary prolonged or repeated manipulations and unneeded referrals to a paediatric orthopaedic surgeon.

Pediatric Posterior Ankle Impingement- Arthroscopic Management and Outcomes: A Prospective Study

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LOE-Therapeutic-Level IV

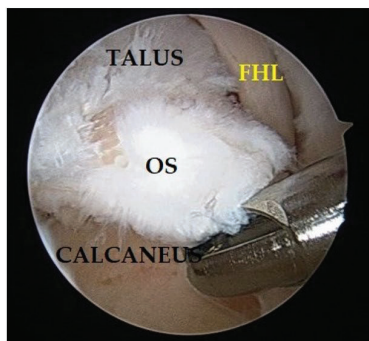
Purpose: To describe outcomes and complications after arthroscopic management of posterior ankle impingement in the pediatric and adolescent population.

Methods: IRB approved prospective study was performed at a tertiary children's hospital from 2016-2020. We enrolled consecutive patients <18 years of age who were diagnosed with posterior ankle impingement and underwent posterior ankle arthroscopy. Pre-operative demographics, sporting activities, clinical, radiologic and arthroscopic findings were recorded. Visual Analogue Scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scores were collected pre-operatively and at post-operative follow-ups.

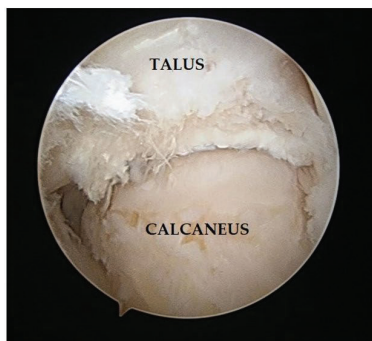
Results: A total of 52 patients (66 ankles; 30 females), were included with mean age 13.3 years. Football and soccer were the most commonly implicated sports. All patients underwent initial conservative management including rest, immobilization and/or physical therapy for an average of 44 weeks. The indication for surgery was failure of conservative management to relieve symptoms or recurrence of symptoms after return to activity. All patients underwent prone posterior ankle arthroscopy with arthroscopic confirmation of impingement pathology followed by debridement. The impingement pathology was predominantly bony (Os trigonum, Stieda process) in 53% patients, and predominantly soft tissue (low-lying flexor hallucis longus belly, ganglion cyst in the ankle, hypertrophied posterior ankle ligaments) in 47%. All 52 patients (100%) returned to previous level of activity/sports at an average 8.3 ± 4.0 weeks. 51 ankles had radiographs done at 1 years post-operatively which did not show any new osseous abnormalities. At mean follow up of 27 months after surgery, there was a statistically significant improvement in VAS scores (7.0 to 0.56) and AOFAS scores (63.5 to 95.6) pre-operatively to post operatively. Complications included persistent numbness over lateral part of the heel (sural nerve distribution) in 1 patient.

Conclusions: Arthroscopic management of PAI allowed patients to return to previous level of activity, and improvement in objective assessment of pain relief and higher level of function parameters. Complications associated with this procedure were minimal.

Significance: The largest prospective study on pediatric PAI showed excellent outcomes with arthroscopic management after failed conservative management.



Arthroscopic appearance of Os Trigonum



Resected Os Trigonum

Does the Stabilization of the Calcaneocuboid Joint With a Steinman Pin in Evans Osteotomy Procedures Affect Its Incidence of Arthritis ?

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LOE-Therapeutic-Level III

Purpose: The purpose of this study is to determine the rates of arthritis following calcaneal osteotomy lengthening procedures and to compare the rates between extended Steinmann pin fixation and removing the pin during surgery. We hypothesized that leaving the pin across the calcaneocuboid joint post-operatively would lead to higher rates of arthritis.

Methods: We performed a single-center retrospective review of all the calcaneal osteotomy lengthening procedures from January 2015 to May 2020. Patients under the age of 18 and with greater than 1-year follow-up were included in the study. Patients were stratified into group 1(pin removed intra-operatively) and group 2(pin left across joint), and all variables were compared between groups. Demographic data were recorded, including age, sex, and BMI. Calcaneocuboid arthritis was determined by radiographic imaging at follow-up. Time to pin removal, size of the pin, and size of the graft were analyzed as possible risk factors for arthritis.

Results: 39 patients met the inclusion criteria. 24 patients had the pin removed post-operatively, and 15 had the pin removed intra-operatively. There were no significant differences between BMI, age, sex, and laterality between groups. Calcaneocuboid arthritis rates were significantly higher in the group with post-operative pin removal compared to intra-operative removal (12(50%) vs. 2(13.3%), respectively; $p=.02$). On multivariate regression, both age (OR, 1.305; $p=.044$) and if the pin was left in the joint(OR, 7.661; $p=.031$) were found as risk factors for arthritis at follow-up. The mean time to pin removal, the size of the pin, and the size of the graft were not found to be significant predictors of arthritis.

Conclusions: This study shows that leaving the Steinmann pin in the calcaneocuboid joint in children for an extended period of time post-operatively to aid fixation may be associated with an increased risk of developing early radiographic signs of arthritis.

Significance: The modified Evans osteotomy is a technique known to increase pressure across the calcaneocuboid joint, leading to consequent arthritis in some adults. However, to our knowledge, this has not been previously shown in pediatric populations. As the long-term fixation is associated with calcaneocuboid arthritis in our study, further studies to evaluate if the pin is necessary to prevent subluxation following surgery are needed.

Table 1. Demographics

Factor	Pin left in	Pin not left in	p-value
n	24	15	
Sex			0.204
Female	13	5	
Male	11	10	
Foot Laterality			0.265
Left	10	9	
Right	14	6	
Average age(y)	12.46±3.06	11.91±3.53	0.625
BMI	20.50±5.34	19.65±5.37	0.633

A Retrospective Analysis of Nonoperative Treatment of Idiopathic Toe Walking: Outcomes and Predictors of Success

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LOE-Therapeutic-Level III

Purpose: This study aims to determine the outcomes of nonoperative treatment techniques in a large cohort of patients with idiopathic toe walking (ITW) to better inform management.

Methods: This is a retrospective cohort study of patients treated nonoperatively for ITW at a single tertiary care children's hospital from 2008-2015. Patients were stratified by severity of equinus contracture at presentation (mild $\geq 10^\circ$ ankle dorsiflexion (DF) with knee extended; moderate 0° - 10° ; severe $<0^\circ$). Treatment modality was recorded: observation, home stretching, physical therapy, bracing, and/or serial casting. The primary outcome measure was resolution of toe walking at last visit defined as $\geq 10^\circ$ of ankle DF with knee extended or walking on toes $<25\%$ of the time. A multivariate logistic regression model was used to identify patient and treatment factors associated with resolution of toe walking. Recurrence was defined as regression of DF to $<10^\circ$ or resumption of time toe walking $>25\%$ during or after successful treatment. Not meeting resolution criteria or requiring surgical intervention was considered failure of treatment.

Results: Of 204 patients with ITW (median age 5 years [IQR 4–6 years]), 121 (59.3%) attended ≥ 1 follow up visit. Of those, 55 (45.5%) had resolution of ITW ($\geq 10^\circ$ DF: 44/118 [37.3%]; $\leq 25\%$ -time toe walking: 29/54 [53.7%]) at last follow up (mean 13.9 months, range 1 day-6.5 years). Four of eleven patients treated with observation only (mild 4/4; moderate 0/3; severe 0/3) had a successful outcome at last follow up. Fourteen patients (6.8%) ultimately underwent surgery and 17 patients had ≥ 1 recurrence with 6/17 (35.3%) having a successful outcome at last follow up. Increasing ITW severity was associated with increased rate of follow up (mild 13/35 [37.1%]; moderate 64/104 [61.5%]; severe 35/51 [68.6%]; $p = 0.03$) and lower rate of successful outcome (mild 7/13 [53.8%]; moderate 32/64 [50.0%]; severe 11/35 [31.4%]; $p = 0.03$, Table 1). Bracing was the only treatment modality associated with a successful outcome ($p = 0.03$, Table 1).

Conclusions: Loss to follow up is common in patients with ITW. Less than half of patients with follow up had a successful outcome with nonoperative management. The only technique associated with short-term resolution of toe walking was bracing. Equinus contracture was associated with increased likelihood of follow up and treatment failure.

Significance: Nonoperative treatment of ITW has high recurrence and failure rate. Prolonged recommendation of these techniques may be futile and costly. Prospective studies are needed to better evaluate nonoperative and operative outcomes.

Covariate	Odds Ratio	95% Confidence Interval	P
Age	0.957	(0.660-1.388)	0.82
Race			
White/Caucasian	1		
Others	0.666	(0.284-1.562)	0.35
ITW Severity			
Mild/Moderate	1		
Severe	0.340	(0.129-0.899)	0.03
Observation			
No	1		
Yes	1.902	(0.490-7.380)	0.35
Home Stretching			
No	1		
Yes	2.232	(0.864-5.768)	0.10
Physical Therapy			
No	1		
Yes	1.559	(0.695-3.497)	0.28
Bracing			
No	1		
Yes	4.808	(1.907-12.119)	0.001
Serial Casting			
No	1		
Yes	2.044	(0.750-5.573)	0.16

Table 1: Association of modality employed at any time point in treatment with successful treatment outcome based on ankle range of motion or time toe walking

Talectomy for the Treatment of Rigid Non-idiopathic Clubfoot Deformity: Long-Term Follow-Up

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LOE-Prognostic-Level III

Purpose: A rigid clubfoot is the most frequent foot deformity in both spina bifida (SB) patients and arthrogyposis (ART). In comparison to favorable results with the Ponseti method for idiopathic clubfoot, SB and ART have a higher recurrence rates. The recurrent deformity in SB and ART is often more severe, rigid and requires a talectomy. The purpose of this study was to investigate the long term clinical outcomes of talectomy in SB and ART, and identify clinical factors associated with favorable outcomes.

Methods: A retrospective chart review was performed between 1975 and 2010. Cases of clubfoot in SB and ART patients were excluded if follow-up was <5 years or had incomplete charts. Patients were divided into follow-up groups: A <15 years and B ≥ 15 years. A plantigrade, stable and braceable foot was graded as a “good result” by the senior surgeon. Statistical analysis consisted of descriptive statistics, ANOVA for continuous variables and Chi-square or Fisher’s exact tests for categorical variables with $p < 0.05$ reaching significance.

Results: A total of 944 cases of clubfoot in SB and ART were identified. Of those, 53 underwent talectomy and 31 feet were included in the final analysis. Group A: 16 feet (51.6%), mean follow-up 9.0 years. Group B: 15 feet (48.4%), mean follow-up 22.9 years. “Good results” were found in 24 (77.4%) feet. Age ≥ 5 years at time of surgery was associated with good results ($p=0.026$). Primary talectomy was associated with less surgeries per foot when compared with salvage talectomy (relative risk of 1.67 vs 2.60, $p=0.003$). A Functional Mobility Scale (FMS) of 3-1-1 or higher was associated with a good outcome ($p=0.009$). All “poor results” (7 feet, 22.6%) were found in patients with FMS lower than 3-1-1. Comparison between mid-term and long-term follow-up and diagnosis did not show significant differences regarding outcomes. Table 1.

Conclusions: A talectomy was performed in 5.6% of cases, demonstrating its rare use for clubfoot treatment in SB and ART. Nevertheless, these long-term outcomes support talectomy for the treatment of a rigid, non-idiopathic clubfoot deformity. Performing a primary talectomy has favorable outcomes in select cases as it reduces the number of total surgeries required.

Significance: Good clinical outcomes after talectomy are maintained beyond 15 year follow-up, suggesting that when appropriately treated, deformity correction is maintained into adulthood. Additionally, a higher functional mobility score was a good predictor of success of talectomy suggesting that this procedure can and should be performed in ambulatory patients.

Table 1: Clinical Outcome Comparison between Follow-up Groups and Diagnosis Groups

Follow-up	Good Result	Presence of Pain	Poor brace wear	Pressure ulcer
Mid-term < 15 years	12/16, 75%	0/16, 0%	2/16, 12.5%	2/16, 12.5%
Long-term ≥ 15 years	12/15, 80%	3/15, 20%	2/15, 13.3%	1/15, 6.6%
	$p=0.74$	$p=0.06$	$p=0.94$	$p=0.58$
Diagnosis	Good Result	Further surgery required	Deformity Recurrence	
Spina Bifida (SB)	15/18, 83.3%	5/18, 27.8%	10/18, 55.6%	
Arthrogyposis (ART)	9/13, 69.2%	7/13, 53.8%	7/13, 53.8%	
	$p=0.35$	$p=0.14$	$p=0.93$	

Clubfoot Activity, Recurrence & Exercise (CARES): A Pilot Study This study investigates whether patient/parent reported outcomes (PROs) and activity levels for children with clubfoot are different in patients treated for relapse. It also proposes a method to assess outcomes remotely.

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LOE-Prognostic-Level II

Purpose: This study investigates whether patient/parent reported outcomes (PROs) and activity levels for children with clubfoot who are treated for relapse are different than patients who did not relapse. It also proposes a method to assess clubfoot outcomes remotely.

Methods: CARES is an observational, cohort study to compare PROs and physical activity in 25 clubfoot patients with and without relapse over two weeks using Fitbits®. Recruited participants are 5 to 10 years old, diagnosed with idiopathic clubfoot at birth and had last clubfoot treatment at least 6 months ago. Participants with relapsed clubfoot had additional casting or surgical correction. Consented participants completed a demographics survey, Child Health Questionnaireä, and the clubfoot disease-specific instrument. A package was shipped to them, including a daily activity journal and a Fitbit®. Participants wore their Fitbit® at all times for 14 consecutive days, and activity was monitored through Fitabase.

Results: Participants with and without clubfoot relapse had similar daily step counts ($12,040 \pm 3,847$ vs $11,124 \pm 3,744$ steps), distance walked (6.3 ± 1.6 vs 5.5 ± 1.6 Km), and similar step intensities. Total steps, total distance, distances (very active, moderately active), minutes (very active, moderately active), and lightly active step intensity were significantly higher for patients whose families make more than \$100,000 per year, adjusting for treatment, height, and sex of the child. Participants reported various daily activities: swimming, dancing, football, soccer, basketball, softball, rope jumping, running, parkour, hiking, karate, wrestling, trampoline, surfing and jiu-jitsu. Neither demographics, clubfoot disease-specific instrument scores or the Child Health Questionnaireä scores differed significantly between the two groups. Physical functioning, bodily pain, self-esteem, parent impact (emotional & time), and family activities were positively associated with clubfoot disease instrument scores ($p < 0.05$ for all).

Conclusions: Children corrected with Ponseti method for clubfoot who are treated for relapse have comparable physical activity and PROs to clubfoot children who have not relapsed. Step counts are comparable to the general pediatric population. These reassuring findings can guide conversations with parents when addressing their concerns regarding expected outcomes and physical activity post-clubfoot relapse and surgery. Clubfoot outcomes and activity levels in children can be assessed remotely, which may facilitate multicenter studies.

Significance: Prospective study of 5-10 year old clubfoot patient-reported outcomes and activity levels found no difference in patients who were treated for relapse when compared to patients who did not relapse, and a “real-world” assessment of clubfoot patient activity showed levels similar to general pediatric populations.

The Atypical Clubfoot: Is it doomed from the start?

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LOE-Therapeutic-Level IV

Purpose: The treatment of the atypical clubfoot presents a challenge for many pediatric orthopedists. Characterized by severe equinus, supination, a shortened forefoot and a deep medial to lateral plantar crease, the atypical foot often proves recalcitrant to conventional casting. The modified Ponseti maneuver may be implemented once a diagnosis of atypical is made, altering both the casting and orthosis phase of treatment. We hypothesize that if diagnosed early and treated appropriately, the atypical foot has no greater risk for revision surgery than the typical foot.

Methods: We retrospectively identified 113 consecutive patients with congenital clubfoot (170 feet) from a single institution with one treating orthopedic surgeon and a minimum of two years follow-up. All patients were treated with the Ponseti method and Achilles tenotomy prior to transition into boots and bars. Chart review was undertaken by two fellowship trained pediatric orthopedic surgeons. Demographics included age at treatment onset, sex and clubfoot laterality. Patient characteristics included number of casts pre tenotomy, radiographic dorsiflexion improvement post tenotomy, and need for/type of revision surgery. For the atypical group, the cast number at initial diagnosis was recorded. Continuous variables were compared with Student's t-test, while categorical variables were compared with chi-square analyses.

Results: In total, 140 (82%) feet were diagnosed as typical and 30 (18%) atypical. The average age at onset of treatment was 3 weeks for both groups ($p = 0.691$) with similar breakdown of male (79% vs 70%) and female (21% vs 30%) patients ($p = 0.311$). The average number of casts prior to tenotomy was 6 ± 2 in both groups ($p = 0.235$). After tenotomy, the average degree improvement in dorsiflexion was 17.5 degrees in the typical group versus 21.8 degrees in the atypical group ($p = 0.034$). The average number of casts prior to the atypical diagnosis was $4 (\pm 1)$. There were 21 (15%) feet that required revision surgery in the typical group versus 10 (33%) feet in the atypical group ($p = 0.018$). When revision surgery was performed on the typical group, 38% required joint opening procedures versus 60% in the atypical group ($p = 0.014$).

Conclusions: Though post-tenotomy dorsiflexion improvement was statistically greater amongst atypical feet, revision surgery was done more often in this group and required more extensive surgical techniques.

Significance: Expedient diagnosis of the complex foot and conversion to the modified Ponseti maneuver, while critical, may not lower revision surgery rates to the level of the typical foot.

Table 1. Patient Demographics

	Clubfoot (n= 140)	Atypical Clubfoot (n=30)	P-value
Age at Treatment Onset in Weeks (SD)	3 (\pm 5)	3 (\pm 2)	0.691
Sex			0.311
Male	110 (79%)	21 (70%)	
Female	30 (21%)	9 (30%)	
Clubfoot Laterality			0.308
Left	65 (46%)	17 (57%)	
Right	75 (54%)	13 (43%)	

Table 2. Casting and Revision Results

	Clubfoot (n= 140)	Atypical Clubfoot (n=30)	P-value
Casts Prior to Tenotomy (SD)	6 (\pm 2)	6 (\pm 2)	0.235
Improvement Post Tenotomy (Degrees)			
Right Foot	17.5 (\pm 7.1)	21.8 (\pm 7.8)	0.034
Left Foot	17.4 (\pm 6.3)	21.2 (\pm 6.5)	0.047
Revisions	21 (15%)	10 (33%)	0.018
Type of Revision			
Repeat casting	4 (19%)	2 (20%)	0.244
Open soft tissue surgery/joint-sparing	9 (43%)	2 (20%)	0.848
Open joint surgery	8 (38%)	6 (60%)	0.014

Acetabular Coverage Decreases at the End of Skeletal Growth: a 3D CT Study of Healthy Hips

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LOE-Diagnostic-Level III

Purpose: This study aimed to use 3D CT reconstructions to identify the acetabular lunate cartilage and measure its size at varying ages of development and between sexes to provide a baseline for evaluating patients with symptomatic hips.

Methods: Patients aged 10-18 years with asymptomatic hips and a CT pelvis for appendicitis were reviewed. Patients were stratified by sex and age: preadolescent (10-12), young adolescent (13-15), and old adolescent (16-18) in equal proportions. Materialise 3-matic was used to generate a 3D pelvic model (Figure 1A), and the acetabular lunate cartilage surface area was calculated (Figure 1B). The lunate cartilage was divided into anatomic segments: superior (11:00–1:00), anterior (1:00–4:00), and posterior (8:00-11:00) (Figure 1C). The femoral head surface area was calculated to control for patient size. Mixed effects models were generated predicting segment size where side was treated as a repeated measure. Absolute and relative (lunate cartilage to femoral head) models were generated.

Results: 62 patients (124 hips) were included. Females showed a significant decrease in femoral head coverage as age increased overall and in the 3 subsegments. The majority of changes occurred between the preadolescent and young adolescent groups. Males did not show an overall change, but the superior and anterior anatomic subgroups showed a significant decrease in coverage between the young and old adolescent groups. Male lunate cartilages were absolutely, but not relatively, larger than females. No clinically significant side-to-side differences were noted.

Conclusions: The relative femoral head coverage by the acetabular lunate cartilage reduced with increasing age, suggesting the growth of the femoral head outpaces that of the acetabular lunate cartilage. This was more prominent in females. This study has important implications for expected acetabular coverage changes in the latter aspects of pediatric and adolescent development.

Significance: The size of acetabular lunate cartilage found in preadolescent, young adolescent, and old adolescent healthy hips may serve as a reference for comparison when evaluating patients with potential developmental hip dysplasia and femoroacetabular impingement.

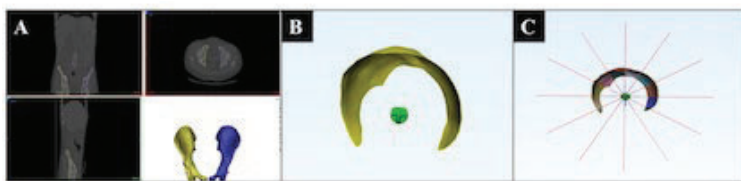


Figure 1. Generation of 3D Pelvic Model and Calculation of Lunate Cartilage Coverage. **A.** Segmentation of a patient's right and left pelvis from a CT scan, using Materialise Mimics. **B.** Acetabulum lunate cartilage following trimming in 3-matic. **C.** Lunate cartilage division into anatomic segments.

Patients That Undergo Concomitant Hip Arthroscopy and Periacetabular Osteotomy Obtain Minimal Clinically Important Difference More Than Patients That Undergo Isolated Periacetabular Osteotomy: An analysis of 231 hips

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LOE-Therapeutic-Level IV

Purpose: The purpose of this study is to elucidate the risk factors for patients that do not obtain minimal clinically important difference (MCID) after undergoing periacetabular osteotomy (PAO) surgery.

Methods: Patients undergoing PAO for acetabular dysplasia were enrolled prospectively from a single-center, institutional hip preservation registry. The modified Harris Hip Score (mHHS) and International Hip Outcome Tool (iHOT-33) were collected at baseline and at annual post-operative intervals starting 1 year after surgery. Based on a previous study from our institution the threshold for meeting MCID was 9.6 for mHHS and 22.9 for iHOT. If the patient did not meet MCID for either mHHS or iHOT at any time point, they were considered as a patient that did not meet MCID. These patients were compared to patients that did meet MCID for mHHS and iHOT. Chart review was performed to assess if any of the following was a significant risk factor for not obtaining MCID: Gender, PAO vs concomitant hip arthroscopy and PAO (Scope/PAO), Osteochondroplasty, Mental Health, Prior Ipsilateral Surgery, Prior Contralateral Surgery, Lateral Center Edge Angle at Baseline, Lateral Center Edge Angle Post Op, Pre-operative CT measurements (Alpha Angle, Acetabular Version at 1,2, and 3 o'clock).

Results: There were 231 hips included in the study. The average age of hips at the time of surgery was 26.3 (SD 26.5). Of the 231 hips in the study, 188 (94%) were female. 200 hips obtained MCID and 31 hips did not meet MCID (86.5% of patients met MCID). The only significant difference between patients that met MCID vs those that did not was in patients that underwent a Scope/PAO vs PAO. Those that had a scope/PAO were more likely to meet MCID than patients that underwent an isolated PAO (93.4% vs 84.5%; $p=0.049$). All other variables assessed did not reach significance.

Conclusions: Overall, the vast majority of patients that underwent a PAO met MCID. Patients that underwent scope/PAO met MCID at a higher rate than those that underwent an isolated PAO.

Significance: Appropriate indications is paramount to obtaining MCID in post-operative PAO patients. At our institution a concomitant scope/PAO is indicated when intra-articular pathology (i.e. labral tear) is elicited on physical exam and demonstrated on imaging. Patients indicated for scope/PAO have a significantly better rate of meeting MCID.

Intermediate Term Results of Combined Surgical Dislocation and Periacetabular Osteotomy for Complex Perthes Deformities: Can We Save the Hip?

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LOE-Prognostic-Level II

Purpose: Residual Legg-Calve-Perthes (LCP) deformities in skeletally mature patients represent one of the most challenging disorders in hip reconstruction surgery. In severe cases combined instability (acetabular dysplasia) and multifocal FAI (proximal femoral deformities) require correction on both sides of the joint. Optimal surgical strategies have not been determined and published surgical outcomes are very limited. The purpose of this study was to analyze deformity correction, mid-term PROs, complications and failures associated with a combined surgical dislocation (SD) and periacetabular osteotomy (PAO) for comprehensive treatment of severe, residual LCP deformities.

Methods: We reviewed prospectively collected data on 32 hips with complex LCP deformities. The average age was 21 (range 13-36), 56% female and minimum 5 year follow-up. All were treated with combined SD/PAO for concurrent instability and complex FAI. 44% had previous surgery. Treatment included femoral head reshaping, relative neck lengthening, trochanteric advancement, management of intra-articular lesions and PAO. PROs (HHS, UCLA and WOMAC), radiographs, complications and failures were analyzed.

Results: At an average 8.3 years, 87% of hips were preserved and 13% had THA. Average HHS increased from 61 to 80 ($p<0.001$). The surviving 87% hips had a final average HHS of 81 and WOMAC-pain improved from 62 to 80 ($p<0.001$). UCLA (7.5-8.6) and WOMAC-function (67-82) scores increased but not statistically ($p=0.2$). Major correction was observed with average improvements of acetabular inclination 9° , LCEA 21° , extrusion index 20%, ACEA 24° and trochanteric height 18mm (all, $p<0.001$). Major complications included one deep infection, one hip arthroscopy for labral tear and one superficial wound dehiscence. There were no nerve palsies, thromboembolic events, fractures or nonunions. Four hips required THA (including the one infection).

Conclusions: At intermediate follow-up combined SD/PAO for complex LCP deformities preserves 87% of hips and provides reliable deformity correction, major pain relief, and acceptable complication/failure rates.

Significance: At intermediate follow-up, combined SD/PAO for complex LCP deformities preserves 87% of hips and provides reliable deformity correction, major pain relief, and acceptable complication/failure rates.

Analyzing Impingement Patterns and Planning Corrective Osteotomy Using Patient-specific 3-Dimensional CT Models for Collision Detection in Patients with Severe Slipped Capital Femoral Epiphysis

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LOE-Diagnostic-Level III

Purpose: Residual deformity after SCFE may lead to femoroacetabular impingement (FAI) and articular cartilage damage. We investigated the hip motion, location of impingement, and quantification of the obligatory external rotation in hips with severe SCFE. We further investigated the improvement of impingement-free motion after an isolated osteochondroplasty, after isolated derotation osteotomy, and combine flexion-derotation osteotomy.

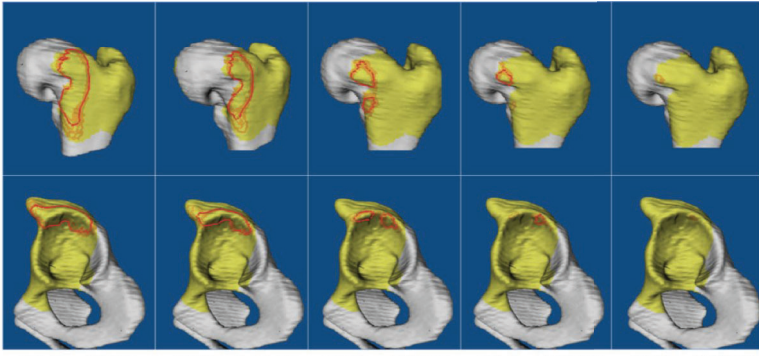
Methods: This is a retrospective IRB-approved study of 3D-CT of 20 hips of 17 patients with severe SCFE (slip angle $>60^\circ$). Mean age was 13 ± 2 years, and 67 % were males. The contralateral hips of the 15 patients with unilateral SCFE were used as controls. We used a semi-automatic 3-D reconstruction and a collision detection software to determine impingement-free flexion and internal rotation in 90° of flexion (IRF- 90°). Internal rotation in 0° , 30° , 60° and 90° of flexion was used quantify the obligatory external rotation sign. A simulation of an isolated osteochondroplasty, femoral osteotomy with derotational, and osteotomy with derotational and flexion components was performed with specific software.

Results: Impingement-free flexion ($26 \pm 32^\circ$, range -20 – 93 vs. $102 \pm 9^\circ$, range 87 – 118 ; $p < 0.001$) and IRF- 90° ($-23 \pm 15^\circ$, range -63 – 5 vs. $18 \pm 11^\circ$, range 5 – 38° ; $p < 0.001$) were significantly reduced in severe SCFE compared to the control hips. Impingement was observed in the superior-anterior (1-3 o'clock) with as low as 30° of flexion. With increased flexion, the zones of impingement were more anterior and inferior (obligatory external rotation sign). Simulation of isolated osteochondroplasty did not significantly improve impingement-free motion. Impingementfree flexion increased significantly ($p < 0.001$) from 24° to 82° after simulation of a derotational osteotomy (20° correction). However, impingement free IRF- 90° was only improved to 3° . Adding a 30° flexion and 30° derotational correction increased the impingement-free flexion from 24 to 118° ($p < 0.001$) and the impingement-free IRF- 90° from -23 to 16° ($p < 0.001$).

Conclusions: Patient-specific 3D models and collision detection software facilitate diagnosis of FAI patterns and surgical planning for patients with severe SCFE. Impingement-free flexion is majorly restricted in severe SCFE (impingement may occur as early as 30 degrees). Isolated osteochondroplasty or isolated derotational osteotomy did not restore normal range of impingement-free motion. Although planning should be patient-specific, in general, we found that a minimum 30° flexion and 30° derotational should be performed at the time of osteotomy to achieve normal range of hip motion without impingement.

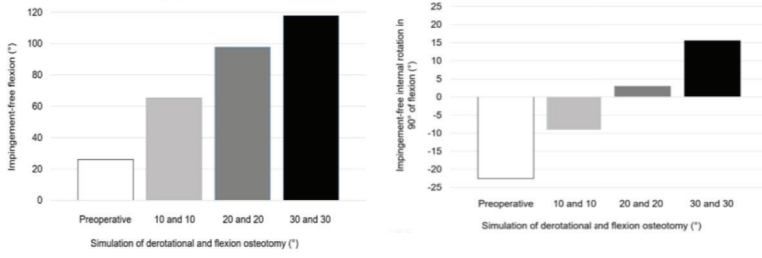
Significance: Patient-Specific 3-D modeling and collision detection software may improve the surgical management of patients with severe SCFE by allowing for precise simulation of procedures necessary to achieve an impingement free motion.

Patient-specific 3D-CT model and collision detection software



90° F and 0° ER 90° F and 10° ER 90° F and 20° ER 90° F and 30° ER 90° F and 40° ER

Simulation of combined derotation and flexion osteotomy



Surgical Hip Dislocation Combined with Femoral Head Osteoplasty and Intertrochanteric Osteotomy as a Delayed Reconstruction of Slipped Capital Femoral Epiphysis (SCFE)-induced femoroacetabular impingement (FAI): a 10-year Experience

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LOE-Therapeutic-Level III

Purpose: Slipped Capital Femoral Epiphysis (SCFE) is most commonly acutely stabilized by in-situ surgical fixation (percutaneous pinning with a single screw). Yet, SCFE-induced late-onset femoroacetabular impingement (FAI) due to the residual deformity has been increasingly recognized as a cause of pain and disability in this population. There is no consensus regarding its treatment and various techniques have been reported. In this study, we present our 10-year experience with a combination of surgical hip dislocation, open osteoplasty (SDO) with or without intertrochanteric osteotomy (SDOIO) in order to address both aspects of the proximal femoral deformity.

Methods: Children with SCFE-induced FAI and late surgical reconstruction (SDO or SDOIO) by a single surgeon between 2010 and 2020 were retrospectively reviewed. Clinical data were collected: demographics, comorbidities, functional outcome (Merle d'Aubigné-Postel). Radiographic measurements were made pre and post-surgical stabilization, pre and post-reconstruction, and at last follow-up: epiphyseal-slip angle (ESA), neck-shaft angle (NSA), articular surface to trochanter distance (ASTD), medial proximal femoral angle (MPFA), alpha angle. Continuous data before and after surgery were compared by a paired t-test (significance set at 0.05).

Results: Eighteen patients (9 females, 9 males) and 19 reconstruction cases (14 SDOIO and 5 SDO) were included. Seven patients (38%) had bilateral SCFE. Average BMI was 31.1 ± 7.6 kg/m². One patient had avascular necrosis (AVN) of the femoral head prior to the reconstruction. Elapsed time between SCFE presentation and reconstruction was 2 ± 2.4 years (range: 1 month-10 years). Age at surgery was 14 ± 2.4 years. Operative time was 147 ± 30 min. Blood loss was 347 ± 176 mL. No perioperative complications were recorded. At last follow-up (22.7 ± 18.2 months), compared with preoperative baseline values: ESA decreased by $27.5 \pm 38\%$ ($p < 0.05$) and ASTD increased by $6.9 \pm 9^\circ$ ($p < 0.05$). NSA, MPFA, and alpha angles did not vary significantly. There was no AVN post-SDOIO. There were four revisions (surgical site infection, revision osteotomy, redislocation with osteoplasty, and revision osteotomy). The Merle d'Aubigné-Postel score significantly improved after proximal femoral reconstruction (11.5 ± 4.5 vs 14.5 ± 0.5 , $p < 0.01$).

Conclusions: This study suggests that combining surgical dislocation, osteoplasty, and osteotomy to address the post-SCFE residual deformity of the femoral head is an effective and safe method to improve long-term radiographic parameters and functional outcome.

Significance: This is the first study reporting both clinical and radiographic outcomes of this specific combined reconstruction strategy for SCFE-induced FAI. Further controlled studies are required to assess the performance of this strategy versus arthroscopic treatment or femoral osteotomies alone.

Capital Realignment for High Grade Slips Using Anterior Approach and Subcapital Osteotomy

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LOE-Therapeutic-Level IV

Purpose: In recent years Safe surgical dislocation has been aggressively reported to be utilized for Capital realignment procedure for severe slipped capital femoral epiphysis. Complications like Avascular Necrosis of femoral head and neurapraxia are still an issue. Moreover longer learning curve and complexity of the procedure makes it difficult for Young pediatric orthopaedic surgeons to adopt it. In this paper we discuss use of anterior hip approach to perform realignment osteotomies for severe slips and its results

Methods: 42 hips treated with subcapital osteotomy and re-alignment procedures by anterior approach for severe : acute, acute on chronic SCFE were studied retrospectively and assessed for a minimum follow up of 2 years and rate of complications like AVN, Chondrolysis ,FAI and Implant Failure were studied. Harris Hip Score was used to assess functional outcome. Mean Pre OP and post slip Capital Realignment angle were assessed.

Results: In our series of 42 hips all were available for two year follow ups. Mean slip angle correction achieved was 29.7 degrees(range 23.5 to 33.2deg). four (9.5%)had AVN,1(2.4%) chondrolysis and none had implant failure or FAI at two year follow up. The Harris Hip Score was good to excellent in 38 (90.4%) of hips.

Conclusions: The anterior approach can be used as a safe approach for subcapital osteotomy and re-alignment procedures with comparable complication rates. It is also a less complex and more familiar approach to most surgeons than the safe surgical dislocation approach

Significance: The anterior approach to the hip is a familiar approach to most Pediatric Orthopaedic Surgeons as a standard approach to deal with Open reduction of DDH, Septic Arthritis drainage , and Open reduction and Fixation of Fracture neck femur. Severe grade SCFE poses a challenge as the Capital realignment using Modified Dunn procedure through the SSD approach as popularised by Ganz et al , needs a larger learning curve fraught with dangers of AVN & other complications varying from 5-45%.as reported from various centres. We present a method to achieve same correction through an anterior approach with AVN rates of about 10 % and a 2 year review of results in 42 consecutive cases.

The Role of the Artery of Ligamentum Teres in Revascularization in Legg-Calve-Perthes Disease

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LOE-Prognostic-Level III

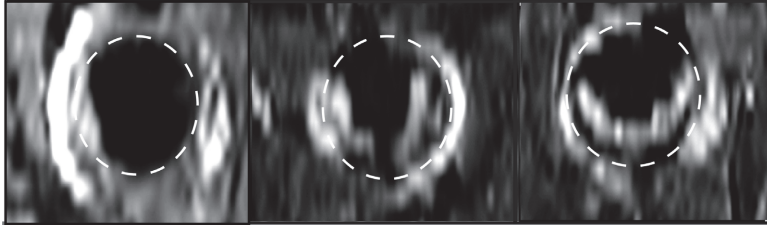
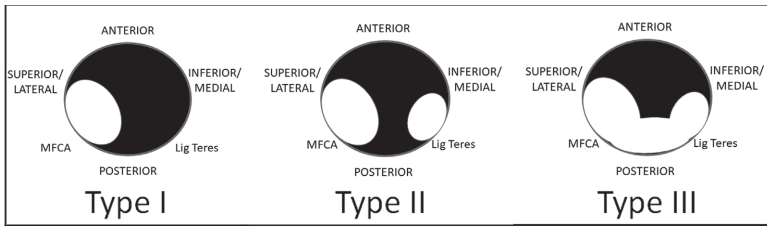
Purpose: Historical anatomic literature suggests that the artery of ligamentum teres supplies the capital femoral epiphysis (CFE) in the minority of immature hips. However, a recent cadaveric study supported that most immature hips are supplied by the artery of ligamentum teres and suggested that this medial vascular source may influence the pattern of revascularization in Legg-Calve-Perthes Disease (LCPD). The purposes of this study were to characterize the perfusion pattern of the CFE and to determine the role of the artery of ligamentum teres in early revascularization of LCPD.

Methods: Retrospective review of perfusion MRI (pMRI) from 64 hips in early stage LCPD (Waldenstrom Stage I-IIa) was performed. Two independent graders determine the presence of one of three patterns of perfusion based on the presence of perfusion medially (from artery of ligamentum teres) or laterally (from the medial femoral circumflex artery/MFCA) on coronal and sagittal MRI series: Type I – lateral perfusion only, Type II – separate medial and lateral perfusion, or Type III – coalescent medial and lateral perfusion (Figure). Lateral pillar classification was obtained for the 60 hips that reached late fragmentation.

Results: We identified 64 patients (75% male) with mean age at diagnosis of 8.5 ± 2.1 yrs (range 5.1 – 14.1 yrs). 36% (23/64) hips underwent pMRI during Stage I and 64% (41/64) during Stage IIA. Perfusion MRI revealed separate and distinct medial and lateral sources of perfusion (Type II) in 50% (32/64) hips. In Stage I, the distribution of Type I/II/III hips was found to be 26%/52%/22%. However, in Stage IIA there was a non-significant trend towards greater coalescence of the medial and lateral perfusion with a distribution of Type I/II/III of 7%/49%/44% ($p=0.057$). During late fragmentation stage, the distribution of Lateral Pillar B, B/C, and C hips was 38%/37%/25%. There was a weak, but significant negative linear correlation between perfusion type and lateral pillar classification ($r= -0.30$, $p=0.02$). A kappa value of 0.92 confirms excellent agreement between grader in classifying perfusion category.

Conclusions: The presence of separate and distinct areas of perfusion of medial and lateral CFE provides further evidence of the important role of the ligamentum teres vessels in revascularization during the early stages of LCPD. The changes in perfusion pattern with disease progression likely reflect that MFCA and ligamentum teres vessel revascularization occur separately, but ultimately coalesce posteriorly over time.

Significance: This study furthers our understanding of the mechanism of revascularization of CFE in LCPD.



Axial reconstructions of perfusion MRI in early stage Perthes Disease reveal three patterns of perfusion. MFC = medial femoral circumflex artery; Lig Teres = Ligamentum teres

Hip morphology in early-stage LCPD: Is there an argument for anatomic-specific containment?

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LOE-Not Applicable-Level IV

Purpose: Early containment surgery has become increasingly popular in Legg-Calvé-Perthes Disease (LCPD), especially for older children. These procedures can target the proximal femur, the acetabulum, or both, and most surgeons endorse the same surgical option regardless of the individual anatomy of the patient in question. This “one-surgery-fits-all” approach, however, fails to consider potential variations in baseline anatomy that may make one surgical option more sensible than another. Therefore, the purpose of this study was to describe hip morphology in a large series of children with newly-diagnosed early-stage LCPD, hypothesizing that variations in anatomy may support the concept of anatomic-specific containment.

Methods: A retrospective review of a prospectively-collected multicenter database was conducted for patients aged 6-11 at diagnosis. To assess anatomy prior to morphologic changes secondary to the disease itself, only patients in Waldenstrom stages IA/IB were included. Standard hip radiographic measurements including acetabular index (AI), lateral center-edge angle (LCEA), proximal femoral neck-shaft angle (NSA), and articulo-trochanteric quartiles (ATQ) were made on printed AP pelvis x-rays using pencils and hand-held goniometers. Age-specific percentiles were calculated for these measures using published population norms. Significant outliers (<10th percentile or >90th percentile) were reported where applicable.

Results: A total 168 patients with mean age at diagnosis of 8.0 ± 1.3 years met inclusion criteria (81.5% male). Mean AI for the entire cohort was $16.8 \pm 4.1^\circ$; 58 hips (34.5%) were significantly dysplastic compared to normative data. Mean LCEA was $15.9 \pm 5.2^\circ$ at baseline; 110 (65.5%) were <10th percentile indicating dysplasia (according to this metric). Mean NSA overall was $136.5 \pm 7.0^\circ$. Fifty-one (30.4%) and 20 (11.9%) hips were significantly varus (<10th percentile) or valgus (>90th percentile) respectively. Thirty-five hips (20.8%) were the 3rd ATQ or higher suggesting a higher trochanter at baseline. All metrics were subdivided into two separate age cohorts (6.00-7.99 and 8.00-10.99 years) for reporting purposes (Table 1).

Conclusions: The present study finds significant variation in baseline hip anatomy in children with early-stage LCPD, including a high prevalence of coexisting acetabular dysplasia as well as high/low NSAs.

Significance: These morphologic variations suggest that the “one-surgery-fits-all” approach to surgical containment may lack specificity for a particular patient. Matching a specific containment operation to a patient’s individual anatomy may be preferable (e.g. acetabular-sided osteotomy for coexisting dysplasia, varus femoral osteotomy for valgus NSA). Further study is necessary to determine whether anatomic-specific containment actually improves clinical outcomes.

Table 1. Baseline Hip Morphology in Early-Stage LCPD by Age Group

Values reported as number (%) or mean \pm SD.

Variable	Ages 6-8	Ages 8-11
N	93	75
Acetabular Index (deg)	17.1 ± 4.4	16.4 ± 3.8
≥90 th percentile (%)	30 (32.3)	28 (37.3)
Lateral Center Edge Angle (deg)	16.3 ± 5.6	15.5 ± 4.8
≤10 th percentile (%)	57 (61.3)	53 (70.7)
Neck Shaft Angle (deg)	136.0 ± 6.6	137.1 ± 7.4
≤10 th percentile (%)	34 (36.6)	17 (22.7)
≥90 th percentile (%)	5 (5.4)	15 (20.0)
ATD Quartile	2.0 ± 0.6	2.1 ± 0.5
Hips 3 or above (%)	20 (21.5)	15 (20.0)

Reliability and Validity of Assessment of Legg-Calve-Perthes Disease Hypoperfusion with Perfusion MRI

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International Perthes Study Group, Dallas, TX*

LOE-Diagnostic-Level III

Purpose: The treatment of Legg-Calve-Perthes disease continues to be controversial. Assessing the severity of the disease is an important component of decision-making for surgery. The use of perfusion MRI scans has improved our ability to assess the hypoperfusion of the femoral head, and the use of graphical analysis software has allowed even more precise quantification for research purposes. In the clinical setting, however, visual estimation is used to assess the hypoperfusion on perfusion MRI. Currently, the reliability of visual estimation method is unknown. The purpose of this study was to determine the reliability of visual estimation of hypoperfusion on perfusion MRI scans, and compare the results to measurements obtained with the HipVasc software (Texas Scottish Rite Hospital for Children, Dallas, TX).

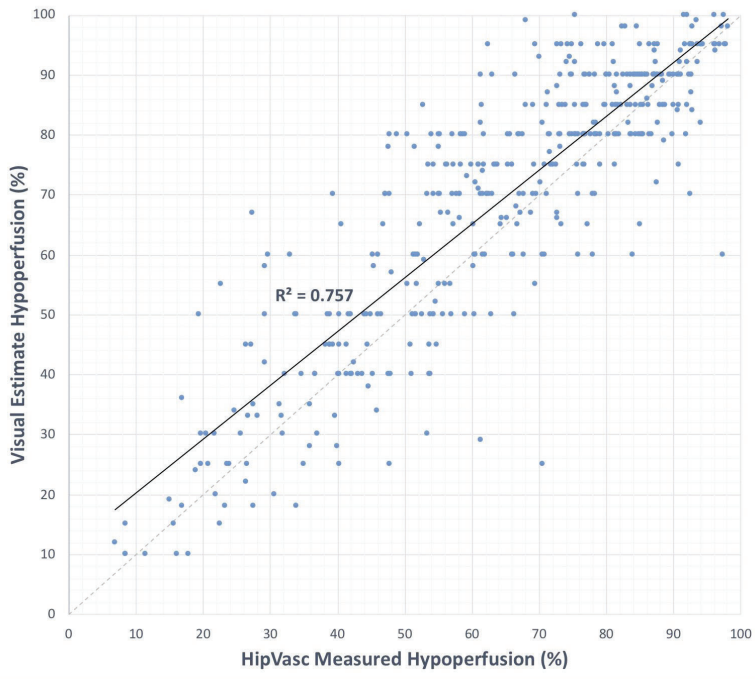
Methods: Fourteen pediatric orthopedic surgeons participated in this study and were divided into four working groups. Stratified by category of severity, 122 MRIs were randomly assigned to one of the four groups so that each group measured the same set of approximately 30 MRI scans. Each surgeon completed a 30-minute in-person training on the imaging analysis software before proceeding with data collection. The estimation of visual hypoperfusion was provided, and then each surgeon documented the results from HipVasc analysis using the software output. Inter-observer reliability was assessed at the group level by calculating the intraclass correlation coefficient (ICC).

Results: Good correlation and reliability was found between the visual estimate and HipVasc measurements with an overall mean intra-class correlation coefficient of 0.87 and mean Pearson coefficient of 0.90. The mean inter-rater reliability of visual estimation was 0.84. Observers had a tendency to overestimate hypoperfusion with visual estimation.

Conclusions: This study demonstrates the reliability of visual estimation as a clinically applicable method for determining the femoral head hypoperfusion. However, the HipVasc software continues to be the gold standard for more reliable measurement of hypoperfusion for research purposes. Our study is the first to measure the reliability of visual estimation and HipVasc with a large cohort of clinicians, and specifically, pediatric orthopedic surgeons with varying levels of experience with computer graphical software analysis.

Significance: In summary, our study demonstrates the reliability of visual estimation as a clinically applicable method for determining the femoral head hypoperfusion on perfusion MRI. It is reliable and comparable to graphical software analysis. We would recommend using visual estimation as a clinically applicable method to make treatment decisions with accuracy comparable to HipVasc software analysis.

Visual Estimate vs. HipVasc Measured Hypoperfusion (%)
All Observers (n=14)



Self-Reported Physical Function Doesn't Correlate with Pain or Functional Limitations in Adolescents Undergoing Hip Preservation Surgery

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LOE-Prognostic-Level III

Purpose: To investigate the frequency of responses on questions involving the physical function of patients with hip pathology prior to undergoing hip preservation surgery (HPS).

Methods: Patients with hip pathology were prospectively enrolled in a HPS registry. Data analysis was performed on pre-operative data collected between 2007-2018. The following diagnoses were included: acetabular dysplasia (AD), femoroacetabular impingement (FAI), Legg-Calvé Perthes disease (Perthes). Patients with neurologic or syndromic conditions were excluded. Patients completed the modified Harris Hip Score (mHHS-80), UCLA activity scale, Western Ontario and McMaster Osteoarthritis Index (WOMAC). Table 1 lists the daily functional activities that were analyzed. A Kruskal-Wallis test compared the mHHS-80 and UCLA across the diagnoses ($\alpha=0.05$). A Chi-Square test compared the distribution of responses to each question across the diagnoses.

Results: 158 patients (avg. age 16 ± 3 yrs.; AD 59, FAI 65, Perthes 34 patients) met inclusion criteria. There was no statistical difference in the mHHS-80 (AD 51 ± 10 , FAI 48 ± 13 , Perthes 51 ± 7 , $p=0.28$) or UCLA activity score (AD 7 ± 3 , FAI 7 ± 3 , Perthes 7 ± 3 , $p=0.36$) across the groups. The majority of patients reported having moderate or greater pain in their hip (AD 75%, FAI 75%, Perthes 65%). In terms of sitting in a chair comfortably for 30 minutes, 41% of AD, 43% of FAI and 44% of Perthes patients reported that they were limited to that length of time. Patients reported having difficulty donning socks/shoes (AD 24%, FAI 43%, Perthes 41%) and indicated that they walked with a moderate or greater limp (AD 34%, FAI 29%, Perthes 53%). Moderate or greater pain during walking was prevalent across the diagnoses (AD 51%, FAI 59%, Perthes 47%). When navigating stairs, moderate or greater pain was reported in 56% AD, 62% FAI and 41% Perthes patients. There was a statistically significant difference in the distribution of the responses in terms of level of pain while sitting/lying; moderate or greater pain was reported in 29% AD, 51% FAI and 27% Perthes. While standing moderate or greater pain was reported in 39% AD, 51% FAI and 44% Perthes.

Conclusions: Adolescent patients presenting for HPS report significant daily functional limitations associated with moderate or greater pain. There were no correlations between reported pain and limitations to self-reported activity levels.

Significance: Self-reported physical function does not represent the entire functional capacity of an adolescent undergoing hip preservation surgery. Understanding the prevalence of functional limitations of these patients aids clinicians in establishing complete clinical assessments and helps in establishing postoperative expectations.

Variable	Acetabular Hip Dysplasia (AHD 59 patients)	Femoroacetabular Impingement (FAI 65 patients)	Legg-Calvé Perthes (Perthes 34 patients)	p-value
mHHS-80	51±10	48±13	51±12	0.282
UCLA Activity Score	7±3	7±3	7±3	0.364
Describe the pain in your hip?	None Reported	0	1 (3%)	0.551
	Slight/Mild	15 (25%)	15 (23%)	
	Moderate+	44 (75%)	49 (75%)	
Sitting tolerance	Unable	8 (14%)	4 (12%)	0.947
	< 30 Minutes	24 (41%)	15 (44%)	
	1 hour	27 (46%)	15 (44%)	
Donning shoes and socks	Easily	45 (76%)	20 (59%)	0.058
	Difficult	14 (24%)	14 (41%)	
How much do you limp?	None Reported	9 (15%)	3 (9%)	0.147
	Slight/Mild	30 (51%)	13 (38%)	
	Moderate+	20 (34%)	18 (53%)	
How much pain do you have walking on a flat surface?	None Reported	9 (15%)	6 (18%)	0.811
	Slight/Mild	20 (34%)	12 (35%)	
	Moderate+	30 (51%)	16 (47%)	
How much pain do you have going up/down stairs?	None Reported	12 (20%)	8 (24%)	0.090
	Slight/Mild	14 (24%)	12 (35%)	
	Moderate+	33 (56%)	14 (41%)	
How much pain do you have sitting or lying?	None Reported	20 (34%)	10 (29%)	0.043
	Slight/Mild	22 (37%)	15 (44%)	
	Moderate+	17 (29%)	9 (27%)	
How much pain do you have standing?	None Reported	11 (19%)	10 (29%)	0.322
	Slight/Mild	25 (42%)	9 (27%)	
	Moderate+	23 (39%)	15 (44%)	

Acetabular development following treatment of developmental hip dysplasia: Does the addition of bony surgery at index procedure decrease risk of secondary surgery?

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LOE-Therapeutic-Level III

Purpose: There is a lack of consensus on the optimal age for surgical treatment of developmental dysplasia of the hip (DDH) in the pediatric population. Controversy exists if bony surgery, such as a pelvic and/or femoral osteotomy, ought to be performed at the index procedure or based on further acetabular remodeling. The purpose of this study is to determine if addition of bony surgery at the index procedure affects the acetabular depth ratio (ADR) development compared to those who did not undergo bony surgery. Additionally, this study examined the predictive value of ADR two-years postoperatively regarding the risk of secondary bony surgery later in childhood.

Methods: 70 patients with DDH who underwent closed reduction only (CR, n=32), open reduction only (OR, n=31), or an open reduction with a concomitant bony osteotomy (ORB, n=7; pelvic only n=4, femoral only n=1, and combined pelvic/femoral n=2) as their index procedure at a single institution were retrospectively reviewed from 1/1/2004-9/23/2020. Acetabular Index (AI) and ADR were measured preoperatively, 1-year postoperatively, 2-years postoperatively, and at final follow-up. Cox-proportional hazards regression models were used to compare the hazard of secondary surgery across the three surgical groups and linear mixed models were used to test for changes in the radiographic parameters.

Results: The cumulative incidence of secondary surgery within five years of the index procedure was 31.3% (CR), 22.2% (OR), and 13.3% (ORB). After adjusting for age and baseline radiographic measurements, on average there was a significant decrease in AI ($p<0.000$) and a significant increase in ADR ($p=0.0446$) following surgery. However, the slope or change in radiographic parameters per month during the postoperative period was not significantly different across groups for the AI ($p=0.2031$) or ADR ($p=0.3621$) measurements (Figure 1). 8/9 (CR) and 3/8 (OR) secondary surgeries occurred prior to two years postoperatively. Finally, increased ADR at baseline was associated with increased risk of a secondary surgery during childhood.

Conclusions: Our results suggest that patients in the ORB cohort were less likely to undergo secondary surgery within the first five years after surgery. All three groups demonstrated a similar increased ADR and decreased AI over time. Further study is necessary to delineate how timing of pelvic and/or femoral osteotomy impacts final acetabular depth at skeletal maturity.

Significance: The present study suggests a decreased risk for secondary surgery during childhood for patients undergoing open reduction with concomitant bony osteotomy, with similar trend in radiographic improvement during initial years following the index procedure.

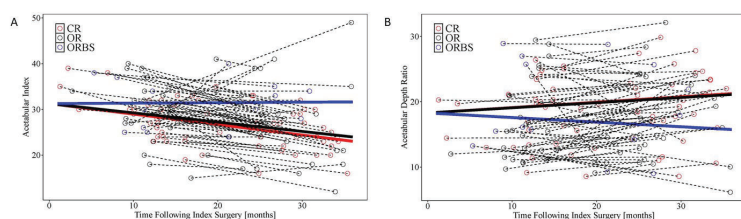


Figure 1. Changes in Acetabular Index (AI) and Acetabular Depth Ratio (ADR) Following Surgery: Figure 1a displays the overall average slope within each of the surgical groups (see blue, black, and red lines) for AI. Figure 1b displays the overall average slope within each of the surgical groups for ADR. The group specific slopes are adjusted for age at time of surgery and AI/ADR values prior to surgery. The dashed lines represent the subject specific slopes between the two post-surgical radiographs.

Quasi-static MRI Motion Analysis to Study Hip Translation and Its Association with Hip Rotation and Morphology

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LOE-Diagnostic-Level II

Purpose: Growing number of studies have shown significant hip translation in cadaveric models and in vivo. The presence of translation and coupled motion can completely change hip contact and impingement patterns, however we know little about how hip translation and rotation are related in normal and pathologic hips. Here we have used magnetic resonance imaging (MRI) to study hip translation during a range of physiologic movements in healthy asymptomatic subjects.

Methods: 11 subjects (23-47 years old; 36% female) with asymptomatic hips underwent hip MRI in the following postures: neutral (supine), mid-flexion, max-flexion, internal rotation, internal rotation + mid-flexion, internal rotation + max-flexion, adduction, FABER, extension, lateral abduction. Images were used to generate 3D hip models. All models for each subject were then co-registered and aligned based on their pelvis position (Figure 1A). Femoral head translations were then calculated in mm and percentage after normalizing to the acetabulum diameter.

Results: The femoral head translation ranged from 6mm posterior to 5mm anterior, from 6mm inferior to 7mm superior, and from 5mm medial to 4mm lateral (Figure 1B and 1D). These translations were less than 15% of the acetabular diameter (Figure 1C and 1E). Hip flexion was correlated with increased posterior translation ($R^2=0.23$, $P=0.005$; Figure 1F) and hip abduction was correlated with medial translation ($R^2=0.57$, $P=0.012$; Figure 1G). There were inverse associations between range of translation in anterior-posterior direction and the alpha angle ($R^2=0.55$, $P=0.014$; Figure 1H), superior-inferior translation and neck-shaft angle ($R^2=0.49$, $P=0.024$; Figure 1I), and medial-lateral translation with femoral anteversion ($R^2=0.45$, $P=0.033$; Figure 1J).

Conclusions: The observed significant translations suggest that the assumption of a fixed hip center of rotation does not seem to be physiologically relevant. Although small, these translations can significantly influence hip biomechanics and impingement, casting doubt on the validity and relevance of the existing impingement analysis algorithms which assume a fixed center of rotation for the hip joint. While the relationships between the rotational and translational motions were extremely complex, some associations were noted between the hip rotation and translational motions in certain positions that warrant further investigations. Interestingly, we saw associations between key morphological features of the proximal femur and range of hip translation, which can explain different movement patterns and hip biomechanics in people with different hip morphology.

Significance: The observed hip translations and their association with rotation and femur morphology have direct impact on understanding FAI pathology and optimizing current conservative and surgical treatment options to improve outcomes.

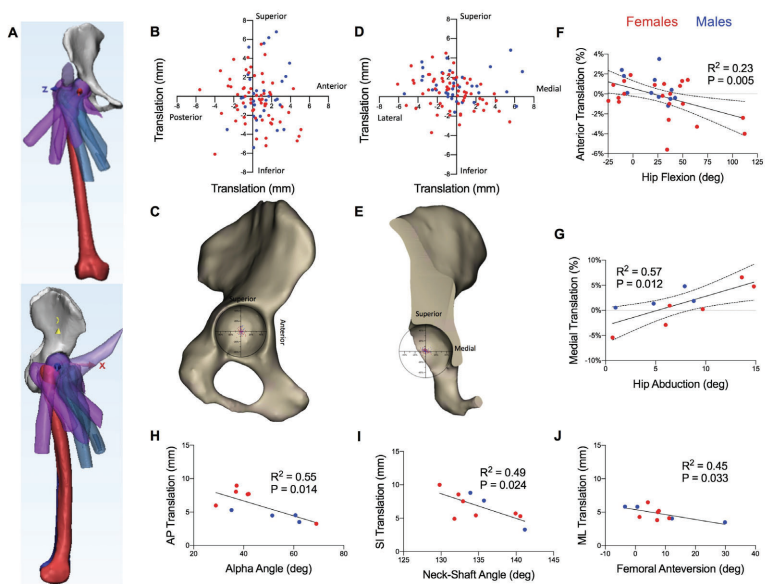


Figure 1. (A) 3D segmented bones registered based on pelvis geometry. Range of absolute (B and D) and normalized (C & E) femoral head translations. Associations between (F) normalized anterior translation and hip flexion (G) normalized medial translation and hip abduction, (H) range of anterior-posterior translation and alpha angle, (I) range of superior-inferior translation and neck-shaft angle, and (J) range of medial-lateral translation and femoral anteversion.

Severe Hip Subluxation in Non-Ambulatory Cerebral Palsy (CP): What Factors Lead to Lasting Success Of Reduction?

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LOE-Therapeutic-Level III

Purpose: Up to 80% of non-ambulatory children with spastic CP suffer progressive hip subluxation or dislocation which may lead to pain, seating imbalance, and hygiene issues. These children are commonly medically fragile, so determination of factors that lead to lasting hip stability after reconstruction is critical. Surgery usually includes varus rotational osteotomy (VRO) and soft tissue releases (STR); additional procedures such as pelvic osteotomy (PO) and capsulorrhaphy can increase blood loss, operative time, and complication rate. We studied the impact of various factors on the survivorship of hip reconstruction in patients with >50% initial migration percentage (MP).

Methods: 183 non-ambulatory children with CP underwent surgical reconstruction of 305 hips. 218 hips had initial MP over 50%, and an average follow-up of 6.5 years. Pelvic osteotomy consisted of Dega or Pemberton techniques. Survivorship was defined as a final MP of <25%. A stepwise regression model to assess age, gender, initial MP, capsulorrhaphy, STR, and PO was used to determine effects on final MP.

Results: Regression analysis showed that PO affected survivorship. 125 hips with initial average MP of 76.4% had PO while 93 hips with a significantly less average MP of 68.4% did not have PO ($p=0.0013$). Final average MP after hip reconstruction with PO was 21.8% which was significantly better than the 38.5% average without PO ($p<0.0001$). 86/125 PO hips met survivorship criteria compared with only 44/93 without PO (2.5 odds ratio, $p=0.0014$).

Conclusions: Pelvic osteotomies, combined with VRO, gave the best survivorship (final MP<25%) in severely subluxated hips in non-ambulatory CP children. Although hips that had PO were initially more severe, the final MP was significantly better in the PO group and odds of a successful outcome were improved by a factor of 2.5. This suggests that the added risk of PO during hip reconstruction has value in this fragile patient population. Reducing the risk of recurrence of deformity and the need for a second complex hip reconstruction is highly valuable. Although capsulorrhaphy has been suggested for high degrees of MP, our data does not show a significant benefit.

Significance: The addition of a reshaping PO is highly significant in the long-term survivorship of hip reconstruction on non-ambulatory children with CP.

3-D Acetabular Morphology of the Neuromuscular Hip: Implications for Pre-operative Planning

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Rady Children's Hospital-San Diego, San Diego, CA

LOE-Diagnostic-Level III

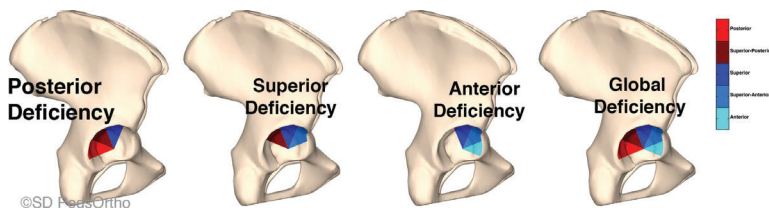
Purpose: To identify differences in three-dimensional (3-D) morphology between normal hips and dysplastic neuromuscular hips (NM DDH), specifically to identify the location of acetabular deficiency to guide pre-operative decision-making.

Methods: Patients treated for NM DDH at a single institution (2009–2017) with pre-operative high-resolution pelvic computed tomography (CT) scans were included. Dysplasia was defined by center-edge angle of $<25^\circ$ on antero-posterior radiographs. Custom software measured 3-D acetabular morphology including version, tilt, and surface area. Acetabuli were divided into equal octants and coverage angles were calculated for the five weight-bearing octants. Variables were compared with age- and sex-matched normal controls receiving pelvic CTs for non-orthopedic reasons. Over- or under-coverage was defined by acetabular coverage angles with Z-scores >2 or <-2 from normal controls.

Results: A total of 39 hips in 22 patients were identified (23 F, 16 M); mean age 12.0 ± 2.2 years (range: 8.1 to 16.2 years). Diagnoses were cerebral palsy (n=32), chromosome 8 partial deletion (n=2), muscular dystrophy (n=2), polio (n=2), and arthrogyrosis (n=1). Seventy-eight hips were used for normal controls. There was no difference in version (NM DDH $12.6 \pm 10.4^\circ$, Normal $14.3 \pm 6.6^\circ$; $p=0.53$) or tilt (NM DDH $35.8 \pm 6.9^\circ$, Normal $36.0 \pm 4.8^\circ$; $p=0.982$) between the NM DDH and control groups. Acetabular surface area was decreased in NM DDH (NM DDH $25.1 \pm 6.9^\circ$, Normal $29.5 \pm 5.6^\circ$; $p<0.001$). One hip (3%) was over-covered anteriorly. Three hips (8%) were retroverted (over-covered anteriorly and under-covered posteriorly) and three hips (8%) were anteverted (over-covered posteriorly and under-covered anteriorly). The remaining pathology was under-coverage located posteriorly [n=8 (21%)], superiorly [n=6 (15%)], anteriorly [n=7 (18%)], or globally [n=6 (15%)](FIGURE). Five hips (13%) had no sectors with abnormal coverage.

Conclusions: This study confirms the existence of posterior superior acetabular coverage deficiency in neuromuscular disease, described in previous publications. However, it also reveals the complex spectrum of deficiency, including anterior and global deficiencies, which can be difficult to appreciate without 3-D imaging. It is imperative to define the specific 3-D acetabular deficiency for each individual patient prior to surgical correction so the correct procedure can be selected and performed (i.e. Dega osteotomy for anterior superior deficiency, San Diego osteotomy for posterior superior deficiency, or Triple innominate osteotomy for posterior wall or global deficiency).

Significance: NM DDH is not merely isolated to the posterior-superior region. Individual patients have unique deformities that do not uniformly conform to a specific area of acetabular deficiency. It is essential to define the patient-specific 3-D acetabular deficiency location and magnitude for accurate pre-operative planning.



Hip Pain and Scoliosis in Non-Ambulatory Children with SMA

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LOE-Not Applicable-Level IV

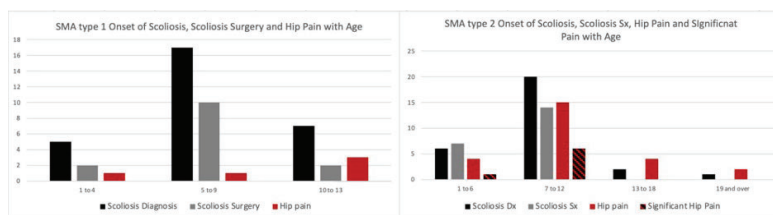
Purpose: To define the prevalence of hip pain in non-ambulatory (types 1, 2) children with SMA treated with aggressive modern medical management prior to widespread disease modifying drug use.

Methods: A single institution retrospective chart review (1993-2017) was performed on children diagnosed with SMA with minimum of two years clinical follow-up. Charts notes were used to identify subjective complaints of hip pain and interventions, while radiographs were evaluated to determine hip instability and spinal deformity.

Results: Seventy-two patients (33 type I, 39 type II) met inclusion criteria. 96% of patients were confirmed with genetic (N=61) or EMG/muscle biopsy (N=8). Average age at first and last clinic visit was 1.23 ± 1.82 and 9.56 ± 3.51 years for type 1 and 3.44 ± 4.24 and 15.81 ± 6.54 years for type 2. Hip pain was more frequent in type 2 (59% vs 15%, $p < 0.0002$). Average age for the onset of hip pain was 8.73 ± 3.88 for type 1 and 9.92 ± 4.42 for type 2 ($p = 0.56$). 25% (6/24) with two SMN copies, 63% (12/19) with three copies, and 100% (2/2) with four copies reported hip pain. 97% type 1 and 100% type 2 had abnormal hip radiographs at the onset of pain or latest follow-up. No type 1 and only 18% (7/39) type 2 experienced pain significant enough to undergo invasive intervention ($p < 0.01$). Average age of onset of those with “significant hip pain” was $7.18 \text{ yrs} \pm 2.62$. There was no significant difference in terms age of onset of scoliosis (7.79 ± 2.72 vs 7.52 ± 2.80 , $p = 0.96$), age of scoliosis surgery (7.72 ± 2.83 vs 8.58 ± 3.83 , $p = 0.33$) or type of scoliosis surgery in those with or without significant hip pain. Treatments for pain included intra-articular injection (N=6), spinal hardware revision (n=2) and proximal femoral resection (n=1) which improved pain in most but completely eliminated it in only one.

Conclusions: Despite 99% of patients having abnormal hip radiographs, 15% type 1 and 59% type 2 reported hip pain and < 20% (all type 2) experienced pain significant enough to undergo invasive treatment.

Significance: This is the largest reported assessment of hip pain in types 1 & 2 SMA children receiving aggressive modern medical management, prior to the widespread use of disease modifying agents. These data may prove useful in assessing the effects of disease modifying agents on the natural history of hip pain and suggests that symptoms rather than radiographs be utilized to direct care.



Bone Deficits in Spina Bifida Accelerate During Puberty

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LOE-Prognostic-Level IV

Purpose: Pathologic fractures of the femur and tibia are common in youth with spina bifida (SB) and are likely due to deficient bone accrual. This prospective cohort study assessed cortical and cancellous bone properties in children and adolescents with SB using quantitative computed tomography (QCT).

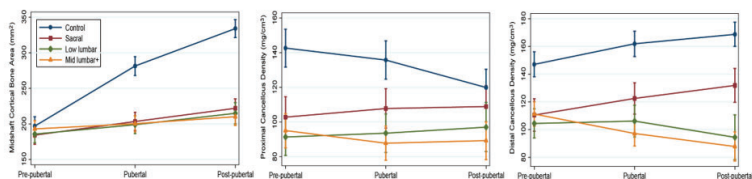
Methods: Eighty-three ambulatory youth with SB underwent QCT imaging of the tibia at up to 4 annual visits between ages 6-16 years (294 total visits averaging 3.5 visits/patient). 177 controls without disability and 10 non-ambulatory youth with SB underwent imaging once. Bone geometric properties (cortical bone area, cross-sectional area, cortical thickness, cortical density, and moments of inertia) were measured at the mid-diaphysis (50% of bone length); cross-sectional area, cancellous density, and density-weighted area were measured in the proximal (13% of bone length) and distal (90% of bone length) metaphyses. Bone properties were analyzed using linear mixed models adjusted for sex, age, height percentile, and body mass index percentile.

Results: Only cancellous density of both metaphyses ($p < 0.001$) and density-weighted area of the proximal metaphysis ($p = 0.002$) differed between ambulatory children with SB and controls before puberty. However, significant deficits in all bone properties manifested during ($p < 0.003$) and after ($p \leq 0.003$) puberty as moderate bone growth in the SB group failed to keep pace with the large increases normally observed during puberty (Figure 1, left). The bone deficits primarily affected patients with myelomeningocele, and similar deficits were observed at all neurosegmental levels except that cancellous density was closer to normal in the sacral group (Figure 1, center and right). Descriptive analysis of the 10 non-ambulatory youth with SB showed greater bone deficits than ambulatory children.

Conclusions: Tibial bone properties are close to normal in ambulatory children with SB before puberty except for low cancellous density in the metaphyses. However, normal pubertal growth in bone size and density is not observed in adolescents with SB, resulting in increasing bone deficits in both the diaphysis and metaphyses during and after puberty. Bone deficits were greater in myelomeningocele compared with lipomyelomeningocele, but surprisingly most bone properties were similar across neurosegmental levels. This suggests that even a small amount of ambulation may be sufficient to stimulate deposition of a baseline level of bone mass.

Significance: Puberty is a critical period for preventing bone deficits from developing in youth with spina bifida. Even a small amount of ambulation may be important to build a baseline level of bone mass in this patient population.

Figure 1: Selected bone properties (predicted mean and 95% confidence interval) as a function of pubertal stage



Long and Short Term Kinematic Outcomes of Rectus Femoris Transfers in Ambulatory Children with Cerebral Palsy

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LOE-Therapeutic-Level IV

Purpose: To assess long and short term kinematic gait outcomes of rectus femoris transfers (RFT) in ambulatory children with cerebral palsy (CP).

Methods: A retrospective review was conducted of ambulatory children with spastic diplegic CP, who had RFT plus motion analysis preoperatively and 1 year post-operatively (+/- 5 and 10 years post-operatively). Primary variables were: peak knee flexion range of motion in swing (PKFSW), timing of peak knee flexion in swing as a percent of the gait cycle (PKF%GC), and knee range of motion from peak to terminal swing (KROM). Responders and non-responders were identified. Descriptive, kinematic and kinetic variables were evaluated as predictors of response.

Results: 119 ambulatory children (237 limbs) with spastic diplegic CP who had RFT were included. Mean age at surgery was 10.2 years (range 5.5 to 17.5). Sixty-seven participants were classified at GMFCS Level II and 52 at GMFCS Level III. All participants had a preoperative and 1 year postoperative motion analysis. Motion analysis at 5 and 10 years post-operatively included 82 limbs and 28 limbs, respectively. Ninety-three (39%) limbs improved in both PKFSW and PKF%GC. PKFSW improved to a normal range in 59% of limbs ($p < 0.05$) at 1 year postoperatively and was maintained at 5 and 10 years postoperatively. Those at GMFCS level II were more likely [OR 1.71, CI 1.02, 2.89] to have improved PKFSW at 1 year postoperatively than those at GMFCS level III. PKF%GC improved in 70% of limbs. Responders had delayed PKF%GC, starting 10 SD above the mean (later in the gait cycle) preoperatively. Their timing significantly improved towards normal values (earlier in the gait cycle) at 1, 5 and 10 years postoperatively, respectively ($p < 0.05$). KROM improved in only 24% of limbs. For all variables, there was a significant difference in mean preoperative values between responders and non-responders ($p < 0.05$).

Conclusions: The majority of children responded to RFT with improvements in PKFSW or PKF%GC at 1, 5, and 10 years post RFT. GMFCS level is a predictor of improved PKFSW, with children at GMFCS Level II having an increased likelihood of improvement at 1 year post surgery. Children who have worse preoperative values of PKFSW, PKF%GC, and KROM have a greater potential for benefit from RFT. Characteristics associated with responders who maintain long term positive outcomes need to be identified.

Significance: RFT improves short and long-term kinematic outcomes in ambulatory children with cerebral palsy.

Outcomes of Patellar Tendon Imbrication for Crouch Gait

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LOE-Therapeutic-Level IV

Purpose: Crouch gait is one of the most frequent gait abnormalities observed in children with cerebral palsy. Distal femoral extension osteotomy (DFEO) with re-tensioning of the extensor mechanism is a common treatment strategy to address the pathologic knee flexion contracture and patella alta. Many studies have reported the results of patellar tendon insertional advancement, or patellar tendon shortening. Each of these techniques requires detachment and repair of the extensor mechanism. An alternative strategy is to imbricate the lax tendon, which does not require disruption of the extensor mechanism. The goal of this study was to review the results of patellar tendon imbrication (PTI) to address quadriceps insufficiency in the setting of children with crouch gait undergoing DFEO.

Methods: After IRB approval, all patients with crouch gait treated at a single institution with DFEO and PTI were identified. Clinical, radiographic, and instrumented gait analysis data were analyzed preoperatively and at 1 year following surgery.

Results: Twenty-eight patients (54 extremities) with a diagnosis of cerebral palsy and crouch gait were included. Knee flexion contracture significantly improved from -18.4 degrees to -2.7 degrees from full passive extension ($p < 0.0001$). Quadriceps strength significantly improved from an average of 3/5 strength to an average of 4/5 strength ($p = 0.005$). Knee extensor lag and popliteal angle also demonstrated significant improvement ($p < 0.0001$). Kinematically, knee flexion at initial contact and during midstance improved significantly ($p < 0.0001$), and knee moments in late stance were significantly reduced ($p < 0.01$). Radiographic improvements were seen in the knee flexion angle and patellar station as assessed by the Koshino Sugimoto Index ($p < 0.0001$). Four patients (14.2%) developed recurrence of knee flexion contracture requiring further intervention.

Conclusions: Patellar tendon imbrication is a simplified and safe technique to address quadriceps insufficiency when performing DFEO. The short-term results of patients who underwent DFEO with PTI demonstrated improvements in clinical, radiographic, and gait analysis variables of the knee. Investigating long-term outcomes, comparing quadriceps tensioning techniques, and assessing quality of life measures are important next steps in research. Level of Evidence: Level IV Case Series

Significance: The simplified technique of patellar tendon imbrication is appealing as it does not require disruption and repair of the extensor mechanism. Short-term results show it is both safe and effective when addressing quadriceps insufficiency for children with crouch gait undergoing distal femoral extension osteotomy.

The Effects of Lower Extremity Rotational Malalignment on Pediatric Patient-Reported Outcomes Measurement and Information System (PROMIS) Scores

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LOE-Prognostic-Level IV

Purpose: There is sparse literature demonstrating the relationship between lower limb pediatric Idiopathic Rotational Malalignment (IRM) and Patient Reported Outcomes Measurement Information System (PROMIS) scores. Our goal was to determine and quantify the amount that IRM deformities, as measured with 3D gait analysis, affect childrens' pain interference, mobility and peer relationship PROMIS domains. Secondary outcomes include investigating the potential relationships between IRM and various subgroups (PODCI, gender, BMI, femur vs tibia). We also examine whether the PROMIS domains correlate with PODCI in this population.

Methods: This study was a retrospective cohort, single institution, consecutively recruited cases series. We identified children from a 3-year period who were evaluated at the Motion Analysis Center (MAC) at our tertiary care hospital, with increased torsion of the femur or tibia. Only children with IRM, documented PROMIS data and a gait analysis were considered.

Results: Femoral malrotation had a significant relationship with female gender ($p=0.003$) and increased BMI ($p<0.005$). Femoral malrotation had a strong correlation with PROMIS pain interference ($p=0.017$), while tibial rotation was approaching significance ($p=0.064$). In the ANOVA regression analysis, there was a strong prediction of the PROMIS mobility domain when both malrotation and pain interference were present ($p=0.007$). There were Pearson Correlations of PROMIS and PODCI domains for Mobility versus Sports of 0.524 ($p=0.007$) and Pain Interference versus Comfort/Pain of 0.568 ($p=0.003$).

Conclusions: Femoral and tibial rotation are correlated with PROMIS pain interference, indicating that more rotation results in more pain interference. Additionally, femoral and tibial rotation with increased PROMIS pain interference contributes significantly to a worse PROMIS mobility score. Finally, the relationship between PROMIS and PODCI domains demonstrates the credibility of this tool in evaluating IRM and the value of appropriate management.

Significance: The evident relationship between lower limb rotational malalignment and PROMIS scores signifies the likelihood for gait and pain disturbance. This in turn could show us which children are likely to be more debilitated and thus may benefit from timely correction. We aim to conduct this as a multicentre trial to confirm our findings.

Patient reported PROMIS assessment in pediatric patients with tibial deficiency, fibular deficiency, and proximal focal femoral deficiency - A multicenter study

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LOE-Prognostic-Level II

Purpose: The objective of this study was to characterize Patient-Reported Outcomes Measurement Information System (PROMIS) scores among pediatric lower limb deficient patients clinically treated as amputees and evaluate differences in these scores across specific diagnosis type and severity within each diagnosis.

Methods: This IRB-approved, multicenter study reviewed PROMIS scores obtained from 138 patients (ages 6 – 18 years) with lower extremity deficiencies. Patients had one of three congenital deficiencies: proximal femoral focal deficiency (PFFD, n=48), fibular deficiency (FD, n=56) or tibial deficiency (TD, n=34), with severity approximated using a common classification within each group (Aitken, Achterman & Kalamchi, and Jones, respectively). Data were collected in four PROMIS domains: Mobility, Pain Interference (PI), Peer-Relationship (PR), and Upper Extremity (UE). Kruskal-Wallis and Wilcoxon's Rank Sum Test were performed to evaluate differences.

Results: PROMIS Mobility scores differed between diagnoses. FD patients reported better median Mobility score than TD/PFFD patients (52 vs 44.4/43.7)(p=0.0036). There was a trend towards lower PI score in patients with FD compared to TD/PFFD (39.7 vs 45.8/47.6)(p=0.21). PROMIS Mobility scores did not differ by severity within diagnoses. PROMIS Mobility and PI scores were affected by bilaterality in FD, with unilaterals demonstrating better Mobility (median 52 vs 36, p=0.0008) and lower PI scores (median 38.6 vs 56.9, p<0.0001). Bilaterality also affected PROMIS Mobility scores in TD (median 46 vs 39, p=0.0077). PFFD PROMIS scores were not affected by the presence or absence of knee fusion.

Conclusions: Median PROMIS Mobility scores are rated "normal" in patients with FD and "mild impairment" in children with PFFD or TD. There is a trend towards better PI scores in FD patients, but median values for all diagnoses scored "normal". The severity of disease was not associated with PROMIS score changes, and interpretation of scores was normal for almost every category, with exceptions all in the "mild impairment" range. Bilateral FD/TD patients reported significantly lower PROMIS Mobility score averages; interpreted in the "moderate impairment" range. Bilateral FD patients had worse PI scores. Presence or absence of knee fusion did not affect PROMIS scores, though small numbers for analysis limit interpretation of this data (25 knee fusions, 11 no fusion). PROMIS PI, PR & UE score averages were consistently within the normal range, consistent with overall lack of pain complaints. Domains may be influenced by factors other than diagnosis, bilaterality, or severity.

Significance: PROMIS Mobility scores appear to distinguish functional differences among lower extremity deficient children and adolescents.

◆ Treatment of Congenital Pseudarthrosis of the Tibia: 2-year Minimum Followup

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LOE-Therapeutic-Level IV

Purpose: The purpose of this study was to investigate the healing, refractures and complications of an all-internal, cross-union technique for the treatment of congenital pseudarthrosis of the tibia (CPT) with a 2-year minimum follow-up.

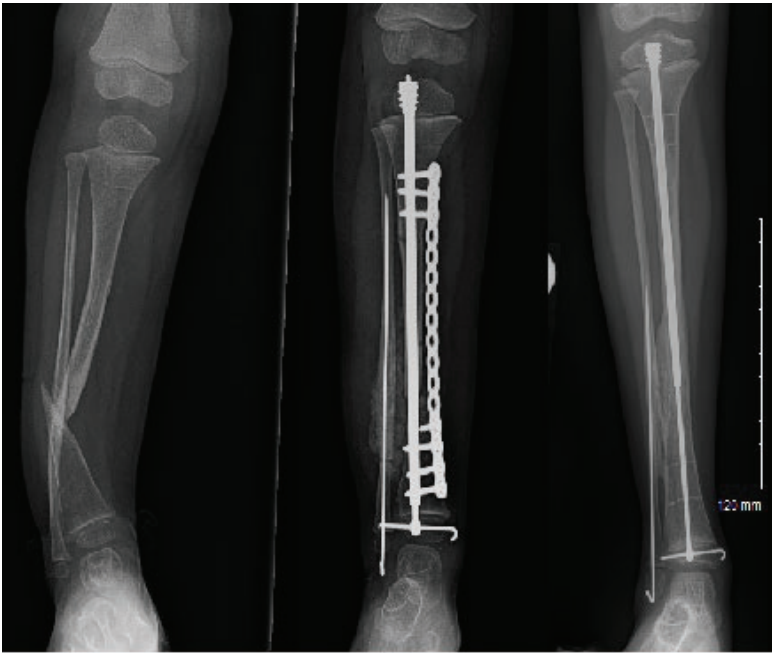
Methods: A retrospective review was performed of all CPT patients treated at our institution. Inclusion criteria included two years of follow-up from the index procedure to the last clinical visit. Patients were excluded if external fixation was used to obtain healing of the pseudarthrosis. Evidence of healing, refracture and deformity parameters were measured from radiographs. Charts were reviewed for complications, including transfusions, unanticipated returns to the operating room, delayed union, etc. Student's t-test compared the operative side with the non-operative side.

Results: 14 patients were included. The mean age at surgery was 31 months (range 13-126 months). The mean follow-up was 33 months (range 24 – 40 months). All patients were healed at both the tibia and fibula at final follow-up. No patients refractured their tibia or fibula at the final follow-up. Radiographic analysis demonstrated no difference between leg lengths or coronal deformity when compared to the non-operative side. Distal fibular station was the only significant difference (4.4 vs 0mm; $p < .001$); however, fibular station was unchanged from its preoperative level. Intraoperative transfusions were recorded 13/14 patients. Nine patients had additional procedures for deformity correction (7 guided growth, 1 acute correction of the distal tibia, 1 gradual correction of the proximal tibia). Two patients had delayed union of their pseudarthrosis and required additional insertion of BMP, this was performed at the time of plate dynamization (1 patient) or Fassier-Duval (FD) rod exchange (1 patient). One patient required an additional bone grafting for fibular delayed union. Three patients returned to the OR for complications associated with FD rods (1 rod backed out, 2 required reinsertion of the distal locking wire). One patient had wound breakdown requiring a skin graft.

Conclusions: This technique successfully obtained union of all tibias and did not result in refracture after two years. Over 90% of the patients required intraoperative transfusion, with no complications related to transfusion. There were 4 unplanned return trips to the OR due to delayed union (2), FD rod complications (1) and wound breakdown (1).

Significance: This is the first report with a minimum 2-year follow-up detailing the healing and refracture rates of an all-internal cross-union technique for CPT and complications.

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



Complications Requiring Readmission Following Lower Limb Lengthening: A 10 Year U.S. Database Study

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LOE-Prognostic-Level IV

Purpose: Historically, the management of severe shortening of the lower extremity has involved external fixation. Attempts to decrease the time and use of external fixation have led to the incorporation of internal fixation and hybrid techniques for limb lengthening. Our goal was to report the rate of various complications of lengthening of the femur and tibia using a publicly available inpatient database.

Methods: Inpatient data was acquired using the Healthcare Cost and Utilization Project (HCUP) database from 2005 to 2014 from six U.S. states. Patients with ICD-9 codes for limb lengthening of the femur, tibia, or both were included. Patients were subdivided based on lengthening technique, bone lengthened, and underlying diagnosis. Rates of hospital readmission up to 1 year following the index lengthening procedure were collected. The cumulative rates of specific orthopedic complications at 1 year were calculated across various subgroups. Statistical analysis was conducted using chi square analysis with significance < 0.05 .

Results: 1,954 patients were identified as having undergone a femoral and/or tibial lengthening between 2005-2014. Overall, 756 patients (39%) were readmitted by 1 year. The most common complications requiring readmission among all patients were infection (10.2%) and non-union (7.4%). Tibial lengthening had a higher overall rate of readmission than femoral lengthening (41.0% vs. 35.8%; $p<0.05$). In patients undergoing femoral lengthening, patients undergoing internal lengthening had the lowest complication rate (26%), versus hybrid techniques (39%), or external fixation (42%) ($p<0.05$) (Figure 1). Patients undergoing femoral lengthening with an external fixator had a higher rate of deep infection, knee dislocation, and knee contractures compared to both hybrid and internal lengthening ($p<0.05$). Patients undergoing lengthening for congenital shortening had a higher rate of knee dislocation (6.7% vs. 2.6%; $p<0.05$) and lower rate of non-union (0.8% vs. 4.2%; $p<0.05$) compared to patients with non-congenital diagnoses.

Conclusions: Limb lengthening procedures have a high rate of 1-year hospital readmission. Patients undergoing tibial lengthening have a higher readmission rate than those undergoing femoral lengthening. Knee dislocations and contractures are more frequently seen with femoral lengthening, especially in patients with congenital etiology. There is a lower rate of readmission with internal lengthening of the femur compared to external and hybrid lengthening. A more in-depth analysis of clinical and patient-reported outcomes based on recent advancements in available lengthening techniques is warranted.

Significance: These findings demonstrate a high rate of readmission among a large cohort of patients undergoing limb lengthening. Rates of readmission may differ based on bone lengthened, lengthening technique, and underlying diagnosis.

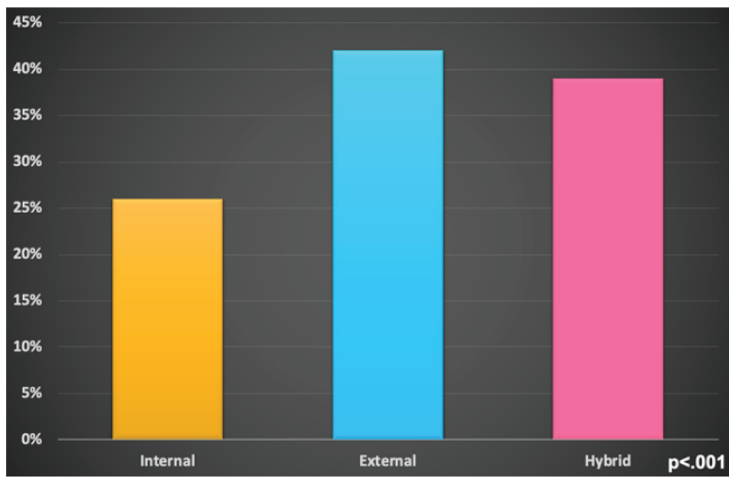


Figure 1: Overall Readmission Rate – Femoral Lengthening By Technique

Angular Deformity before and after Temporary Epiphysiodesis for Leg Length Discrepancy

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LOE-Therapeutic-Level IV

Purpose: To describe limb angulation and associated factors before and after temporary epiphysiodesis for limb length discrepancy.

Methods: Records of patients who underwent temporary epiphysiodesis of either the distal femur or proximal tibia between 2000 and 2020 were reviewed. The Mechanical Axis Deviation (MAD) was measured on preoperative and last follow up radiographs. Surgical complications were reported. Data was analyzed using Fisher's exact test and paired t-tests. An angular deformity was defined as having a MAD greater than 10 mm.

Results: A total of 20 limbs from 13 individuals were included in the study. Mean age at the time of surgery was 11.4 ± 2.1 years. Mean postoperative follow up was 61 ± 26 months. The procedure was performed only on the distal femur in 35% of limbs (7/20), only on the proximal tibia in 5% limb (1/20), and on both distal femur and proximal tibia in 60% limbs (12/20). For the whole group, the mean MAD change over follow up was 13.5 ± 10 mm (Table 1). Of the femoral only procedures, 57% (4/7) of limbs had medial direction of MAD change, and 29% (2/7) had lateral MAD change. Of the tibial only procedures, 100% (1/1) of limbs had medial direction of MAD change. Of the combined femoral and tibial procedures, 8% (1/12) of limbs had medial direction of MAD change, and 75% (9/12) had lateral MAD change. At the last follow up, 65% (13/20) of limbs had greater than 10mm of MAD, which they did not have before surgery.

Conclusions: This study suggests that, for patients with limb length discrepancy, temporary epiphysiodesis around the knee with tension band plating might result in mechanical axis deviation. This finding needs to be expected with caution especially when this procedure is planned for patients who are close to skeletal maturity.

Significance: Utilizing temporary epiphysiodesis as opposed to permanent drill epiphysiodesis for these patients may increase the potential for introducing an angular deformity.

Patient	Limb	Age at surgery (years)	Follow up (months)	Location of the procedure	Preop MAD (mm)	Direction of MAD Preop	Last follow up MAD (mm)	Direction of MAD Postop	MAD change (mm)	Direction of MAD change
3	Right	13	103	Femur	0	Neutral	10	Valgus	10	Medial
7	Left	7	39	Femur	0	Neutral	10	Valgus	10	Medial
8	Left	8	71	Femur	19	Valgus	18	Valgus	1	Medial
9	Left	12	33	Femur	0	Neutral	11	Valgus	11	Lateral
10	Right	14	103	Femur	0	Neutral	0	Neutral	0	Neutral
13	Right	14	97	Femur	0	Neutral	31	Valgus	31	Medial
13	Left	14	97	Femur	18	Neutral	21	Varus	3	Lateral
4	Left	11	24	Tibia	8	Varus	0	Neutral	8	Medial
1	Right	9	55	Combined	0	Neutral	0	Neutral	0	Neutral
1	Right	9	55	Combined	0	Neutral	0	Neutral	0	Neutral
2	Right	14	75	Combined	16	Varus	0	Neutral	16	Lateral
5	Right	11	71	Combined	9	Varus	35	Varus	26	Lateral
5	Right	11	71	Combined	9	Varus	35	Varus	26	Lateral
6	Right	12	84	Combined	0	Neutral	22	Varus	22	Lateral
6	Right	12	84	Combined	0	Neutral	22	Varus	22	Lateral
11	Right	10	19	Combined	13	Valgus	0	Neutral	13	Lateral
11	Right	10	19	Combined	13	Valgus	0	Neutral	13	Medial
12	Right	11	61	Combined	0	Neutral	23	Varus	23	Lateral
12	Right	11	61	Combined	0	Neutral	23	Varus	23	Lateral
2	Right	14	35	Combined	0	Neutral	11	Valgus	11	Lateral

Novel Treatment for Improving Knee Range of Motion in Patients with Arthrogryposis and Severe Knee Flexion Deformity

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LOE-Therapeutic-Level IV

Purpose: The purpose of this study was to describe a novel treatment, the outcomes and complications for patients with arthrogryposis and severe knee flexion deformities.

Methods: A retrospective chart review of all arthrogryptic patients since 2016 was performed. Patients were included if they had a knee flexion deformity and underwent posterior capsular release, proximal femoral shortening and peroneal nerve decompression. Patients were excluded with less than 6 months of follow-up. Postoperative and preoperative range of motion (ROM) and ambulation status was collected and compared. Complications were examined. We used the Wilcoxon rank sum test and paired t-test to determine statistical significance of pre- and post-operative knee range of motion ($p = .05$).

Results: 21 patients (age: 5 yrs. \pm 3 yrs.) were analyzed for each affected limb ($n = 36$). Mean preoperative knee extension lacked $50 \pm 21^\circ$ and flexion measured $101 \pm 24^\circ$ with mean preoperative knee ROM measuring $45 \pm 23^\circ$. All patients achieved full extension in the operating room; however, there was some translatory subluxation noted. Mean final followup was 14 ± 9 months. All patients were followed for at least 6 months. Mean postoperative knee extension lacked $9 \pm 10^\circ$ and flexion measured $83 \pm 19^\circ$ with mean postoperative knee ROM measuring $74 \pm 22^\circ$. There was significant improvement for knee extension of 43° ($p < .0001$), but a significant decrease in knee flexion 20° ($p < .0001$). There was a significant improvement of overall knee range of motion 24° ($p < .0001$). 18/21 patients were ambulating and most using an orthotic. Complications included avascular necrosis of the femoral head (1), wound breakdown (2), neurogenic pain (10) and fracture of the femur (4).

Conclusions: Our results indicate that knee range of motion can be increased through surgical intervention for patients with arthrogryposis and severe knee flexion deformities. Although there is loss of knee flexion, the overall improvement of the range of motion is significant. The majority of complications appear to be related to nerve stretch and improve with symptomatic treatment over time. The major complications of avascular necrosis and femur fractures occurred at least 1 year after the knee surgery was performed but were included for completeness.

Significance: This is the first study to evaluate the outcomes of peroneal nerve decompression, posterior capsulotomy and proximal femoral shortening for the treatment of knee flexion deformities in patients with arthrogryposis.

How low can you go? Evaluation of Implant Density in Growing Construct Conversion to Posterior Spinal Fusion for Early Onset Scoliosis

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LOE-Therapeutic-Level III

Purpose: Larson et al. demonstrated that implant density (ID) does not correlate with outcomes in fusions for adolescent idiopathic scoliosis, but the role of implant density in conversion of growing constructs to fusions was not addressed. Our purpose was to determine if Early Onset Scoliosis (EOS) patients treated with low implant density constructs have similar outcomes to patients treated with high density constructs when undergoing conversion to fusion.

Methods: EOS patients treated with growth-friendly constructs converted to fusion between 2000-2017 were reviewed from a multicenter database. Implant density was defined as the number of pedicle screws, hooks, and sublaminar/bands per level fused. Patients were divided into high ID (≥ 1.6), low ID (1.3-1.6) and ultra-low ID (< 1.3). Exclusion criteria were < 2 years follow-up from fusion or inadequate radiographs.

Results: 152 patients met the inclusion criteria with 39(25.6%) patients in the high ID group, 33(21.7%) patients in the low ID group, and 80 patients in the ultra-low ID group (52.6%). Duration of radiographic follow up after fusion was similar for all groups (high ID=2.9 years; low ID=2.9 years and ultra-low ID=3.0 years; $p=0.37$) The high ID group had a trend towards higher EBL and longer operative times (946.8 \pm 606.0 mL; 406.4+199.8min) than the low ID (733.9+434.5 mL; 401.6+140.9 min) and ultra-low groups (617.4+517.2mL; 372.8+144.4 min) though this did not reach significance (EBL: $p=0.18$; operative time: $p=0.09$). Initial improvements in major curve from pre- to post-fusion were: high ID group=21.6 $^{\circ}$, low ID=18.0 $^{\circ}$ and ultra-low =12.6 $^{\circ}$ ($p=0.51$). During post-fusion follow-up, there was slightly greater loss of correction in the high ID group (-7.1 $^{\circ}$) vs the low ID (-2.6 $^{\circ}$) and ultra-low ID (-2.8 $^{\circ}$) groups ($p<0.01$). Consequently, there was no significant difference in major curve correction from pre-fusion to final follow up between the groups (high ID:14.5 $^{\circ}$, low ID:15.5 $^{\circ}$ and ultra-low ID: 9.7 $^{\circ}$, $p=0.20$). At final follow-up, there was no significant difference in T1-S1 length gain between the groups (high ID=2.3cm; low ID=2.4cm; ultra-low ID=1.9cm ($p=0.21$)). Revision rate was higher in the ultra-low group (13.8%) compared to the high ID (5.1%) and low ID (0%) groups, ($p=0.04$).

Conclusions: In the largest series of growth-friendly construct conversion to fusion reported to date, similar curve correction and spinal length gain were seen for all implant density constructs. However, with ultra-low implant density (< 1.3 anchors/vertebrae) a higher revision rate was observed.

Significance: While length gain and curve correction were similar at all implant densities, more revisions occurred in ultra-low implant densities (< 1.3 anchors/vertebrae) in growing rod conversions.

Superiority of convex first differential rod technique in three-dimensional correction of Lenke 1&2 Adolescent Idiopathic Scoliosis

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LOE-Therapeutic-Level III

Purpose: This is a single surgeon comparison of three intraoperative deformity correction techniques utilized during posterior spinal fusion for Lenke 1&2 Adolescent Idiopathic Scoliosis (AIS). We hypothesize that a dual rod technique utilizing differential rod contouring yields superior sagittal plane alignment.

Methods: Three sequential cohorts of patients with Lenke 1&2 AIS treated with posterior spinal fusion were evaluated over an 11-year period utilizing the following deformity correction maneuvers: concave rod derotation (CCRD), concave en bloc reduction (CCEB), and convex first differential rod reduction (CVDR), which is a dual rod technique in which the hypocontoured convex rod is placed first for apical translation and cantilevering followed by placement of hypercontoured concave rod for sagittal correction and derotation. Preoperative, intraoperative, and minimum 2-year postoperative variables and radiographs were compared across groups.

Results: 94 sequential Lenke 1&2 AIS patients were evaluated: 34 CCRD, 27 CCEB, and 33 CVDR. No significant preoperative differences in patient demographics, frontal or sagittal plane deformity magnitude, or pelvic incidence existed amongst these groups. In addition to differences in corrective maneuver, the CVDR group utilized higher implant density than CCRD or CCEB (1.51 vs 1.41 vs 1.44; $p=0.008$) and more Ponte osteotomies (1.7 vs 0.48 vs 0.92 per case; $p=0.041$). When comparing 2-year postoperative radiographic outcomes, there was equivalent coronal correction index (72% vs 70% vs 66%, $p=0.191$) and shoulder balance (clavicle angle 0.81° vs 1.7° vs 1.6° , $p=0.625$) in the CVDR, CCRD, and CCEB cohorts. However, the CVDR technique significantly improved sagittal plane parameters, including improved final T5-T12 kyphosis (22.3° vs 15.9° vs 14.3° , $p=0.004$), delta T5-T12 kyphosis ($+2.6^\circ$ vs -2.9° vs -9.1° , $p=0.004$), and delta 3D kyphosis (18.8° vs 12.8° vs 7.4° , $p<0.001$), and also improved axial plane correction as evidenced by apical rod:rod distance on the lateral view ($p=0.001$). There were no differences in postoperative complications, readmissions, or reoperations amongst groups.

Conclusions: Convex first differential rod reduction technique demonstrates superiority in restoration of normal thoracic kyphosis and axial plane correction when compared to traditional concave rod derotation and concave en bloc reduction techniques for the treatment of Lenke 1&2 AIS.

Significance: Restoration of thoracic kyphosis to normalize sagittal alignment is imperative for early and late outcomes in AIS. As opposed to traditional concave rod derotation or concave en bloc reduction techniques, which yield excellent frontal correction at the expense of iatrogenic hypokyphosis, convex first differential rod reduction technique provides superior restoration of thoracic kyphosis with normalization of sagittal plane parameters.

	Concave rod derotation (CCRD)	Concave <i>en bloc</i> reduction (CCEB)	Convex first differential rod reduction (CVDR)	p value
Pre-op Thoracic Cobb (degrees)	56.0°	55.6°	56.6°	p=0.739
Pre-op Raimondi Rotation (degrees)	31.4°	29.0°	30.8°	p=0.44
Preop T5-12 kyphosis (degrees)	18.8°	23.3°	19.7°	p=0.322
Preop 3D Kyphosis (degrees)	1.5°	5.1°	3.2°	p=0.365
Preop Pelvic Incidence (degrees)	50.7°	51.4°	51.2°	p=0.984
Flexibility Index (%)	44.7%	43.5%	38.7%	p=0.196
Implant Density	1.44	1.41	1.51	p=0.005
Ponte osteotomy (#/case)	0.52	0.93	1.7	p=0.044
% Correction thoracic Cobb (%)	66.2%	70.0%	71.7%	p=0.191
Post-op clavicle angle (degrees)	1.7°	1.6°	0.8°	p=0.625
Post-op T5-12 kyphosis (degrees)	15.9°	14.3°	22.3°	p=0.004
Delta T5-12 kyphosis (degrees)	-2.9°	-9.1°	2.6°	p=0.0003
Delta Kyphosis using 3D preop (degrees)	12.8°	7.4°	18.8°	p<0.0001
Rod:rod distance lateral radiograph (mm)	7.0 mm	4.3 mm	3.6 mm	p=0.001

Predictors of Optimal Outcomes of Selective Thoracic Fusion at Five Years

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LOE-Therapeutic-Level II

Purpose: Prior work by Schulz et al. (2014) identified optimal outcomes at 2 years following selective thoracic fusion (STF) for adolescent idiopathic scoliosis (AIS) and found that a preoperative lumbar curve $<45^\circ$ and lumbar bend $<25^\circ$ were the best predictors for a successful STF. The purpose of this study was to determine whether these published predictors of an optimal outcome at 2 years represent what is required to achieve an optimal outcome with further time and potential growth.

Methods: Patients with primary thoracic AIS (Lenke 1-4C curves) who underwent a STF and had minimum 5 years of follow-up were included. Optimal postop outcomes for a STF as defined by Schulz et al. (2014) included a deformity-flexibility quotient (DFQ) <4 , lumbar curve $<26^\circ$, lumbar correction $>37\%$, C7-CSVL $<2\text{cm}$, lumbar prominence $<5^\circ$, and trunk shift $<1.5\text{cm}$. These outcomes were used to determine whether adhering to “guidelines” for STF increased the likelihood of obtaining an optimal outcome at 5 years. The “guidelines” tested included a preop lumbar curve $<45^\circ$, a lumbar bend $<25^\circ$, apical vertebral translation ratio >1.2 , and a thoracic/thoracolumbar Cobb ratio >1.2 .

Results: 127 patients met inclusion. A preoperative lumbar curve $<45^\circ$ was associated with an increased likelihood of achieving 3 of the optimal outcomes: DFQ <4 , lumbar curve $<26^\circ$, and lumbar prominence $<5^\circ$ ($p<0.05$; Table). AVT >1.2 and following the 25° bend rule resulted in 2 optimal outcomes while a Cobb ratio >1.2 only increased the chance of achieving 1 optimal outcome.

Conclusions: The previous study by Schulz et al. suggested that performing a STF in patients with a preoperative lumbar Cobb less than 45° or a preoperative lumbar bend less than 25° increased the chances of success at 2 years. This study found that at 5 years, performing a STF when there is a preoperative lumbar Cobb less than 45° remained the best guideline for increasing the likelihood of an optimal outcome. In conclusion, of the established guidelines for when to perform a STF, having a lumbar curve $<45^\circ$ preoperatively was most likely to result in optimal outcomes at 5 years.

Significance: Of the parameters tested, a preoperative lumbar curve $<45^\circ$ was the most likely variable to result in an optimal outcome 5 years postoperatively when performing a selective thoracic fusion for AIS. Understanding predictors of optimal outcomes at 5 years postoperatively should enhance surgical decision making and improve outcomes for future patients.

	45 degree rule		25 degree bend		AVT > 1.2		Cobb ratio >1.2	
	< 45	> 45	<25	> 25	> 1.2	< 1.2	> 1.2	<1.2
DFQ < 4	52%	33%	50%	22%	31%	49%	53%	30%
Lumbar Cobb < 26	65%	39%	50%	61%	51%	57%	62%	46%
L correction > 37%	56%	67%	100%	60%	67%	55%	67%	48%
C7-CSVL < 2 cm	63%	76%	68%	65%	67%	68%	64%	74%
L prominence < 5	58%	39%	56%	35%	46%	55%	56%	44%
Trunk shift < 1.5 cm	52%	44%	52%	39%	39%	55%	44%	56%

Highlighting represent statistical differences. Values represent the % of cases in which an ideal outcome was achieved.

Scoliosis Surgery Normalizes Cardiac Function in AIS Patients

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LOE-Therapeutic-Level III

Purpose: Spinal deformity in AIS can increase right atrial and ventricular pressures secondary to restrictive lung disease. Pulmonary hypertension leading to cor pulmonale is the most feared outcome, however mild pulmonary hypertension in AIS patients has been reported in the past. No study has examined these changes including the improvement of right heart function following scoliosis surgery. We hypothesize that scoliosis repair resolves cardiac functional abnormalities.

Methods: Group 1, 202 AIS patients undergoing PSF from 2009-2013 at a single institution. Group 2 control patients, 179 healthy, age-matched adolescents. Cobb angle, 2D-echo signs of structural heart disease, aortic root dimensions, tricuspid regurgitant jet velocity (TRV), PFTs, ABG, and patient demographics reviewed. Right ventricular systolic pressure (RVSP) was estimated using Bernoulli's equation $[4(\text{TRV})^2]$ and right atrial pressure. $\text{RVSP} \geq 36\text{mmHg}$ is a surrogate marker for pulmonary hypertension. All echocardiograms were read by board certified Pediatric Cardiologists. Group 3, 47 AIS patients from group 1 with elevated preoperative TRV underwent corrective PSF. Logistic regression was used to assess for differences in TRV between groups.

Results: Mean preoperative RVSP was significantly elevated in AIS patients (26.9 ± 0.49 ; $p < 0.001$) compared to controls (17.25 ± 0.88). 47 (21%) group 1 patients had elevated preoperative TRV (≥ 2.8 m/s) versus no group 2 patients ($p < 0.001$). Additionally, logistic regression showed AIS patients have an odds ratio of 3.29 for elevated TRV (p value = 0.007) – an indirect measure of pulmonary hypertension. In all Group 3 patients, the cardiac function normalized postoperatively (mean TRV = 2.09 ± 0.23 ; $p < 0.001$). No association was found in Cobb angle, aortic root parameters, or PFTs.

Conclusions: This study found that 21% of patients with AIS had elevated TRV while age-matched controls had no TRV abnormalities. Additionally, RVSP measurements demonstrated mild pulmonary hypertension in AIS patients. These abnormal values normalized postoperatively, indicating the benefits of scoliosis surgery on cardiac function in AIS.

Significance: AIS patients have abnormal right heart function which normalizes postoperatively, indicating the medical benefit of PSF in AIS.

Spinal Fusion Effects on Pulmonary Function and Breathing Mechanics in Adolescent Idiopathic Scoliosis

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LOE-Therapeutic-Level II

Purpose: Posterior spinal fusion (PSF) has mixed effects on pulmonary function in adolescent idiopathic scoliosis (AIS) patients. The purpose of this study was to quantify changes in pulmonary function and breathing kinematics in subjects with AIS before and after PSF.

Methods: Thirty AIS pre-operative PSF subjects had torso kinematics (3D motion system) collected prior to and during spirometry measurements (forced vital capacity [FVC] and forced expiratory ventilation in 1 second [FEV1]). Kinematics were divided into four regions: upper thorax, lower thorax, upper abdomen, and lower abdomen. Subjects were evaluated preoperatively, at 6-months, and 1-year after PSF surgery. One-way repeated measures ANOVAs were used to determine differences between visits for FVC, FEV1, FEV1/FVC, and kinematic maximum volume, as well as regional contribution to total breathing volume. Pearson's correlation was used to determine relationships between FVC maximum kinematic volume and absolute measurement.

Results: Absolute increases in FVC were observed from preoperative visit to 6-months (7.7%) and 1-year postoperative (12.9%; $p < .001$). Similarly, FEV1 increased from preoperative to 6-months (12.4%) and 1-year postoperative (14.6%; $p < .001$). Absolute FEV1/FVC ($p = .003$) increased in both follow-ups. Predicted volume increased for FVC ($p = .012$; 68.3%, 75.9%, 76.0%) and FEV1 ($p = .003$; 68.5%, 76.3%, 74.8%) for preoperative, 6-months, and 1-year respectively. Additionally, 15/30 (50.0%) subjects were below 65% predicted values for FVC or FEV1 preoperatively, while only 7/30 (23.3%) and 8/30 (26.6%) were below 65% at 6-months and 1-year follow-ups. Normal tidal breathing was distributed 46.9% lower thorax, 23.6% upper abdomen, 17.0% upper thorax, and 12.7% lower abdomen ($p < .001$). PSF had no impact on regional contributions during normal tidal breathing or during the FVC maneuver ($p > .271$). Kinematic maximum volume was strongly correlated with FVC during the preoperative visit ($r^2 = .94$, $p < .001$). Kinematic maximum volume showed similar improvements to spirometry measurements, with differences between the three visits ($p = .002$).

Conclusions: Absolute and percent-predicted pulmonary function values improved 6-months after PSF surgery while trending to greater improvement at one year. While pulmonary function improved, no changes occurred in regional contribution during normal tidal breathing or during the FVC maneuver. Improvements occurred in maximum kinematic volume during the FVC test similar to spirometry measurements.

Significance: Fifteen patients had pre-op FVC or FEV1 that were below 65% of predicted values and 7/15 (46.6%) had pulmonary improvements that surpassed the threshold of 65% of predicted values for FVC and FEV1. Spinal curve correction using PSF improves pulmonary function and maximum kinematic volume, but does not change breathing mechanics.

Airway Management of Pediatric Cervical Fusions

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LOE-Therapeutic-Level IV

Purpose: There is a paucity of literature on airway management after pediatric cervical spine fusions. This study aims to report the incidence of postoperative airway adverse events in a single-center cohort of cervical fusions.

Methods: A single-center retrospective review of cervical fusions utilizing modern instrumentation between 2002-February 2019 was conducted. Multivariable logistic regression using a GEE approach was used to study airway complications or changes that were seen either immediately postoperative or during subsequent surgeries. Pre- and post-occipitocervical angles were measured via X-ray or CT to assess whether a decrease in this angle could be used as a predictor for airway complications.

Results: 213 surgeries were performed on 162 patients undergoing cervical fusion (mean age at index, 11.7, range, 0.23 - 20.47 years, 54% male). 23% (37/162) had at least one revision. Forty-eight of 162 patients had occipitocervical fusions (mean age at index 9.9, range 0.23-20.14 years, 48% male) and made up 30% of total surgeries (64/213). A Grade 1 laryngeal view was seen during intubations in 84% (136/161) of cases on both direct and indirect views but decreased to 77% in the occipital group. Twenty-one cases (10%) ended with a difficult extubation though increased to 16% in the occipital group. Significant airway complications were seen in five cases in the occipital group (8%), but only 3 in the non-occipital group (2%; $p=0.12$). Of the five occipital patients, the airway complications involved failed attempts at extubation requiring re-intubations or emergent tracheostomies. The placement of halo-vest was also noted to contribute as 4/5 of the occipital and 2/3 of the non-occipital complication groups had this device in place. Eight patients were also noted to have an airway change after fusion, meaning that the laryngeal view had changed from a 1-2 to a 3-4 during a subsequent surgery. 21 of 45 (47%) occipital patients who had available imaging had a decrease in the occipitocervical angle after fusion.

Conclusions: This cohort experienced severe adverse airway events, particularly for occipitocervical fusions, indicating the need for intraoperative assessment, with possible extubation in the ICU rather than OR when swelling and lingering effects of anesthesia have been eliminated. This is especially true for patients in halo-vest as this device makes airway manipulation close to impossible. Occipitocervical fusions may alter the airway anatomy indicating the need for individualized anesthetic management for future procedures.

Significance: This study demonstrates the need for specialized anesthetic care both during occipitocervical fusions and subsequent surgeries.

Transcranial Motor Evoked Potential Monitoring During Scoliosis Surgery in Children with Cerebral Palsy: Is it Feasible?

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LOE-Diagnostic-Level III

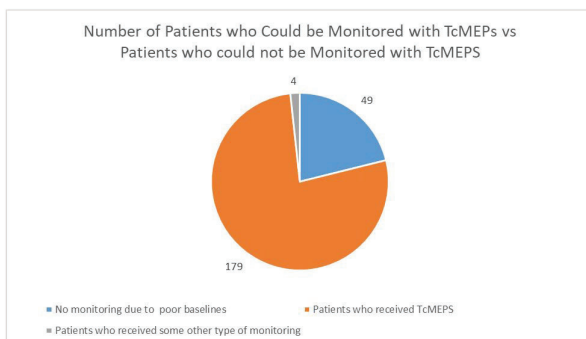
Purpose: Routine use of spinal cord monitoring in children with spastic quadriplegic cerebral palsy (CP) and neuromuscular scoliosis is both challenging and controversial. Previous reports suggest low success rates in using motor evoked potentials in the setting of CP, and it is unclear whether repetitive high-voltage transcranial electric stimulation for motor evoked potential (TcMEP) monitoring is contraindicated in the presence of active seizure disorder. The purpose of this study was to determine: 1. Are patients with CP able to be appropriately monitored during spine surgery with TcMEP? 2. Does TcMEP cause an increase in seizure activity in patients with CP and an active seizure disorder?

Methods: This was an Institutional Review Board approved retrospective cohort study that observed 305 patients from 2011 to 2020. Inclusion criteria included all patients with CP undergoing posterior spinal fusion (PSF). Preoperative datapoints including seizure history, medical history, and GMFCS levels were recorded from their medical records. Perioperative datapoints including anesthesia data (blood pressure, heart rate, and anesthetic levels) and neuromonitoring data. Patients were followed for 3 months postoperatively to determine any increase in seizure activity.

Results: Of the 305 patients that were observed, monitoring was attempted in 232. Seventy three patients were not attempted due to senior surgeon preference, and this group was used as an internal control to determine the rate of increased seizure activity postoperatively. Of the 232 that were attempted, 49 patients (21.1%) were unable to be monitored because they lacked baseline signals from the extremities, and 4 patients had some monitoring but not motors. One hundred seventy nine of the 232 patients (77.2%) were successfully monitored with TcMEPs. Twenty-six patients had a temporary intraoperative loss of signal; none of those patients had permanent change in their neurological function. None of the patients that were monitored with TcMEPs had any increase in seizure activity postoperatively.

Conclusions: At our institution, a high percentage of children (77%) with CP were able to be successfully monitored with TcMEPs during PSF. This differs from what has previously been published and the common practice at many institutions. Furthermore, the concerns about increased seizure activity after TcMEPs were not supported by the data from this cohort. Technical details of successful neuromonitoring these patients are important, and included increased stimulation voltage requirements and latency times.

Significance: TcMEP can be successfully and safely used in the majority patients with CP undergoing PSF to improve intraoperative safety.



Breaking the Dogma: Does UIV have to be T2 in CP Patients Undergoing Spinal Fusion for their Neuromuscular Scoliosis?

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LOE-Therapeutic-Level III

Purpose: “T2 to the pelvis” has become the common term for the surgical treatment of CP patients with neuromuscular scoliosis. While some studies have analyzed the need to fuse to the pelvis, no studies have evaluated the need for an upper instrumented level (UIV) of T2. The purpose of this study was to compare the clinical and radiographic outcomes between T2 and T3/T4.

Methods: A prospective, multicenter registry was queried for patients with CP and scoliosis who underwent posterior spinal fusion with segmental screw fixation and minimum 2 years of follow-up. Patients were grouped according to UIV: T2 vs T3 or T4. All other UIVs were excluded due to low numbers. ANOVA with Bonferroni corrections were used to compare differences in radiographic and caregiver reported outcomes between the UIV groups.

Results: Analysis included 202 patients (65%) with UIV of T2 and 89 (29%) with UIV of T3 or T4. Preoperatively, the T2 group had smaller major curves (78° vs 88° , $p=0.004$), but similar T2-T12 kyphosis (41° vs 42° , $p=0.9$) and proximal thoracic kyphosis (-2° vs -0.7° , $p=0.2$) as compared to the T3/T4 group. GMFCS level distribution was similar between groups with the majority in each being level IV or V ($p=0.2$). The T2 group had longer surgical times (410 vs 367min, $p=0.03$) but similar blood loss (1418 vs 1226ml, $p=0.2$). Postoperatively, there were no differences found between groups in coronal curve correction (62% vs 59%, $p=0.4$), change in kyphosis (-6° vs -6° , $p=1$), change in sagittal balance (-3 vs -4 cm, $p=1$), or PJK (6° vs 6° , $p=0.8$). Improvements in QOL and total CPChild scores were similar between groups ($p>0.2$).

Conclusions: This study supports the idea that surgeons most commonly choose T2 as their proximal level in CP scoliosis surgery. However, in doing so it may increase surgical time without resulting in significant radiographic or clinical benefits. For CP patients without severe kyphosis, surgeons need not be so dogmatic in selecting T2 as the upper instrumented level.

Significance: In patients with CP and neuromuscular scoliosis, fusing to T2 (the “gold standard”) did not show benefits over T3/T4, but rather resulted in similar radiographic and clinical outcomes.

Ambulatory Neuromuscular Scoliosis Patients have Similar Rates of Infection, Perioperative Complications, and Revision to Adolescent Idiopathic Scoliosis Patients

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LOE-Therapeutic-Level III

Purpose: When examined as a collective group, NMS has a worse prognosis and surgical outcomes than its AIS counterpart. However, not all operative patients with diagnoses of Cerebral Palsy, Duchenne Muscular Dystrophy, or other NMS pathology necessarily suffer the same poor outcomes associated with the class. Our aim with this study is to examine more mildly affected NMS patients to determine whether their surgical outcomes are comparable to AIS with regards to patient safety.

Methods: Radiograph and retrospective chart review of NMS and AIS patients undergoing PSF with pedicle screws from 2005-2018 were analyzed. Group 1 included NMS patients who could ambulate without assistance (GMFCS I-III). Group 2 was AIS patients. Demographics, intra-op parameters, and radiographic measurements were collected at pre- and post-op. Wilcoxon rank sums tests and chi-square tests were performed.

Results: Group 1 (n = 48) and Group 2 (n = 158) were similar in age, sex, preoperative kyphosis, pre- and postoperative Cobb angle, and Cobb correction. Additionally, EBL (600mL v 500mL; p=0.143), postoperative transfusions (4 v 9; p=0.5), and perioperative complications within 30 days (4 v 10; p=0.5) were similar between groups. Specifically, infections (0 v 5; p = 0.592), DVT (0 v 1; p = 0.232), revisions (1 vs 4; p = 1.0), and mortality (p = 1.0) were statistically similar. However, group 2 NMS patients did have increased fusion levels (p<0.001), fixation points (p=0.002), pelvic fixation (p=0.002), anesthesia (p<0.001) and surgery time (p<0.001), ICU (p<0.001) and hospital stay (p<0.001), intraop transfusions, pulmonary complications (3 v 0; p=0.012) and fewer patients extubated in the OR (p<0.001).

Conclusions: NMS inherently confers high risk of blood loss, longer surgeries and fusions, complications, ICU and hospital stays. Our data confirms longer fusion levels, surgical time, and hospital stay, with lower extubation rates. Infection rate, revisions, and overall complications were similar to the AIS population as were the radiographic outcomes. This suggests that NMS patients who are ambulating can expect surgical outcomes quite comparable to AIS patients with further room for improvement in surgical duration and anesthesia protocols.

Significance: NMS patients usually have severe curves with more comorbidities and procedural complexity. These patients require extensive fusion levels, increased blood loss, and suffer increased periop complications. However, NMS patients have a variable spectrum of severity. Our study finds that ambulatory NMS patients can achieve periop outcomes similar to AIS patients with regards to surgical complication rate, infections, revisions, and blood loss.

Prophylactic Application of Local Vancomycin onto Surgical Field Shows No Decrease of Acute Surgical Site Infection in Adolescent Idiopathic Scoliosis Patient

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LOE-Therapeutic-Level III

Purpose: Perioperative surgical site infection (SSI) after posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) ranges from 0.5-1.6%. Morbidities associated with SSI following PSF include hospital readmission, additional surgical procedures, and long term antibiotics. Local topical administration of vancomycin on to the surgical field has been shown to decrease rates of SSI among the adult population. Many pediatric deformity surgeons have adopted prophylactic application of vancomycin topically in an effort to decrease SSI in the AIS population. However, efficacy has not been established in this population.

Methods: A multicenter retrospective database query of seven sites belonging to an organization of non-profit medical facilities was performed for data from 2008-2019. ICD-9, ICD-10, and CPT codes were used to identify AIS patients who underwent a primary posterior spinal fusion and instrumentation. Identified patients were then separated into two groups. The Vancomycin group had application of prophylactic local vancomycin into the wound prior to closure and Non-vancomycin group had no local vancomycin added. SSI rates were tabulated and compared between the two groups using a Chi square test of independence.

Results: A total of 1,942 AIS patients (1568F, 80.7%), average age (14.39±2.16 years), underwent PSF surgery from 2008-2019. The Vancomycin group had 1,264 (65.09%) patients (1014F, 80.2%) with 8 patients (0.63%) diagnosed with SSI. The Non-vancomycin group had 678 (34.91%) patients (554F, 81.7%) with 7 patients (1.03%) diagnosed with SSI. Infection rate between the two groups were found to not be statistically significant (p=0.34). Differences in average age at surgery, average Body Mass Index, female to male ratio, and fusion levels by CPT code were not statistically significant in both groups. A greater percent of patients in the Non-vancomycin group underwent an osteotomy at least one level (p= .0004).

Conclusions: The prophylactic use of intra-wound topical vancomycin did not demonstrate decreased rate of surgical site infection in adolescent idiopathic scoliosis patients undergoing posterior spinal fusion.

Significance: Use of prophylactic intra-wound topical vancomycin did not show a statistical difference in the rate of surgical site infection in adolescent idiopathic scoliosis patients undergoing posterior spinal fusion.

◆ Multimodal Treatment for Severe Spinal Deformity in Osteogenesis Imperfecta: Rationale, Outcomes and Complications

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LOE-Therapeutic-Level IV

Purpose: Patients with osteogenesis imperfecta (OI) often develop progressive spinal deformity, which can adversely affect pulmonary function, sitting balance, mobility, self-care and quality of life. Historically, surgical outcomes of spinal fusion for OI patients have been notable for minimal correction of rigid curves, post-fusion progression, and high complication rates including failure of fixation in poor quality bone. We report the outcomes of treating scoliosis in OI with a multimodal approach using preoperative bisphosphonate therapy to improve bone quality, posterior spinal fusion (PSF) with rib and/or posterior spinal osteotomies, segmental pedicle screw instrumentation, and cement augmentation, followed by early mobilization.

Methods: Consecutive patients with OI and thoracolumbar scoliosis managed with PSF and pedicle screw augmentation with cement between 2008-2019 at a single institution and at least one year follow-up were included. Radiographic data were collected from pre-operative and most recent follow-up visits. Incidence of surgical site infection (SSI), proximal junctional kyphosis (PJK), implant failure, cement extravasation, or unplanned return to the OR (UPROR) were recorded.

Results: 28 patients met inclusion criteria. The mean age at surgery was 14.9 years with mean follow-up of 45 months. The average number of levels fused was 13.1 and EBL was 1450mL. There was a moderate correlation between number of levels fused and EBL (Pearson’s $r=0.4$, $p=0.03$). The median length of stay was 6 days. Major curve magnitude, apical vertebral translation (AVT), lower instrumented vertebra (LIV) tilt, global coronal balance (GCB), thoracic kyphosis (T1-T12), and lumbar lordosis (L1-L5) are tabulated in Image 1 (left panel). Significant improvements were found in major curve magnitude (74° to 37° , $p<0.001$), AVT (47mm to 22mm, $p<0.001$), and LIV tilt (22° to 9° , $p<0.001$) from preoperative to postoperative values. No significant differences were detected for the remaining variables. There was one SSI (4%; a superficial infection), one implant failure (4%; screw pullout proximally), one instance of PJK (4%), and one occurrence of adding-on of the proximal thoracic curve cephalad to instrumentation (4%). There was no UPROR, cement extravasation, or neurologic deficit in any patient. Representative pre- and postoperative radiographs are include in Image 1 (middle and right panels).

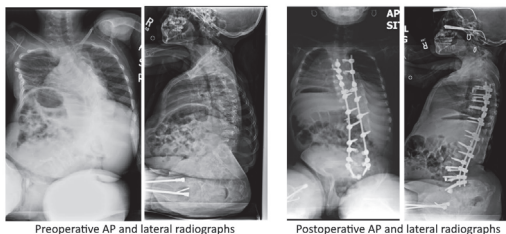
Conclusions: Patients with OI and scoliosis can be safely treated with a multimodal contemporary approach of preoperative bisphosphonate treatment, creating spinal mobility, pedicle screw fixation, and cement augmentation with low complication rates.

Significance: This is the largest series to date of patients with OI and scoliosis undergoing modern pedicle screw fixation and cement augmentation.

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

Variable	Preop	Postop	P value
Major Curve (°)	74 (63-111)	37 (9-68)	< 0.001
AVT (mm)	47 (9-98)	22 (2-35)	< 0.001
LIV tilt (°)	22 (1-53)	9 (1-26)	< 0.001
GCB (mm)	22 (2-72)	23 (1-88)	0.9
Thoracic Kyphosis (°)	35 (12-86)	25 (1-75)	1.0
Lumbar Lordosis (°)	58 (18-135)	64 (9-140)	0.1
Sagittal Balance (mm)	-1 (80-111)	11 (91-109)	0.3

Values are reported as mean (range). GCB = global coronal balance.
 AVT = apical vertebral translation; LIV = lowest instrumented vertebra



Preoperative AP and lateral radiographs

Postoperative AP and lateral radiographs

Post-Operative Complications Assessment for Patients with Early-Onset Scoliosis and Baclofen Pump Usage Undergoing Growth-Friendly Spinal Instrumentation Surgeries

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LOE-Therapeutic-Level III

Purpose: There is limited literature on the post-operative complication rates of patients undergoing growth-friendly spinal surgery for early-onset scoliosis (EOS) who also have baclofen pumps. We sought to fill this gap and characterize how complications in this population are managed.

Methods: A prospective multi-center database was queried to analyze 25 patients with neuromuscular EOS and baclofen pumps treated with either traditional growing rods (TGRs) or magnetically-controlled growing rods (MCGRs); 18 pumps were implanted prior to, 5 after, and 2 during spinal surgery. Patients were matched with a 50-patient cohort in a 2:1 no-pump:pump ratio based on treatment center, gender, diagnosis, surgery type, and curve severity. Univariate analysis and multivariate logistic regression were used with $\alpha = 0.05$.

Results: Patients undergoing both baclofen pump and TGR/MCGR procedures had 5.8 greater odds (95% confidence interval [CI] 2.0–17, $p=0.001$) of having complications within one year after surgery compared to matched controls. Patients with pumps also had 6.5 higher odds of spinal implant removal (95% CI 1.9-31, $p=0.005$) and 4.9 higher odds of deep surgical site infection (95% CI 1.6-14, $p=0.005$). We found no association between timing of pump implantation relative to surgery and complications. Deep infections occurred in 12/25 patients with pumps, most commonly *S. aureus* (5/12) or *P. aeruginosa* (4/12). Of those 12 patients, pump or tubing removal was performed in 3 (25%), two of whom experienced baclofen withdrawal.

Conclusions: Patients with neuromuscular EOS are more susceptible to complications within one year of TGR/MCGR surgery if they also have a baclofen pump. Pump presence is independently associated with higher rates of implant removal and surgical site infection.

Significance: Overall, our findings expand the current literature to include growth-friendly spinal procedures in neuromuscular EOS patients who also have baclofen pumps. The elevated risk of post-operative complications in this population must be considered in the decision to perform surgery and balanced against both the clinical and quality of life improvements that can be obtained.

	Complications	Early (<1 yr.) Complications	Late (> 1 yr.) Complications	Mechanical	Infection	Unplanned Surgery	Change Treatment	Implant Removal
Pump Cohort (n=25)	16 (64%)	14 (56%)	12 (48%)	9 (36%)	12 (48%)	12 (48%)	8 (32%)	9 (36%)
Control Cohort (n=50)	27 (54%)	9 (18%)	22 (44%)	15 (30%)	8 (16%)	17 (34%)	7 (14%)	4 (8%)
p-value	0.409	0.0008**	0.743	0.460	0.003*	0.168	0.066	0.003*
Total (n=75)	43 (57%)	23 (31%)	34 (45%)	24 (32%)	20 (27%)	29 (39%)	15 (20%)	13 (17%)

Table 1: Univariate analysis between pump vs. no-pump patients for rates of complications and responses.

* indicates statistical significance <0.01.

** indicates significance <0.001.

Descriptive Epidemiology from the Research in OsteoChondritis Dissecans of the Knee (ROCK) Prospective Cohort

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LOE-Not Applicable-Level II

Purpose: Osteochondritis dissecans (OCD) occurs most commonly in the knee of young individuals. The etiology is not well understood and treatment algorithms are not well delineated. The Research in OsteoChondritis Dissecans of the Knee (ROCK) group established a multi-centered prospective cohort to better understand this disease. The purpose is to provide a descriptive analysis of the prospective cohort's demographics, lesion characteristics, clinical findings, and patient reported outcome measures (PROMs) at baseline.

Methods: Patients were recruited from 16 centers throughout the United States. Baseline data were obtained for patient demographics, sports participation, PROMs, physical examination, diagnostic imaging results, and initial treatment plan. Descriptive statistics were completed for all outcomes of interest.

Results: From 2012-2020, 27 orthopedic surgeons from 16 institutions have enrolled 924 knees representing 863 OCD patients (68.5% males; median age, 13 years, range: 6 – 25 years, 73.8% Caucasian, 88.5% non-Hispanic or Latino) into the prospective cohort. The majority of patients considered themselves athletes (91.2%, 423 of 464 patients), with the most common primary sport being basketball for males (27.4%) and soccer for females (27.0%). Lesions were located on the medial femoral condyle (65.8%), lateral femoral condyle (19.0%), trochlea (9.1%), patella (6.0%), and the tibial plateau (0.1%). Median scores for baseline PROMS were: 43.8 [IQR: 25.0,56.3] for the KOOS QOL, 70.7 [IQR: 56.5,84.8]for Pedi-IKCD, 21.0 [IQR: 5.0,28.0] for Pedi-FABS, 55.2 [IQR: 37.9,73.6] for IKDC, and 11.5 [IQR: 3.3,16.0] for Marx Activity. The most common treatment courses consisted of surgical intervention (52.3%) and activity restriction (46.2%). When surgery was performed, surgeons deemed the lesion to be stable in 47.6% of cases. The size of OCD lesions measured on diagnostic imaging can be found in Table 1.

Conclusions: After an 8-year recruitment period, the ROCK group has enrolled the largest knee OCD cohort to date. This study confirms the typical locations and frequency of knee OCD lesions along with the typical age at presentation. Baseline outcome scores and activity levels show a highly active young population limited significantly by this condition.

Significance: The robustness of this dataset will provide needed clarification the OCD pathology, including etiology, associated co-morbidities, and initial presentation and symptoms. This cohort is now being followed longitudinally to expand on this understanding to better define and elucidate the best treatment algorithms based on these presenting signs and symptoms.

Table 1: Size of Lesion Measured on Magnetic Resonance Imaging (MRI) and Radiographs (X-ray)

		MFC n=608	LFC n=176	Patella n=55	Trochlea n=84
MRI					
Coronal					
	<i>Width</i>	14.0 [11.5,17.0]	15.3 [12.0, 19,0]	12.0 [11.0,16.0]	14.1 [11.0,16.9]
	<i>Depth</i>	7.0 [5.5,9.1]	7.0 [5.6,9.5]	7.0 [6.0,8.5]	7.0 [4.5,11.0]
Sagittal					
	<i>Length</i>	19.6 [16.0, 25.0]	20.0 [14.8,25.0]	14.0 [10.5, 18.5]	18.6 [14.2,21.0]
	<i>Depth</i>	8.0 [6.0,10.0]	7.1 [5.8,10.0]	7.6 [5.5,9.6]	7.2 [5.1,9.7]
X-ray					
AP					
	<i>Width</i>	15.0 [11.7,18.0]	15.6 [11.6,20.0]	15.1 [11.0,19.5]	13.7 [9.8,20.5]
	<i>Depth</i>	6.0 [4.0,8.0]	7.0 [5.0,11.5]	6.0 [4.0,8.4]	4.6 [2.4,5.9]
Notch					
	<i>Width</i>	15.1 [11.2,20.0]	19.0 [15.0,25.0]	10.3 [10.0,20.9]	18.0 [12.0,21.0]
	<i>Depth</i>	8.0 [5.0,11.6]	8.0 [5.0,10.4]	10.0 [3.5,11.0]	5.0 [2.0,6.0]
Lateral					
	<i>Length</i>	20.0 [15.0,26.0]	19.5 [15.0,26.8]	13.2 [10.2,18.0]	18.6 [14.8,21.3]
	<i>Depth</i>	6.8 [5.0,9.0]	6.0 [4.2,8.0]	5.0 [4.0,7.0]	5.5 [4.2,6.7]

Measurements in mm, Median [IRQ]

n - Number of knees. Total equals 923 knees, single Lateral Tibial Plateau OCD case not reported.

MFC – Medial Femoral Condyle, LFC – Lateral Femoral Condyle

Osteochondral Allografting for Unsalvageable Osteochondritis Dissecans in the Skeletally Immature Knee: A Comparative Analysis of Radiographic Healing and Early Clinical Outcomes Between Skeletally Mature and Immature Patients

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LOE-Therapeutic-Level III

Purpose: To compare radiographic and patient reported outcomes (PROs) in skeletally mature and immature adolescents following fresh osteochondral allograft (FOCA) in the knee for treatment of unsalvageable osteochondritis dissecans (OCD).

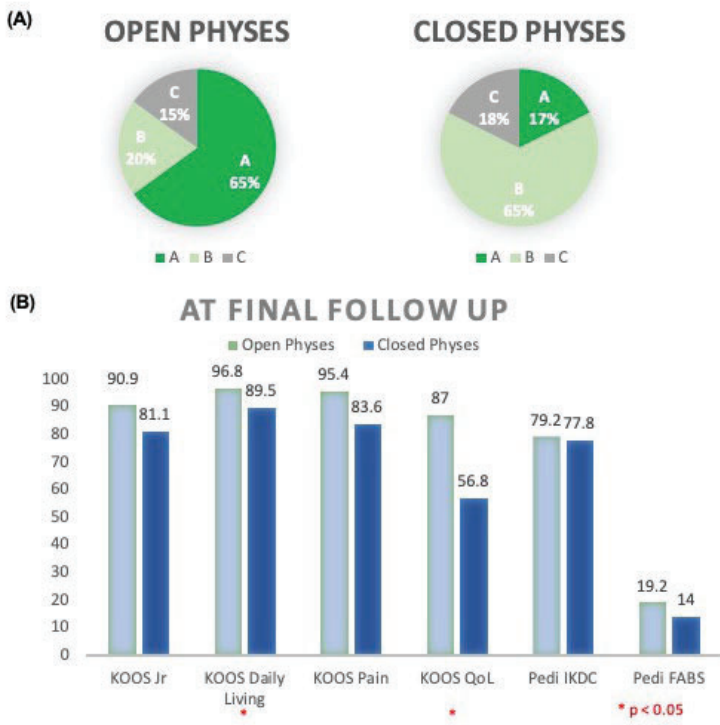
Methods: An IRB-approved review of size-matched FOCA procedure of knee unsalvageable OCD lesions in patients aged < 19 years was performed. Demographics, lesion characteristics, reoperations, and PROs were evaluated and compared between skeletally immature and mature cohorts. A novel grading scale ($k=0.73$) was utilized to evaluate radiographic FOCA incorporation: A=complete, B=>50%, or C=<50% healed.

Results: Thirty-seven patients, average age 15.4 years (9.6-17.6) treated with FOCA for OCD defects of the distal femur or patella (MFC= 16, LFC= 15 Trochlea= 4, Patella= 2), 20 with open and 17 with closed physes, with 2.1 years mean follow up (range 1-5.3 years) were evaluated. Overall average graft size was 5.0cm² and did not differ significantly between groups. Patients with open physes at the time of treatment were younger (14.7 vs 16.2, $p=0.002$) and more commonly male (80% vs 35%, $p=0.008$). 17 (85%) patients with open physes and 17 (82.4%) with closed physes had radiographic healing grades of A or B one year post-operatively (Open: 65% A, 20% B, 15% C; Closed: 17% A, 65% B, 18% C) (Figure 1A). Immature patients demonstrated a high percentage of Grade A. There was no statistical difference in acceptable radiographic outcome based on physeal status, graft size, depth, or location within the knee. There was no difference in pre-operative PROs or activity scores. At final follow-up, open physes FOCA patients demonstrated better KOOS scores [KOOS daily living 96.8 vs 88.5, ($p=0.04$); KOOS quality of life 87 vs 56.8, ($p=0.01$)] (Figure 1B). Final activity scores and Pedi-IKDC were high in the immature group, but did not vary significantly by skeletal maturity [Pedi-FABS immature 19.2 vs mature 14 ($p=0.24$); Pedi-IKDC immature 79.2 vs mature 77.8 ($p=0.31$)]. Radiographic healing grade did not correlate with patient-reported outcomes. Graft failure occurred in only one skeletally mature patient with a trochlear lesion.

Conclusions: Fresh osteochondral allograft treatment in the immature knee may be expected to yield good early results. Despite theoretical concerns regarding incompletely ossified epiphyseal cartilage, open physes, and relatively large graft size; equivalent healing and comparable or superior patient reported outcomes may be expected compared to skeletally mature patients.

Significance: FOCA in the skeletally immature knee is a safe and effective treatment for large, unsalvageable OCD lesions.

Figure 1. Radiographic (A) and Patient Reported (B) Outcomes at Final Follow Up after Osteochondral Allografting in the Open and Closed Physes Groups



Predicting Outcomes of Talar Osteochondritis Dissecans Lesions in Children

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LOE-Not Applicable-Level IV

Purpose: Rates of healing and outcomes following treatment of juvenile osteochondritis dissecans (OCD) of the talus remain scarce. The purpose of this study was to evaluate radiographic healing of talar dome OCD lesions in adolescents.

Methods: This was a retrospective review of patients ≤ 18 years of age with talar OCD from a single pediatric institution within a 12-year period. Charts and radiographs were reviewed for demographic and clinical data, lesion location and size, and physeal status. Final radiographic healing was evaluated at 1-year follow-up. Complete and incomplete healing groups were compared using multivariable logistic regression models to examine the predictive effects of the independent variables. A nomogram was produced from the study sample to allow predictions to be made for individual patients regarding the likelihood of complete radiographic healing at 1-year follow-up.

Results: Ninety-two lesions in 74 patients with a mean age of 13.1 ± 2.7 years (range 7.1-18.0 years; 61% female) were analyzed. Fifty-eight (63%) lesions were treated surgically (drilling, debridement, microfracture, bone grafting, or loose body removal); the rest were treated non-operatively. Forty-three (47%) lesions demonstrated complete radiographic healing. In bivariate analysis, patients with complete healing were younger ($p=0.006$), skeletally immature ($p=0.013$), and had lower a BMI ($p<0.001$) compared to those with incomplete healing. In a multivariate regression model, the factors that correlated significantly with the rate of complete healing were age at diagnosis, BMI, and initial treatment type (conservative vs. surgical). The dimensions of the lesion showed no association with the likelihood of healing. A nomogram was developed using the independent variables that correlated significantly with the likelihood of complete radiographic healing (Figure 1).

Conclusions: Complete radiographic healing of talar OCD lesions was more likely in younger patients with lower BMI. The effects of initial surgical treatment on predictive healing rate is greater in older and heavier patients.

Significance: To our knowledge, this is the first time a nomogram predicting complete radiographic healing has been developed for juvenile OCD lesions of the talus. Besides its potential role in the treatment decision making process, this nomogram can be used to counsel patients and their families with regard to the healing prognosis.

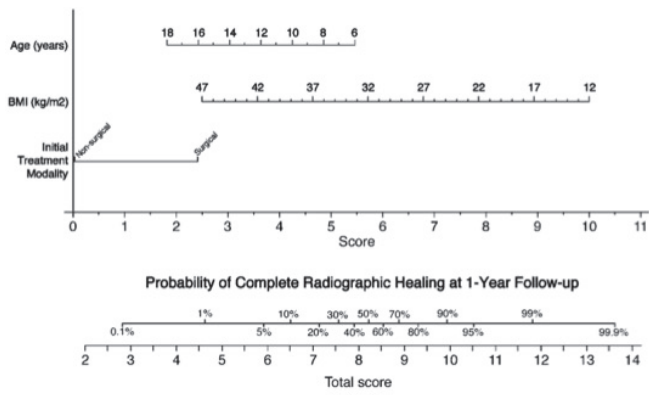


Figure 1. Nomogram used to predict complete radiographic healing at 1-year follow-up on the basis of patient's age, body mass index (BMI) and the type of initial treatment. To calculate the probability of complete radiographic healing, straight vertical lines should be drawn from the points corresponding to patient's age, BMI and initial treatment types on each of the first 3 horizontal lines labelled as "Age (years)", "BMI (kg/m²)" and "Initial Treatment Modality", respectively. Next, record the values that each of these vertical lines provide at their points of intersection on the line labelled "Score". All recorded values should be summed, and this sum is then matched with a value on the line labelled "Total Score". The corresponding % number on the line immediately above the total score is the patient-specific probability of achieving complete radiographic healing at 1-year follow-up.

Activity Specific Differences in Patients Returning to Sports Following Primary Hip Arthroscopy

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LOE-Therapeutic-Level III

Purpose: Hip arthroscopy yields high rates of return to sports when treating intra-articular hip pathology in adolescents. However, the proportion of athletes who return to specific sports and the time required, has not yet been studied in the adolescent population. The purpose of the study was to describe the time to return-to-sport (RTS) following primary hip arthroscopy for specific sports, as well as to describe the proportion of patients who returned to their primary sport or desired sport/activity.

Methods: 42 patients, ages 12-17, underwent a primary hip arthroscopy between September 2015 and July 2019 and completed a survey at least one year post-operatively. Participants reported sport participation prior to/following treatment, date of return to sport, and satisfaction following treatment.

Results: There were no significant differences between groups in their age, proportion of boys/girls, or pre-operative level of play. 59.5% (n=25) indicated they returned to their primary sport, 23.8% (n=10) returned to a different sport at their desired level, and 16.7% (n=7) returned to an undesired level of sports. On average, patients RTS 232 days (8 months) post hip arthroscopy. Flexibility sport athletes (gymnastics/cheerleading/dance) RTS at 187.7 days, while running and contact sports (football, track, cross country, soccer) returned at an average of 221.7 days. Dance, cheerleading, and gymnastics were among the most common pre-operative primary sports (30%) followed by soccer (16%) and running, track, or cross country (16%) (Table 1).

Conclusions: Adolescent athletes returned to previous level of sports at an average 232 days. 83.3% of participants had returned to their desired level of sports or activity following primary hip arthroscopy. While dance, cheerleading, and gymnastics were the most common pre-operative sports, less than half returned and reported satisfaction with treatment. The majority of participants who reported soccer, running, track, and cross country as their primary sport returned following treatment and reported satisfaction with treatment.

Significance: Over 80% of adolescent athletes who undergo primary hip arthroscopy return to their desired level of activity by one-year post-operative. Further research may be warranted to determine whether a patient's primary sport predicts likelihood to successfully RTS, and whether certain sports require longer post-operative rehabilitation for successful RTS.

Table 1. Details of pre-operative and post-operative sport participation for individual sports.

Sport	Number of participants who reported as primary pre-operative sport	Number of participants who reported returning to primary sport	Average time to RTS (days)
Dance/Cheer/ Gymnastics	13	6	187.66
Soccer	7	5	242.75
Football	3	2	218.5
Basketball	3	1	221
Running/Track/ Cross Country	7	5	272.5
Baseball/Softball	2	1	298
Figure Skating	1	1	607
Volleyball	1	1	130
Tennis	1	1	155
No Primary Sport reported	2	-	-

Clinical Outcomes, Survivorship, and Return to Sports After Arthroscopic Capsular Repair with Suture Anchors for Adolescent Multidirectional Shoulder Instability at Mean Follow-Up of 6 Years

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LOE-Therapeutic-Level II

Purpose: Multidirectional shoulder instability (MDI) refractory to rehabilitation can be treated with arthroscopic capsulolabral reconstruction with suture anchors. To the best of our knowledge, no prior studies have reported on outcomes or examined the risk factors that may contribute to poor outcomes in adolescent athletes. The purpose of the study was to identify risk factors for surgical failure by comparing anatomic, clinical, and demographic variables in adolescents who underwent surgical intervention for MDI.

Methods: All patients undergoing arthroscopic shoulder surgery at one institution between January 2009 and April 2017 were reviewed. Patients >20 years old at presentation were excluded. Multidirectional instability was defined by positive drive-through sign on arthroscopy plus positive sulcus sign and/or multidirectional laxity on anterior and posterior drawer testing while under anesthesia. Two-year minimum follow-up was required, but those whose treatment failed earlier were included for reporting purposes. Demographics and intraoperative findings were recorded, as were Single Assessment Numeric Evaluation (SANE) scoring, Pediatric and Adolescent Shoulder Survey (PASS), and the short version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) results.

Results: Eighty adolescents (88 shoulders) were identified for having undergone surgical treatment of MDI. Of these 80 patients, 42 (50 shoulders; 31 female, 19 male) were available at a minimum of 2-year follow-up. Mean follow-up was 6.3 years (range, 2.8-10.2 years). Thirteen (26.0%) shoulders experienced surgical failure defined by recurrence of subluxation or instability, all of which underwent re-operation. Time to re-operation occurred at a mean of 1.9 years (range, 0.8-3.2). None of the anatomic, clinical, or demographic variables tested, or the presence of generalized ligamentous laxity, were correlated with subjective outcomes or re-operation. Number of anchors used was not different between those that failed and those that did not fail. Patients reported a mean SANE score of 83.3, PASS score of 85.0, and QuickDASH score of 6.8. Return to prior level of sport (RTS) occurred in 56% of patients.

Conclusions: Multidirectional shoulder instability is a complex disorder that can be challenging to treat, and that return to previous levels of athletic competition is possible. In patients who do experience failure of capsulorrhaphy, we show that failure will most likely occur within 3 years of the index surgical treatment.

Significance: Adolescent MDI that is refractory to non-surgical management appears to have long-term outcomes after surgical intervention that is comparable to adolescent patients with unidirectional instability.

Table 1. Patient Characteristics

		Cases	Percentage
Mean Age (years)		15.8	
Sex	Male	19	38%
	Female	31	62%
Laterality	Left	22	44%
	Right	28	56%
Generalized Ligamentous Laxity	No	45	90%
	Yes	5	10%

Table 2. Outcomes by Sex

	Male	Female	Total	p-value
SANE	80.6	84.4	83.3	0.462
PASS	80.2	86.9	85.0	0.224
QuickDASH	9.1	5.9	6.8	0.288
RTS	13 (68%)	15 (48%)	28 (56%)	0.166
Surgical Failure	6 (32%)	7 (23%)	13 (26%)	0.481

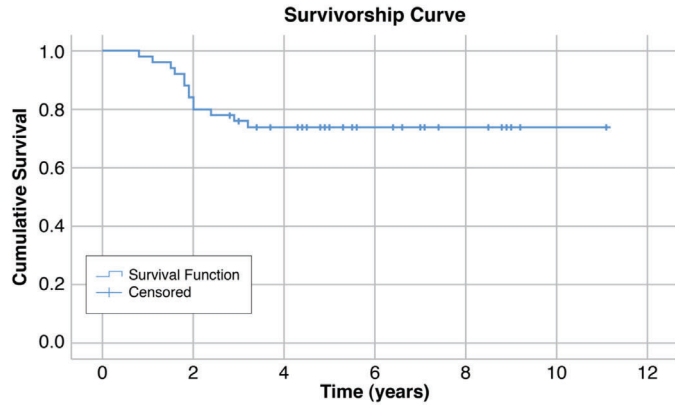


Figure 1. Survivorship curve demonstrating overall survivorship of 96% at 1 year after surgery and 76% at 3 years.

Utility of MRI Assessment of Healing following Marrow Stimulation of Capitellar OCD

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LOE-Prognostic-Level III

Purpose: The purpose of this study was to describe the postoperative MRI appearance of capitellar repair cartilage after debridement and marrow stimulation for capitellar osteochondritis dissecans.

Methods: This is a retrospective study of patients with an OCD of the humeral capitellum who underwent arthroscopic debridement with marrow stimulation and had a postoperative MRI to assess healing. The classification system developed by Marlovits and colleagues (MOCART) for the description of articular cartilage repair tissue following biologic repair procedures was utilized to quantitatively profile the morphology and signal intensity of the cartilage repair tissue in comparison to adjacent “normal” articular cartilage in patients who underwent debridement and marrow stimulation of a capitellar OCD lesion. Study participants completed the KJOC, QuickDASH, the Liverpool-PAQ, and PROMIS modules.

Results: Twenty-nine patients were included, including 18 males (62%), and a mean age at time of surgery of 13.4 years (range, 10.4-17.5). Mean time to post-surgical MRI was 13.2 months. 59% of patients displayed evidence of complete cartilage defect fill, 58% had incomplete integration of border zone cartilage, and in 83% of patients the cartilage surface was not intact. In patients who underwent a revision operation for ongoing pain or disability after the index cartilage repair procedure, subchondral bone edema was a common finding on MRI.

Conclusions: Incomplete cartilage fill is common after microfracture for capitellar OCD. Subchondral bone edema is a common MRI finding in patients who required an additional operation following their index procedure, and this may be an objective imaging finding associated with persistent symptoms and the need for further surgery.

Significance: Cartilage healing by MRI after OCD marrow stimulation is often incomplete; persistent marrow edema is the most common MRI finding in those requiring additional surgery.

Table: Patient characteristics who underwent additional operations versus those who did not.

Variables	Reoperation	No Reoperation	p-Value
Number of Males	6/8 (75%)	12/21 (57%)	0.3300
Age at Surgery (Mean years ± STD)	13.91 ± 1.59	13.26 ± 1.64	0.3578
Time until MRI (Mean months, range)	12.6, 3.9-27.9	13.4, 2.4-53.0	0.8834
Intraoperative Lesion Size (Mean cm ² ± STD)	1.18 ± 0.87	0.90 ± 0.52	0.3422
Sport			0.4260
Baseball	5/8 (63%)	8/21 (38%)	
Gymnastics	1/8 (13%)	7/21 (33%)	
Other	2/8 (25%)	6/21 (29%)	
Complete Defect Filling	3/8 (38%)	14/21 (67%)	0.1580
Complete Integration of Border Zone	1/8 (13%)	11/21 (52%)	0.0600
Intact Surface	0/8 (0%)	5/21 (24%)	0.1710
Homogeneous Structure	1/8 (13%)	10/21 (48%)	0.0920
Isointense Signal Intensity	7/8 (88%)	21/21 (100%)	0.2760
Non-intact Subchondral Lamina	8/8 (100%)	17/21 (81%)	0.2520
Subchondral Bone Edema	8/8 (100%)	13/21 (62%)	0.0470
Synovitis	3/8 (38%)	2/21 (10%)	0.1120
KJOC Score, Mean (STD)	6.46 (3.0)	8.25 (1.6)	0.0670
QuickDASH Score	16.29 (16.2)	5.00 (8.88)	0.0380
Liverpool Score	4.74 (1.1)	5.76 (0.6)	0.0050
PROMIS Mobility	53.34 (7.8)	57.77 (7.2)	0.1950
PROMIS Pain Interference	37.29 (7.0)	38.54 (8.2)	0.7280
PROMIS Upper Extremity	52.71 (6.8)	54.36 (7.1)	0.6110

Do Continuous Peripheral Nerve Blocks Decrease Home Opioid Use Following Anterior Cruciate Ligament Reconstruction in Children and Adolescents? The Envelope Please.

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LOE-Therapeutic-Level II

Purpose: Anterior cruciate ligament reconstruction (ACLR) is commonly performed in youth athletes. Opioid misuse and addiction has reached alarming proportion and is a growing concern in the pediatric population. The purpose of this study was to evaluate whether a continuous peripheral nerve block (CPNB) with placement of an elastomeric reservoir ball would decrease the need for home opioid analgesia when compared to a single-shot peripheral nerve block (SPNB) following ACLR in children and adolescents.

Methods: A retrospective review was performed of prospectively collected data from a consecutive cohort that underwent ACLR by a single surgeon. Group 1 had ACLR and received a CPNB prepared to last 72 hours. Group 2 had ACLR and received a SPNB. Post-operative pain management included cryotherapy, oral acetaminophen and ibuprofen. A prescription for 10 doses of hydrocodone/acetaminophen (5/325 mg) was provided in a sealed envelope with instructions to only be used for uncontrolled pain. All children recorded their Visual Analog Scale (VAS) and medications taken following surgery using a three-day written log. Those reporting no narcotics needed to provide the unopened envelope and unfilled prescription. A state Controlled Substance Utilization Review and Evaluation System (CURES) inquiry was made during the perioperative period. Data was analyzed by an independent statistician. This study was powered to detect a difference of 20% in rate of narcotic consumption which was presumed based on pilot data. All analyses were performed using SPSS v. 24 with alpha set at $p < 0.05$ to declare significance.

Results: One hundred ninety-six children were included in the study with an average age of 15 years (range 10-19y). 58 (30%) took hydrocodone/acetaminophen post ACLR, 39 female (67.2%) 19 male (32.8%). The CPNB group consumed 4.7 ± 10 morphine milligram equivalents (MME) (95 % CI 2.5-6.9) vs 6.5 ± 11.5 MME (95 % CI 4.3-8.7) in the SPNB group ($p=0.427$) There were no significant differences between groups in demographics, operative data or VAS scores.

Conclusions: In children and adolescents requiring narcotics following ACLR the average utilization was 1.3 pills of hydrocodone/acetaminophen with no child using more than 10 pills. The MME can be diminished with a CPNB however not significant enough to recommend routine use. We postulate that the sealed envelope in this study, both physically and psychologically, reduced the filling of the opioid prescription.

Significance: At home postoperative narcotic use can be obviated in 70% of children and adolescents following ACLR regardless of type of PNB continuous vs. single.

Table: Demographic, Surgical Data and Visual Analog Scale (VAS) Scores for Group 1, children and adolescents that underwent ACLR with a CPNB and Group 2 that underwent ACLR with a SPNB.

	GROUP 1 N=82	GROUP 2 N=114	P-value
Age (years)	15.07 ± 1.8	15.28 ± 1.7	0.407
Sex Male/Female	38/44	43/71	0.227
Surgery time (minutes)	97 ± 27.36	104.27 ± 31.96	0.103
Block type Adductor canal	61	83	0.804
Block type Femoral nerve	21	31	
Timing of Block prior to surgery	70	108	0.023
Timing of Block end of surgery	12	6	
ACLR Graft Hamstring tendon	58	79	0.586
ACLR Graft Hybrid Auto / Allograft Hamstring tendon	3	5	
ACLR Graft Patella tendon	14	22	
ACLR Graft Quadriceps Tendon	6	7	
ACLR Graft Iliotibial Band	3	1	
Visual Analog Scale			
VAS Day 1	5.55 ± 2.82	5.59 ± 2.48	0.88
VAS Day 2	5.67 ± 2.56	6.13 ± 2.30	0.26
VAS Day 3	4.76 ± 2.48	5.01 ± 2.48	0.47

Descriptive Epidemiology of Complete Anterior Cruciate Ligament Tears in the Skeletally Immature Population: A Multicenter Investigation of the PLUTO Study Group

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LOE-Therapeutic-Level II

Purpose: To report the demographic characteristics and descriptive epidemiology of a large cohort of skeletally immature patients with complete anterior cruciate ligament (ACL) tears through a prospective, multicenter study.

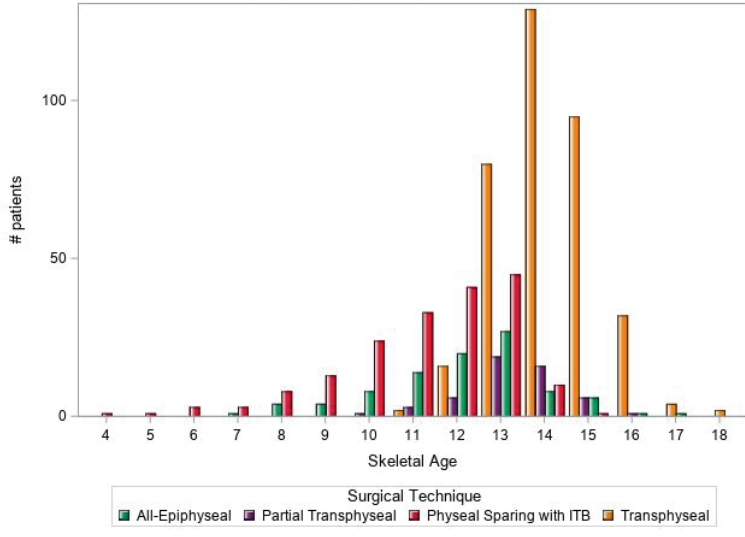
Methods: Upon institutional review board approval at 10 geographically diverse institutions in the United States, consecutive skeletally immature patients diagnosed with complete ACL tears between January 2016 and April 2020 were screened and consented for enrollment. Treatment was provided by one of 23 participating orthopedic surgeons. Patient demographics, including chronological and skeletal age, sex, race, ethnicity, as well as anthropometric measures, mechanism of injury, and ACL treatment type were collected.

Results: 750 skeletally immature patients were included in the final cohort; the mean \pm SD chronological age was 12.3 ± 1.9 years, and 62.3% were male. Mean skeletal age (13.2 ± 1.9 years) was on average 0.8 years higher than mean chronological age (CI: 0.8-0.9; $p < 0.001$). The median BMI percentile for the cohort was 75th (IQR, 51-90), and 13.1% were classified as obese (≥ 95 th percentile). 5.4% reported a previous knee injury on the ipsilateral side, and 32.4% had a family history of ACL injuries. Sport was the predominant mechanism of injury (89.9%), with non-contact injuries the most common (61.7%). When stratified by sex, non-contact injury was significantly higher in females (68.5%) than males (57.6%) ($p = 0.005$). The most common sport resulting in an ACL tear among males was football (40.7%) and among females was soccer (44.2%) ($p < 0.001$). 99.9% percent of skeletally immature patients were treated surgically by one of four reconstruction techniques: transphyseal (52.5%), partial transphyseal (7.2%), all-epiphyseal (13.2%), and the physeal sparing iliotibial band (ITB) technique (27.1%). One patient underwent non-operative treatment. The most common surgical techniques for patients with a bone age younger than 13 years were physeal sparing with ITB (61.6%) and all-epiphyseal (24.8%), while in patients with a bone age of 13 years and older, transphyseal (70.8%) and physeal sparing with ITB (11.6%) were most common ($p < 0.001$).

Conclusions: This multicenter, prospective study is the first to describe the characteristics of an exclusively skeletally immature cohort with complete ACL tears. Almost all patients were injured during sports, surgical treatment was overwhelmingly the treatment of choice, and preferred surgical techniques varied based on skeletal age.

Significance: As ACL injuries are being seen with increased frequency in pediatric and adolescent patients, understanding patient and injury characteristics, and describing treatment strategies are important to help guide surgical decisions in the care of these young patients.

Surgical Treatment Type By Skeletal Age



Anatomic versus Non-anatomic Anterolateral Tenodesis in Combination with Anterior Cruciate Ligament Reconstruction – Sometimes Cheaper is Better

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LOE-Therapeutic-

Purpose: Rotational instability might persist in patients following anterior cruciate ligament (ACL) reconstruction if extra-articular lateral knee structures are injured. A number of procedures have been developed to reduce the anterolateral instability, some based on the anatomy of the anterolateral ligament (ALL) and others based on a non-anatomic constraint against excessive internal rotation. The purpose of this study was to evaluate whether an anatomic ALL tenodesis or non-anatomic lateral extra-articular tenodesis (LET), combined with ACL reconstruction, restores knee kinematics closer to normal.

Methods: Ten human cadaveric knees were mounted on a robotic testing system. A combined external load of 5Nm internal tibial torque, 50N anterior tibial load, 0.5Nm valgus tibial torque, and 100N compression was applied. The kinematic responses were recorded for six conditions (Figure 1) at selected flexion angles between 0° and 90° in random sequence. ACL reconstruction was done with an all-inside technique with quadrupled semitendinosus grafts and dual-suspensory fixation. For the anatomic ALL reconstruction, a gracilis graft was fixed with biointerference screws 5mm proximal/posterior to the fibular collateral ligament (FCL)'s femoral insertion and midway between Gerdy tubercle and the anterior margin of the fibular head. The non-anatomic LET was performed with a central strip of the iliotibial band, with the distal part left attached to Gerdy Tubercle, looped under the FCL, and attached to the femur with the tightrope button sutures of the ACL reconstruction.

Results: Internal rotation was increased in ACL-deficient knees compared to intact knees. Sectioning the anterolateral structures further increased internal rotation, with a relatively greater effect towards higher flexion. Between 0° and 30°, ACL reconstruction reduced the abnormal internal rotation closer to normal, but residual excessive rotation persisted; neither ALL reconstruction nor the LET technique affected internal rotation between 0° and 30°. From 45° to 90°, only the LET technique restored internal tibial rotation close to normal. The applied loads resulted in failure of ALL reconstruction; the LET maintained its structural integrity throughout the tests.

Conclusions: At lower flexion, ACL reconstruction was the primary restraint against excessive internal rotation caused by rupture of the ACL and anterolateral structures, and neither anatomic ALL reconstruction nor LET offered additional restraint. From 45° and higher, only the LET restored internal rotation close to normal.

Significance: The described LET technique is biomechanically superior to the anatomic ALL reconstruction, avoids the need for drilling a tunnel near the ACL femoral tunnel, and requires no additional financial cost to an all-inside ACL reconstruction.

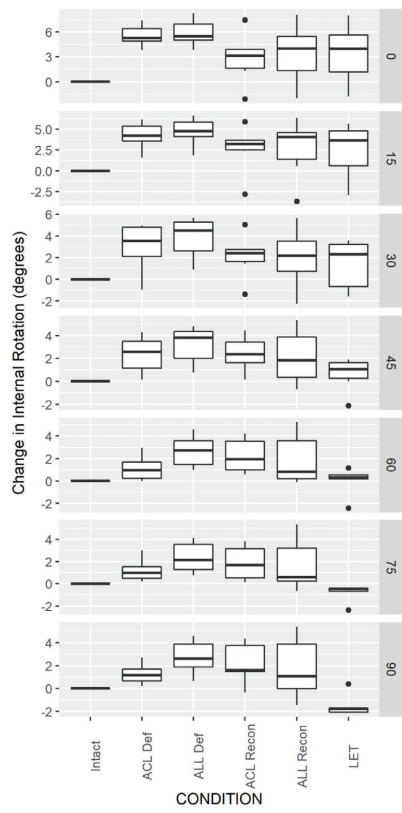


Figure 1. Change in internal rotation ($^{\circ}$) at selected flexion angles, relative to the intact knees, of ACL-deficient (ACL Def), ACL-deficient/ALL-deficient (ALL Def), ACL-reconstructed/ALL-deficient knee (ALL Recon), ACL-reconstructed/anatomic ALL-reconstructed (ALL Recon), and ACL-reconstructed/non-anatomic LET (LET).

Iliotibial Band Autograft Provides The Fastest Recovery Of Knee Extensor Mechanism Function In Pediatric Anterior Cruciate Ligament Reconstruction

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LOE-Therapeutic-Level III

Purpose: Disagreement remains regarding the optimal autograft choice for anterior cruciate ligament reconstruction (ACLR). Autograft options for pediatric patients include iliotibial band (IT), hamstring tendon (HT), quadriceps tendon (QT), and patellar tendon (PT). This study compared knee joint function among pediatric athletes with different types of ACLR autografts.

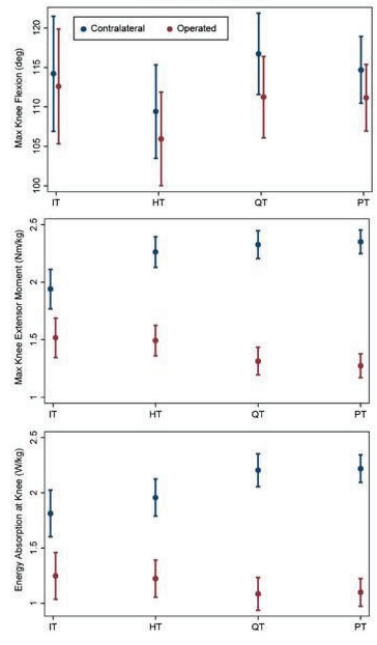
Methods: This retrospective study examined 150 pediatric athletes (79 female; mean age at surgery 15.0, SD 2.2, range 7-21 years) who had undergone biomechanical testing in our motion analysis laboratory following unilateral ACLR. 3D motion capture evaluated kinematics and kinetics during vertical drop-jump landing (41 cm) and 45° cutting. All ACLRs used autografts including 20 IT, 30 HT, 40 QT, and 60 PT. Some subjects had two tests at different timepoints yielding 180 total tests (mean 7.4, range 3-18 months post-surgery). Dynamic function of the knee extensor mechanism was measured by maximum knee flexion angles, internal extensor moments, and energy absorption during the landing phase of each movement and compared among graft types and sides (ACLR vs. contralateral) using linear mixed models with sex, age, and time since surgery as covariates.

Results: Of all graft types tested, dynamic knee extensor function was greatest in the IT band group. Knee flexion was significantly lower on the operated vs. contralateral side for HT, QT, and PT during both drop jump ($p \leq 0.01$, Table 1) and cutting ($p < 0.01$, Table 2). All graft types exhibited lower knee extensor moments and energy absorption on the operated side during both movements ($p \leq 0.01$). This asymmetry was most pronounced for QT and PT and least pronounced for IT (Figure 1). Loading on the operated limb decreased in order from IT to HT to QT and PT, while loading on the contralateral limb increased similarly. Asymmetry of kinetics was significantly lower for IT compared with both QT and PT during both movements ($p \leq 0.01$). Similar patterns were observed for HT but were less pronounced and not always statistically significant. Few differences in asymmetry were observed between IT and HT or between QT and PT.

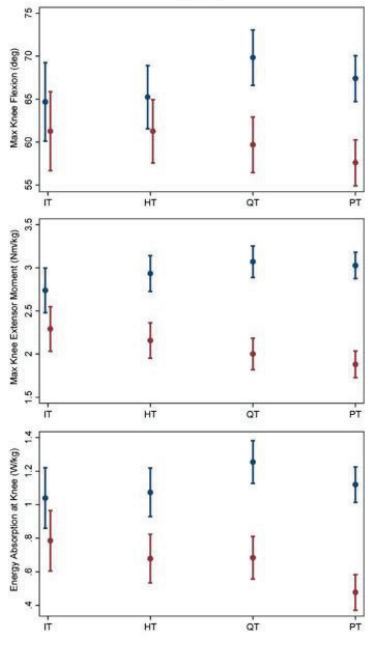
Conclusions: In the return to sport timeframe following ACLR, young athletes with IT band autografts exhibited the greatest engagement of the knee extensors during dynamic loading among all autografts studied. This was evidenced by both higher loading of the reconstructed knee and lower loading of the contralateral knee.

Significance: These results support the use of IT band as a viable autograft option in young athletes undergoing ACL reconstruction.

DROP JUMP



CUT



Functional Recovery After Revision ACL Reconstruction In Adolescents and Young Adults

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LOE-Therapeutic-Level IV

Purpose: Young patients undergoing anterior cruciate ligament reconstruction (ACLR) are at high risk of graft re-injury and need for revision surgery. Although poor performance on functional testing after primary ACLR has been associated with poor outcomes, no study to date has comprehensively investigated the functional recovery of young patients after revision ACLR. The purpose of this study was to evaluate performance in functional return to sports (RTS) assessments six months after revision ACLR in adolescents and young adults and to assess any potential differences in functional deficits following primary and revision ACLR within the same patient.

Methods: A retrospective review of prospectively collected data was performed in patients who underwent revision ACLR at the study institution. Patients ≤ 19 years-old at the time of primary ACLR, ≤ 25 years-old at the time of revision ACLR, and those who underwent functional RTS testing 5-8 months after revision ACLR were included. Exclusion criteria were previous significant lower extremity injury, surgery to the contralateral lower extremity, and multi-ligamentous knee injury. RTS testing included anthropometric measures, isometric strength, Y-Balance, and functional hop testing. Comparisons were made between the operative and non-operative leg after revision ACLR (and primary ACLR, when applicable, as well as between the two time points, in this subset). Paired t-tests were employed to identify significant differences. Statistical significance of $p < 0.05$ was applied.

Results: The study cohort of 63 patients (mean age: 17.46 years; 54% male) underwent RTS testing at a mean of 6.25 months postoperatively (Table 1). Revision ACL patients exhibited significant side-to-side deficits in thigh circumference ($4.32 \pm 3.74\%$, $p=0.006$), knee extension range of motion ($1.44 \pm 2.47^\circ$, $p=0.027$), knee flexion strength (22.11% , $p < 0.001$), Y-Balance anterior ($4.73 \pm 9.61\%$, $p=0.006$), single hop distance ($10.24 \pm 13.57\%$, $p=0.037$), and triple hop distance ($9.92 \pm 11.37\%$, $p=0.048$). In the 23 patients who also underwent testing after primary ACLR (Table 2), significantly worse side-to-side deficits in thigh circumference ($2.40 \pm 2.13\%$ vs $4.48 \pm 2.72\%$, $p=0.009$) and Y-Balance anterior reach ($-0.64 \pm 8.35\%$ vs $5.17 \pm 8.10\%$, $p=0.027$) were detected.

Conclusions: Adolescents and young adults show concerning levels of strength, balance, and functional hop test deficits 6 months after revision ACLR. Despite a similar experience with a prior rehab most of the functional deficits that are present after primary surgery have not seen greater capacity to improve 6 months after revision ACLR.

Significance: Overall, these data underscore the prolonged rehab needs of revision ACLR patients well beyond the 6-month post-operative mark and to a greater degree than primary ACLR patients.

Table 1: Results of Functional Testing 6 months after Revision ACLR

	% Deficit	p-value
Anthropometric Measurements		
Thigh Circumference (%)	4.32±3.74	0.006
Knee Extension (°)	1.44±2.47	0.027
Knee Flexion (°)	1.61±5.40	0.284
Isometric Strength Testing		
Knee Extension (N)	7.26±11.87	0.066
Knee Flexion (N)	22.11±22.63	<0.001
Hip Extension (N)	-2.61±13.91	0.669
Hip Abduction (N)	-5.53±19.41	0.527
Y-Balance Test		
Anterior (m)	4.73±9.61	0.006
Posterolateral (m)	0.37±5.59	0.859
Posteromedial (m)	1.14±10.14	0.532
Composite Score	4.13±10.14	0.068
Hop Testing		
Single Hop (m)	10.24±13.57	0.037
Triple Hop (m)	9.92±11.37	0.048
Timed Hop (sec)	-4.31±10.36	0.558
Crossover Hop (m)	5.96±10.56	0.334

Table 2: Comparison of Functional Testing Deficits after Primary and Revision ACLR

	% Deficit		p-value
	Primary Surgery	Revision Surgery	
Anthropometric Measurements			
Thigh Circumference (%)	2.40±2.13	4.48±2.72	0.009
Knee Extension (°)	0.57±3.29	0.83±2.53	0.698
Knee Flexion (°)	1.87±3.87	1.70±3.57	0.898
Isometric Strength Testing			
Knee Extension (%)	1.50 ± 15.09	5.50 ± 12.79	0.221
Knee Flexion (%)	21.13 ± 16.73	23.83 ± 22.60	0.628
Hip Extension (%)	1.66 ± 15.70	-7.33 ± 16.79	0.062
Hip Abduction (%)	-4.16 ± 18.31	-6.45 ± 22.05	0.712
Y-Balance Test			
Anterior (%)	-0.64 ± 8.35	5.17 ± 8.10	0.027
Posterolateral (%)	-1.55 ± 7.55	1.12 ± 3.69	0.134
Posteromedial (%)	-0.27 ± 5.29	2.62 ± 3.75	0.052
Composite Score (%)	-0.53 ± 5.19	6.85 ± 19.12	0.105
Hop Testing			
Single Hop (%)	7.89±14.97	6.88 ± 13.61	0.943
Triple Hop (%)	5.92 ± 12.72	9.26 ± 13.54	0.310
Timed Hop (%)	-6.76 ± 9.22	-2.01 ± 6.42	0.065
Crossover Hop (%)	2.95 ± 13.91	5.09 ± 9.97	0.242

Risk Factors for Revision Following Anterior Cruciate Ligament Reconstruction in a Pediatric Population: A Prediction Algorithm

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LOE-Prognostic-Level III

Purpose: The authors sought to: 1. Determine the rate of pediatric ACL reconstruction (ACLR) failure requiring revision surgery in a nationally representative sample. 2. Determine the associated patient/injury-specific risk factors for reoperation following ACLR. 3. Develop a preliminary algorithm that estimates the risk of reoperation following ACLR in pediatric patients

Methods: The PearlDiver patient record database was used to identify adult (age ≥ 20 years) and pediatric (age < 20 years) patients between 2010 and 2015 who underwent primary ACLR. Patients were followed for five years with risk of ACL revision surgery compared between adult and pediatric patients by Kaplan Meier survival analysis and Cox-proportional hazards modeling. Contralateral ACL surgery during the study period was also compared using Chi-square analysis. Multivariate logistic regression was used to determine the significant risk factors for ACL revision and overall reoperation rates in pediatric and adult patients. From these risk factors, a risk algorithm was developed using a multivariable logistic regression model.

Results: Included in the study were 2055 pediatric patients, 1778 adult patients 20-29 years old, and 1646 adult patients 30-39 years old who underwent ACL reconstruction. Pediatric patients faced a higher risk of ACL revision following their index ACLR compared to adult patients (at 5 years: 18.0% vs. 9.2% for 20-29 yo and 7.1% for 30-39 yo, $p < 0.0001$), with significantly decreased survivorship of the index ACLR in pediatric patients (log-rank test $p < 0.0001$). Pediatric patients were also at higher risk of sustaining a contralateral ACL reconstruction during the study period compared to adults (5.8% vs. 1.6% 20-29 yo and 1.9% 30-39 yo, $p < 0.0001$). Amongst the pediatric cohort, males (OR=0.78, $p=0.0204$) and patients > 14 years old (OR=0.62, $p=0.0035$) had a decreased risk of overall reoperation. Patients undergoing concurrent meniscal repair (OR=1.84, $p < 0.0001$) or meniscectomy (OR=2.20, $p < 0.0001$) had an increased risk of ACLR revision. The risk algorithm demonstrated the highest probability for ACLR revision in females, less than 15 years of age, with concomitant meniscus and MCL injury, demonstrating a 36% risk of revision.

Conclusions: Compared to adults, pediatric patients have an increased likelihood of ACL revision surgery, contralateral ACLR, and meniscal reoperation within five years of an index ACLR.

Significance: There is limited literature focused on the risk of reoperation following ACLR in pediatric patients. In the present study we examined the rate and risk factors for reoperation following ACLR in one of the largest pediatric cohorts to date and developed a predictive algorithm to help counsel patients on their risk of reoperation

Algorithm for Probability of Pediatric ACLR Revision Given Baseline Characteristics

Multivariate Predictor				Probability of ACLR Revision (%)
Female Sex	Age 10-14	MCL Injury	Meniscus Injury	
Yes	Yes	Yes	Yes	36.3
No	Yes	Yes	Yes	32.7
Yes	No	Yes	Yes	26.5
Yes	Yes	No	Yes	24.8
No	No	Yes	Yes	23.6
No	Yes	No	Yes	22.0
Yes	Yes	Yes	No	20.1
No	Yes	Yes	No	17.7
Yes	No	No	Yes	17.3
No	No	No	Yes	15.2
Yes	No	Yes	No	13.8
Yes	Yes	No	No	12.7
No	No	Yes	No	12.0
No	Yes	No	No	11.1
Yes	No	No	No	8.5
No	No	No	No	7.3

Acute Cast Immobilization of Pediatric and Adolescent Forearm Fractures – Is It Safe?

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LOE-Therapeutic-Level IV

Purpose: Acute forearm fractures of the radius and ulna are common within the pediatric and adolescent populations, however, there is not a standardized treatment protocol for these fractures. Many providers place splints or casts and subsequently bivalve them due to concerns regarding swelling. The purpose of this study was to evaluate the outcomes and safety of acute casting of these fractures.

Methods: A retrospective review was performed over a 10-year period for patients under the age of 17 who had been treated for an isolated radial shaft fracture, isolated ulnar shaft fracture, or both bone forearm fracture (BBFA). Data collected included patient demographics, mechanism of injury, mode of immobilization, reduction parameters, and complications.

Results: 73 patients were identified ranging from 11 months to 17 years of age (mean: 8.69; SD: 3.42). Of the 73 participants, 41% (N=30) sustained isolated radial shaft fractures, 3% (N=2) sustained isolated ulnar shaft fractures, and 56% (N=41) sustained BBFA fractures. 51% of patients had a closed reduction performed. 46% of the cohort were placed into a cast and 51% were placed into a sugar-tong splint. Of the casts applied 88% were long arm casts that were not bivalved, 6% were long arm casts that were bivalved, and 6% were short arm casts that were not bivalved. There were no patients that developed compartment syndrome and no patients returned to the emergency department in order to have their cast bivalved. A long arm cast falling off was the only recorded complication in the cohort which required the 11-month-old patient to return to the emergency department for reapplication of the long arm cast.

Conclusions: This series supports the acute application of long arm casts in pediatric and adolescent forearm fractures without the need for bivalving the cast.

Significance: Avoidance of bivalving a cast, particularly when the patient is under sedation, obviously eliminates the potential for cast saw injuries when one is bivalving a cast.

Long-leg versus Short-leg Cast Immobilization for Displaced Distal Tibial Physeal Fractures

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LOE-Therapeutic-Level III

Purpose: Distal tibial physeal injuries are one of the most commonly reported fractures in children. Traditionally, treatment recommendations consist of utilization of a long leg cast for initial immobilization. The purpose of this study was to compare the efficacy of above long leg (LLC) versus short leg casts (SLC) for immobilization of distal tibial physeal fractures after closed reduction.

Methods: A retrospective review was performed of all patients with distal tibial physeal fractures treated at three Level I Pediatric Trauma Centers between January 2012 and December 2018. Patients undergoing closed reduction of a displaced, extra-articular distal tibial physeal fracture were identified. These were then divided into groups based on initial post-reduction immobilization, either LLC or SLC. Radiographs were analyzed for displacement and angulation at the time of injury, after closed reduction and casting, and at completion of immobilization to evaluate for loss of reduction. Bivariate analysis was used to assess explanatory variables associated with loss of reduction comparing short leg casts to long leg casts and assesses the influence of these variables on the overall loss of reduction.

Results: In total, 148 fractures (148 patients) were identified with 108 LLC and 40 SLC cases. The average age was 12.2 years; 73% of the patients were male. The average displacement on injury films was 12mm with an average of 2mm of post-reduction displacement. A total of 14 fractures (9.5%) experienced a loss of reduction identified at the time of cast removal – 13 in LLC and 1 in SLC groups ($p=0.08$). Loss of reduction was associated with the location of the fracture reduction (OR vs ER) as all fractures that lost reduction were reduced in the emergency department. There was also an association with the type of provider performing the reduction as those performed by residents had a higher rate of loss of reduction compared to those reduced by an advanced practice provider or attending physician (0.01).

Conclusions: The average rate of loss of reduction is 9.5% for extra-articular distal tibia physeal fractures after closed reduction. Short leg casting is an effective alternative for post-reduction immobilization. Loss of reduction is associated with the location in which the reduction is performed and the level of training of the person performing the reduction.

Significance: Short leg cast immobilization can adequately maintain alignment of extra-articular distal tibial fractures. This creates an opportunity to provide increased patient mobility and early knee range of motion.

Conservative Management of Transitional Ankle Fractures in Adolescents: Does Immobilization Type Affect Outcome?

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LOE-Therapeutic-Level III

Purpose: Tillaux and triplane ankle fractures include an intraarticular component, and are treated surgically when displaced. Minimally displaced fractures are typically treated with immobilization alone. Long leg casts (LLC) have been the most traditional method of treatment for these injuries. They may prevent weight bearing by flexing the knee and control ankle rotation, preventing displacement. They have the disadvantages of added weight, decreased mobility, increase area for contact dermatitis, and knee stiffness. Short leg casts (SLC) may be adequate to achieve healing without further fracture displacement. No studies have compared short leg casts versus long leg casts for conservative treatment of transitional ankle fractures.

Methods: All patients with Tillaux and triplane ankle fractures from 2008 to 2018, treated in a large children's health system, were retrospectively reviewed. We included all patients with transitional fractures who had initial conservative management. We excluded tibia fractures other than transitional fractures and patients treated with urgent surgical fixation. Patients were grouped based on the initial treatment of a LLC versus a SLC. The primary outcome variable was a loss of reduction requiring surgery. Secondary outcome variables were the need for advanced imaging, time in the initial immobilization, total time in a cast, fracture displacement, delayed union, and nonunion.

Results: 167 patients met inclusion criteria. 72 were treated initially in LLCs and 95 in SLCs. There was no significant difference for age between the groups. There were more girls (53%) than boys (47%), but this was not significant. 61% of the LLC patients received a CT scan, versus 28% of the SLC patients ($P<0.0001$). Time in the initial cast was 26 days for LLCs and 30 days for SLCs ($P=0.0046$). Total time in any cast averaged 41 days for LLCs versus 30 days for SLCs ($P=<0.0001$). There were no cases of fracture displacement at final follow up, malunion, or nonunion. No patients required surgical fixation.

Conclusions: There were no differences in outcomes for patients initially treated in LLCs versus SLCs for minimally displaced transitional fractures. Patients treated in LLCs were more likely to have CT scans, possibly indicating more suspicion for unacceptable initial displacement, and therefore a desire for more robust immobilization. Total casting time was longer for patients treated in LLCs, since many were transitioned from LLCs to SLCs.

Significance: Patients with minimally displaced transitional ankle fractures can be treated adequately with short leg casts, minimizing immobilization of the knee joint and decreasing the overall time in a cast.

Titanium Elastic Nails System (TENS) in Adolescent Forearm Fractures : Using Bone Age as an Objective guide to its Limits.

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LOE-Therapeutic-Level IV

Purpose: Forearm fractures are the most common paediatric fractures. While management in the preadolescent is often conservative, outcomes in adolescents have improved greatly with the use of intramedullary Titanium Elastic Nail System (TENS) and plate fixation. However, there have been no objective criteria for determining when TENS may be used in adolescents. Hence, the purpose of this study is to, firstly, compare the 27- point Sauvegrain method of skeletal age scoring against chronological age to predict functional outcomes in TENS treated adolescents and secondly to objectively evaluate the limits of TENS in adolescents.

Methods: This was a single centre retrospective study of adolescents aged 10 to 16 years with an isolated, complete diaphyseal forearm fracture managed surgically from January 2014 to 2018. Only cases with closed and open fractures treated by TENS were included. Surgical notes, paper and electronic records were reviewed. Elbow radiographs, which were readily available in the injury films, were interpreted using the Sauvegrain method to provide an objective scoring of the skeletal age. Functional outcomes of TENS-treated adolescents were classified into good and poor based on three factors documented at the final discharge assessment: treatment complications, range of motion and functional ability.

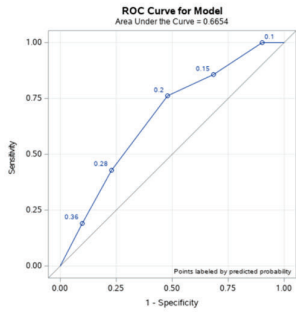
Results: 128 TENS patients, comprising 15 (11.7%) females and 113 (88.3%) males, were included in the analysis. On average, males displayed older skeletal age than chronological age with a mean (SD) difference of 1.29 (1.03) years ($p < 0.001$). The Sauvegrain score was the sole independent predictor of poor treatment outcome in these males (AUC 0.71, 95% CI 0.59-0.83). The Youden J-index identified a Sauvegrain score of ≥ 26 as statistically predictive of high risk of a poor treatment outcome in male adolescents.

Conclusions: In the adolescent age group, the correlation of chronological age to skeletal suitability for TENS treatment is unreliable. The skeletal age which can be readily interpreted via the Sauvegrain method, should part of decision-making in using TENS. At Sauvegrain score ≥ 26 , TENS should be avoided in male adolescents.

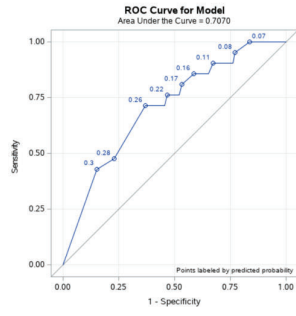
Significance: The result of this study provides a novel and consistent predictor for better functional outcome in adolescents treated with TENS. The Sauvegrain method of skeletal age scoring represents a more cost efficient and objective means to assess the suitability of TENS versus rigid plate fixation without requiring additional scans or incurring additional costs. Objectively knowing the limits of TENS in adolescents based on bone age will allow for better surgical options for earlier return to pre-injury function.

Comparison of chronological age versus Sauvegrain score as predictors of poor outcome in male TENS patients.

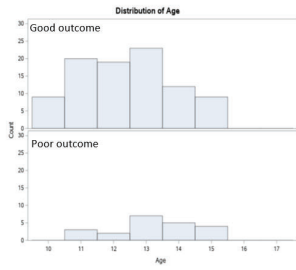
a) ROC curve: Chronological age



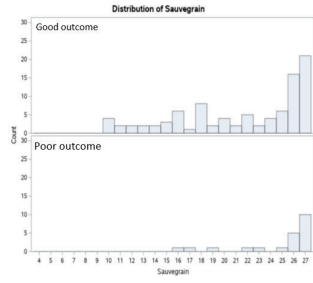
b) ROC curve: Sauvegrain



c) Histogram showing Youden cut-point: Chronological age



d) Histogram showing Youden cut-point: Sauvegrain score



Canal Fill of the Forearm Bones When Placing Intramedullary Nails

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LOE-Therapeutic-Level III

Purpose: To our knowledge there are no studies evaluating flexible nail diameter to medullary canal diameter (ND/MCD) ratio in the treatment of pediatric forearm fractures. In the lower extremity, studies have suggested an optimal ND/MCD ratio of 80% to minimize complications. The goal of this study was to determine if a correlation exists between loss of alignment, complications, final angulation, range of motion and the ratio of the ND/MCD in the forearm. If a relationship is present, we sought out to determine if there is a threshold ratio to be followed to optimize outcomes.

Methods: 85 radius and ulna fractures treated with flexible intramedullary nails were evaluated. ND/MCD ratios were measured. Angulation was measured on immediate post-operative x-rays and final post-operative x-rays. The absence of fracture union at 3 months was classified as a delayed union. Random-effects models were developed to determine the association between complications and ND/MCD ratio, angulation and ND/MCD ratio, and range of motion and ND/MCD ratio. The results were reported for unadjusted models and adjusted models. The adjusted models accounted for age, sex, and BMI as possible confounders.

Results: Of the 85 fractures treated, 3 complications occurred in two patients. One patient presented with a re-fracture of both the radius and ulna and one patient had an EPL tendon rupture. There were no cases of delayed union. The average follow up was 6 months. The nail canal ratios were categorized as <0.50 , $0.50 - 0.59$, and ≥ 0.60 . There was not a significant association between the different ratios and angulation, or risk of complication. There was an association between ND/MCD ratio ≥ 0.60 and decreased pronation -1.58 (-2.77 to -0.38) and supination -2.68 (-4.91 to -0.46) $p < 0.05$.

Conclusions: This study did not identify an association between the nail to canal diameter ratio and post-operative angulation when treating pediatric forearm fractures. Higher ND/MCD ratios likely decrease the degrees of pronation and supination at final follow up, however these changes were quite small and unlikely to be clinically relevant.

Significance: In contrast to the lower extremity, when choosing an intramedullary nail for forearm fractures, there does not appear to be an optimal ratio; it is reasonable to use the nail diameter that passes easily without increased risk of adverse outcomes.

Re-fractures of the Radius and Ulna in Adolescents: Tumbling and Contact Sports may be at Risk in the First Year

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LOE-Therapeutic-Level IV

Purpose: The forearm is the most common site of fracture, and perhaps re-fracture, in the pediatric population. Although both bone forearm (BBFA) fractures represent approximately 30% of pediatric upper extremity fractures, little is known about BBFA re-fractures, particularly among adolescents. The purpose of this study is to evaluate characteristics of BBFA re-fracture and recurrent fractures in the adolescent age group

Methods: An IRB-approved retrospective chart review based on CPT and ICD-9/10 codes of forearm fractures (ages 10-18 years) treated by a single academic pediatric orthopedic group from June 2009 to May 2020 was conducted. All diaphyseal BBFA, radial, or ulnar fractures with ipsilateral same-site, or non-identical ipsilateral or contralateral forearm recurrent fractures were included. Metaphyseal fractures of the radius and/or ulna and surgically treated fractures were excluded. Demographics, injury characteristics, length of immobilization, timing of return to activity, and radiographic data were recorded. An analysis was performed to evaluate associations of ipsilateral same-site re-fracture (RE-FRACTURE) versus other secondary forearm injuries (ipsilateral different site or contralateral or OTHER).

Results: Thirty-six of 717 BBFA and isolated radius or ulna fractures were identified to have recurrent fracture (5.02%; mean age 11.4 years, M:F 6.2:1). 47% percent of recurrent fractures were RE-FRACTURE, while 53% occurred in OTHER. Recurrent fractures occurred 547.6 days (range 77-2209 days) after original fracture. The most common mechanisms of recurrent fracture were contact sports (41.7%), falls (36.1%), and tumbling (13.9%). 82.4% of RE-FRACTURES occurred within one year of original fracture (mean=182.6 days). Compared to OTHER, RE-FRACTURES were significantly associated with sports being played at time of original injury (soccer, cheerleading/gymnastics vs. no sports) ($p=0.03$) and mid-shaft position of fracture on the radius (79.21mm vs. 40.80mm, $p=0.001$) and ulna (70.50mm vs. 34.25mm, $p=0.04$). Increased radius to ulna fracture distance, degree of angulation, fracture-line visibility, and length of immobilization were not significantly associated with re-fracture

Conclusions: Ipsilateral same-site re-fractures tend to occur within the first year of treatment following mid-shaft fractures incurred during contact sports and tumbling, with an overall low rate of re-fractures noted in the age group and fracture pattern.

Significance: In this cohort, re-fractures at the same site tended to occur in mid-shaft both bone forearm fractures. Further research may be warranted to evaluate biologic, bone health, or personality traits that may lead to recurrent and re-fractures in pediatric forearm fractures.

Vitamin D Insufficiency and Metaphyseal Fractures in Children

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LOE-Prognostic-Level II

Purpose: Evidence is mixed on the role of vitamin D in determining fracture risk in children. Previous research has failed to directly correlate hypovitaminosis D and elevated fracture risk in otherwise healthy children. In these studies, all long bone fractures are typically included regardless of the part of the bone involved. In adults, metaphyseal fractures are more commonly associated with poor bone quality than shaft fractures. The purpose of this study was to determine if fracture location – metaphyseal vs. non-metaphyseal – is associated with vitamin D levels in children.

Methods: A prospectively-collected case-control study in children 2-14 years of age was completed. Fractured children were excluded if their injury resulted from a high-energy mechanism or involved hands or feet. Information obtained included race, sex, fracture characteristics, medical history, calcium intake, BMI, serum vitamin D and calcium levels. Serum vitamin D levels in healthy children with low-energy fractures requiring sedation/general anesthesia were compared to healthy children undergoing non-fracture procedures. Statistical comparisons were completed between children with metaphyseal fractures (MET), non-metaphyseal fractures (NonMet) and controls (CON).

Results: One hundred and sixty-two patients were enrolled, including 61 patients with MET, 40 patients with NonMET and 61 CON. Median serum vitamin D was 24.1ng/mL (IQR: 19.6, 29.8) in MET patients, 27.95ng/mL (IQR: 20.7, 33.0) in NonMET patients and 30.8ng/mL (IQR: 23.7, 38.3) in CON patients ($p = 0.0001$). Further, there were significant differences in the distribution of vitamin D deficiency (<20ng/mL)/insufficiency (20-30ng/mL)/sufficiency (>30ng/mL) between MET (29.5% deficient), NonMET (22.5% deficient), and CON (13.1% deficient) ($p = 0.002$). There were significant differences between MET, NonMET, and CON noted in sex and age ($p < 0.05$). After adjusting for both, decreased vitamin D levels were associated with increased risk of MET fracture compared to NonMET (OR: 1.05; 95% CI: 1.0033, 1.12) and CON (OR: 1.11; 95% CI: 1.059, 1.17).

Conclusions: Our findings suggest that metaphyseal fractures in healthy children are associated with lower vitamin D levels.

Significance: To our knowledge, this is the first study to evaluate the association between vitamin D levels and fracture location in children. Vitamin D deficiency may result in an increased risk of pediatric metaphyseal fractures. When evaluating fractured children, a bone health evaluation should be considered in those presenting with metaphyseal fractures.

Pediatric Orthopedic All-Terrain Vehicle (ATV) Injury Patterns, Surgeries, and Complications – Appreciating the True Morbidity and Impact

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LOE-Therapeutic-Level IV

Purpose: Orthopedic injuries are a frequent result of ATV accidents, with children having a disproportionate share of morbidity compared to the adult population. While previous studies have reported the frequency of fractures in ATV injuries, no studies have provided a detailed assessment of fracture patterns, risks associated with injury and operative intervention.

Methods: 489 patients with ATV-related injuries were treated at one tertiary Level 1 pediatric hospital from January 2011-December 2016. Radiographs and hospital records were retrospectively reviewed to define orthopaedic injuries and treatment. Data were organized to identify trends in fracture patterns, surgical procedures, and complications. Chi square analysis was used to evaluate for differences in distribution of fractures and need for surgery across three age groups (0-6, 7-12, and ≥ 13 years) as well as across three BMI categories (Normal/Underweight, Overweight, and Obese).

Results: 270 pelvic and extremity fractures occurred in 215 patients (44% of all ATV-injured patients). 136 patients (63% of those with fractures) required orthopedic surgical intervention. 47 patients (22%) required multiple trips to the operating room. 16% of fractures were open, and 7 patients developed deep musculoskeletal infections. Three patients required amputations, and there was one patient death. No significant differences were found between age or BMI categories in regards to fracture frequency or need for surgery. Surgical rates of supracondylar humerus (97%) and tibial shaft fractures (87%) were substantially higher than published historical norms for these fracture patterns (24% and 5-74%, respectively).

Conclusions: Nearly half of all ATV-related pediatric trauma patients sustained orthopedic injuries. The majority of these fractures required surgical treatment, and nearly one-quarter of ATV patients required multiple surgeries. Younger patients were as likely to need surgery as older patients, highlighting injury severity given their expected lower surgical requirement. Supracondylar humerus fractures and tibial shaft fractures from ATVs require operative intervention at a higher rate than published values for lower-energy mechanisms.

Significance: To date, this is one of the largest single-institution cohorts of ATV-related injuries, and the first to assess specific fracture patterns, surgical morbidity, and risk factors. ATV-related fractures are frequently more severe injuries compared to other mechanisms, with increased surgical requirements. The surgical morbidity of pediatric ATV fractures is substantial, and should influence safety and prevention education for parents.

“You’re O.K. anesthesia”: Closed Reduction of Displaced Pediatric Forearm and Wrist Fractures in the Office Without Anesthesia

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LOE-Therapeutic-Level IV

Purpose: “You’re O.K. anesthesia”: Closed Reduction of Displaced Pediatric Forearm and Wrist Fractures in the Office Without Anesthesia Wrist and forearm fractures are among the most common pediatric fractures and their treatment usually involves closed reduction with some form of anesthesia. There are a number of issues associated with pediatric anesthesia including increased cost, increased time, and several potential medical complications. Despite these issues, there have not been any studies to prove that using anesthesia results in better outcomes or higher caregiver satisfaction in comparison to performing closed reductions without anesthesia. The purpose of this study was to evaluate the quality of closed reductions of pediatric wrist and forearm fractures without the use of anesthesia and to determine caregiver satisfaction with an anesthesia-free reduction technique.

Methods: This study included 54 pediatric patients with closed, angulated fractures of the distal radius, isolated radial shaft, or combined radial and ulnar shafts. All closed reductions were performed by a single pediatric fellowship-trained orthopedic surgeon in the outpatient office setting with no form of anesthesia. Pre-reduction and immediate post-reduction radiographs were obtained to assess the adequacy of the reduction. At the first follow-up visit, the caregivers were asked about their interim use of pain medications. Caregivers were later surveyed about patient use of analgesics and their satisfaction with an anesthesia-free reduction technique.

Results: The average age of the 54 patients in this study was 9 years old (1.8-16.8 years). 33 fractures were combined radial and ulnar forearm shaft fractures, 18 were isolated distal radius fractures, and 3 were isolated radial shaft fractures. Satisfactory reduction was achieved in 98% of patients. Only 9% (5) of the patients in this study required any pain medications and only ibuprofen or acetaminophen was used. 78% of caregivers responded to the telephone and email surveys and all stated that the patients returned to full function and thought that the medical treatment was satisfactory. Only one caregiver would not choose an anesthesia-free reduction technique again.

Conclusions: Closed reduction of pediatric wrist and forearm fractures in the office without anesthesia can achieve satisfactory reductions and high caregiver satisfaction.

Significance: The findings of this study may reduce the need for anesthesia in cases of pediatric forearm fractures thereby reducing the risk of anesthesia related complications.

Non-Operative versus Operative Pediatric and Adolescent Medial Epicondyle Fractures: A Comparison of Outcomes Between Pediatric and Non-Pediatric Fellowship Trained Orthopedic Surgeons

*Jessica Traver MD; Layla Haidar; David Chase McClendon; Kailash Panchapakesan; Timothy C. Borden MD; Surya Mundluru MD; Lindsay Michele Crawford MD; Shiraz A. Younas MD; Alfred A. Mansour MD
UT-Health at McGovern Medical School, Houston, TX*

LOE-Therapeutic-Level III

Purpose: This study aimed to compare the clinical and patient-reported outcome scores of patients undergoing non-operative or operative treatment for medial epicondyle fractures treated by pediatric fellowship-trained versus non-pediatric fellowship trained orthopedic surgeons.

Methods: Patients included were under the age of 18 who sustained medial epicondyle injuries with fracture displacement 4-mm or greater between 01/01/1999 and 11/01/2019. Treatment included either non-operative management with a short course of immobilization or operative intervention by a large academic multi-specialty orthopedic surgery group. Patients were classified as pediatric non-operative (PN), pediatric operative (PO), non-pediatric non-operative (NN), or non-pediatric operative (NO). Patients were contacted via telephone survey. Functional outcome scores collected included Quick-DASH and PROMIS Pediatric Physical Function UE.

Results: A total of 98 patients were eligible for inclusion (14 PN, 37 PO, 47 NO, 0 NN). The rate of surgical intervention was 72.5% by pediatric-trained faculty versus 100% non-pediatric trained faculty. The rate of associated elbow dislocations consisted of PN 3 (20%), PO 20 (54%), NN 0 (0%), and NO 5 (10%). Among patients treated with surgical intervention, patients requiring secondary surgery were 15/37 (40.5%) PO versus 4/47 (8.5%) NO. Of the patients requiring secondary surgery, the rate of hardware removal was 15/15 (100%) PO versus 2/4 (50%) NO. Two additional patients required revision surgery, both in the NO group. The overall rate of revision surgery was PO 2/37 (5.4%) versus NO 4/47 (8.5%). Of the eligible patients, patient-reported outcomes were obtained for 28 patients (7 PN, 11 PO, 0 NN, 10 NO). The mean Quick-DASH scores were 6.3 PN, 4.1 PO, 4.4 NO. The mean PROMIS PF UE scores were PN 37.3, PO 35.85, NO 37.87. Patients who reported they were able to perform at the same level of performance after their treatment intervention was 100% PN, 90.9% PO, 90.9% NO. A patient seen by a non-pediatric orthopedic surgeon was 21 times more likely to receive operative treatment.

Conclusions: This study showed comparable patient reported outcomes following both non-operatively and operatively treated medial epicondyle fractures. Non-pediatric fellowship trained orthopedic surgeons treated patients with medial epicondyle fractures more commonly with surgical intervention and were more likely to require a revision surgery than patients treated surgically by pediatric-trained orthopedic surgeons.

Significance: Non-pediatric fellowship trained surgeons operate on medial epicondyles at a higher rate than pediatric trained surgeons with a higher rate of revision surgery, while clinical and patient-reported outcomes are comparable.

AP, Axial, and External Oblique Views Reliably Measure Medial Epicondyle Displacement Using Corresponding Point Methodology but the Measurements Only Moderate Correlate with True Displacement as Measured by CT Scan

*J Todd Lawrence MD; Ryan Guzek; Kathleen Harwood; Divya Talwar; David Isaacs; Donna M. Pacicca MD; Michael Saper; Peter D. Fabricant MD; Scott D. McKay MD; Eric W. Edmonds MD; Stephanie Watson Mayer MD; Matthew Ellington MD; V Elaine Joughin MD; Medial Epicondyle Multicenter Outcomes Study Group
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LOE-Diagnostic-Level II

Purpose: Medial epicondyle fractures account for up to 20% of pediatric elbow fractures. Despite surgeon familiarity with these fractures, a lack of consensus exists on the best method for evaluation and management. This study aims to determine the reliability of plain film views in the evaluation of displaced medial epicondyle fractures.

Methods: 10 raters completed a randomized order survey that included five plain film views (AP, lateral, axial, internal oblique, external oblique) and three CT views (axial, 3D horizontal, 3D vertical) from six unique patients with a medial epicondyle fracture. All raters were attending physicians from the Medial Epicondyle Multicenter Outcomes (MEMO) Study group. Raters were instructed to use a corresponding points method for measuring displacement. For each image the rater measured the absolute displacement (in mm), categorized the degree of displacement (0-49%, 50-100%, >100%, incarcerated, or unable to determine), and indicated a treatment option (operative, nonoperative, or unable to determine). Inter-rater reliability was calculated for each view using the appropriate statistic for the data distribution. Pearson correlation was used to compare absolute differences in displacement between plain film and CT measurement methods.

Results: For absolute displacement, AP and external oblique (EO) views showed excellent inter-rater reliability ($\alpha = 0.948$ and 0.972 , respectively) and axial showed good reliability ($\alpha = 0.814$) (Table 1). When categorizing displacement, axial view showed excellent inter-rater reliability (ICC = 0.911) and AP, internal oblique (IO), and EO showed good reliability (ICC = 0.821; 0.871; 0.869, respectively). No to fair reliability was observed for treatment decisions across all views. Pearson correlation coefficient for absolute displacement on AP, axial, and EO views as compared to average absolute displacement across CT methods was only moderately correlated with values of 0.554, 0.532, and 0.541, respectively. Correlation between the axial view and CT scan when categorizing displacement was moderate with 40% of raters identically categorizing the fractures.

Conclusions: Using a corresponding point measurement system, fracture displacement can be reliably measured on AP, EO and axial plain film views. There was only moderate correlation between any of the plain film views and the gold standard CT scan assessment. Fracture categorization was also moderate for axial view compared to CT scan.

Significance: This study shows that raters can reliably measure fracture displacement on standard plain films, including the axial view, but only with moderate correlation to the real degree of displacement. These findings will help inform ongoing and future medial epicondyle research studies.

Table 1: Inter-rater reliability across views for each survey question.

	Absolute Displacement (α)	Displacement Category (ICC)	Treatment (κ)
XR AP	0.948	0.821	0.167
XR Lateral	-	0.123	-0.016
XR Axial	0.814	0.911	0.279
XR Internal Oblique	-	0.871	0.062
XR External Oblique	0.972	0.869	0.267
CT Axial	0.967	0.863	0.152
3D CT Horizontal	0.924	0.773	0.169
3D CT Vertical	0.832	0.934	0.134

Green indicates excellent inter-rater reliability, yellow indicates good inter-rater reliability and red indicates no to fair inter-rater reliability. A dash is present in those cells for which an insufficient number of raters could measure displacement for reliability calculation.

All Epiphyseal vs Trans-epiphyseal screw fixation for Tillaux fractures– Does it matter?

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Texas Children's Hospital, Houston Texas

LOE-Therapeutic-Level III

Purpose: The purpose of the study is to compare the healing and functional outcomes of Trans-physeal (oblique) and all-epiphyseal (parallel to ankle joint) screw fixation in Tillaux fractures. We hypothesized that oblique fixation would not lead to any difference in bone healing or functional outcomes compared to parallel fixation as these are transitional fractures.

Methods: IRB approved retrospective review of patients who underwent surgical fixation of Tillaux fractures a tertiary children's hospital. Data analysis included demographics, mode of injury, diagnostic imaging, management protocols, and functional outcomes. Patients were divided into two groups 1(oblique) and group 2(parallel), and statistical analysis was performed between the groups.

Results: A total of 42 patients (28 females and 14 males) were included. The mean age was 13.5 years .There were no significant differences in BMI, sex, age, or time to surgery between both groups (table 1). Sports injuries accounted for 62% of the cases, particularly non-contact (57%) and skating (29%) injuries. Groups 1 and 2 consisted of 17 and 25 patients, respectively. For mid to long-term functional outcomes, there were 14 and 10 patients in groups 1 and 2, respectively. Statistical analysis revealed no difference in the functional outcomes, pain scores, or patient's satisfaction (table 1). The mean follow-up for mid to long-term outcomes analysis was 3.52 ± 2.88 years. No infections, non-unions, physeal arrest, or post-operative ankle deformities were reported. Two patients had difficulty returning to sports post-surgery due to pain. One was a dancer, and the other patient had running pain, which prompted hardware removal. Both patients had parallel fixation. Hardware removal for groups 1 and 2 were 4 and 5 patients, respectively. The reason for removal was pain in 2 patients, and parental preference in the remaining.

Conclusions: This is the largest study on tillaux fractures comparing functional outcomes of different methods of screw fixation orientation to the physis. We concluded that there were no functional or healing differences.

Significance: Since Tillaux fractures are transitional fractures, obliquely oriented transphyseal screws, which provide better compression of the Tillaux fracture based on fracture orientation are recommended over parallel screws, which can create more joint forces and require a more difficult screw trajectory parallel to the joint.

Table 1. Demographics and Functional Outcomes

Factor	Oblique	Parallel	p-value
Demographics			
n	17	25	
Sex			0.331
Female	13	15	
Male	4	10	
Average age(y)	13.45±1.72	13.06±1.20	0.728
BMI	26.38±4.31	26.38±7.35	0.93
Time to Surgery(d)	6.88±4.66	8.00±11.77	0.718
Functional Outcomes			
n	14	10	
Sane Score	88.50±16.34	90±18.58	0.718
Pain 0-10	1.70±1.89	1.79±1.72	0.84
Oxford Score			
Physical Scale Score	82.50±20.95	76.19±20.64	0.471
School and Play Scale	93.75±13.50	91.52±14.63	0.38
Score			
Emotional Scale Score	96.88±7.93	91.52±14.63	0.306
Satisfaction			1
Satisfied	13	10	
Unsatisfied	0	1	

SCIENTIFIC PROGRAM

FRIDAY, MAY 14

AWARDS PART 1

Moderator: Todd Milbrandt, MD
Co-Moderator: Michelle Caird, MD

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7:35 AM–7:40 AM



Effectiveness of Various Cast Covers in the Pediatric Population

Amit Parekh; John Moon; David Roberts, MD;
Verena Schreiber, MD

NorthShore University HealthSystem, Evanston, IL

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7:41 AM–7:46 AM

Pediatric Back Pain: A Scoring System to Guide Use of Magnetic Resonance Imaging

Michael Nolte; Garrett Harada;
Ryan LeDuc; Arash Sayari; Bryce Basques; Philip Louie;
Ethan Gordon; Dino Samartzis; Howard An; Monica Kogan
Rush University Medical Center, Chicago, IL

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7:57 AM–8:01 AM

MSC exosomes enhance physal regeneration and reduce limb length discrepancy in a rat model of growth plate injury

Si Heng Sharon Tan; Keng Lin Wong; Shipin Zhang;
Shang Jiunn Chuah; Ruenn Chai Lai; Sai Kiang Lim;
James Hui; Wei Seong Toh

National University of Singapore, Singapore, Singapore

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8:02 AM–8:06 AM

Sirt6 overexpression improves bone properties in the mouse model of osteogenesis imperfecta

Jung-Ryul Kim, MD; Young Jae Moon

Jeonbuk National University Hospital, Jeonju, Korea, Republic of

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8:16 AM–8:21 AM

Impact of Spinal Deformity and Surgery on Health-Related Quality of Life in Cerebral Palsy: A Multicenter Prospective Controlled Trial

Patrick Cahill, MD; Unni Narayanan, MBBS, MSc, FRCS(C); Firoz Miyanji, MD; Burt Yaszay, MD; Stefan Parent, MD;

Joshua Pahys, MD; Mark Abel, MD; Suken Shah, MD;
Peter Gabos, MD; John (Jack) Flynn, MD; Amer Samdani, MD;
Peter Newton, MD; Harms Study Group; Paul Sponseller, MD
Children's Hospital of Philadelphia, Philadelphia, PA



SCIENTIFIC PROGRAM

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8:22 AM–8:27 AM

Anterior Vertebral Body Tethering in Idiopathic Scoliosis: a Prospective, Multicenter Analysis

*Firoz Miyanji, MD; Paul Rushton; Isabelle Turgeon; Luigi Aurelio Nasto; Sultan Aldebeyan; Stefan Parent, MD
British Columbia Children's Hospital, Vancouver, BC, Canada*

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8:38 AM–8:43 AM

Who Will Need a Second Surgery? A Study of Cases of Isolated Septic Arthritis from the CORTICES

*Keith Baldwin, MD; Benjamin Shore, MD, MPH, FRCSC; Danielle Cook; David Spence, MD; Jennifer Laine, MD; Jaclyn Hill, MD; Anthony Riccio, MD; Joshua Murphy, MD
Children's Hospital of Philadelphia, Philadelphia, PA*

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8:44 AM–8:49 AM



Intramedullary Kirschner-wires are equivalent to titanium elastic nails for pediatric femur fractures: Results from a randomized clinical trial in Dar es Salaam, Tanzania

*Msami Ngowi; Edmund Eliezer; Revocatus Luziba; Bryson Ikoshi, MD; John Ibrahim; Emmanuel Lema; David Shearer; Saam Morshed; Patrick Curran
Muhimbili Orthopaedic Institute, Dar es Salaam, Tanzania*

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9:00 AM–9:04 AM

Molecules in Necrotic Femoral Head Inhibit Osteogenesis and Promote Fibrogenesis and Adipogenesis of Mesenchymal Stem Cells

*ZHUO DENG; Yinshi Ren; Harry Kim, MD
Texas Scottish Rite Hospital for Children, Dallas, TX*

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9:05 AM–9:09 AM

Does NRG/ErbB Signaling Modulate Contractures after Neonatal Brachial Plexus Injuries?

*Brendan Ho; QINGNIAN GOH; Sia Nikolaou; Liangjun Hu; Kritton Shay-winkler; Roger Cornwall, MD
Cincinnati Children's Hospital, Cincinnati, OH*

SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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9:19 AM–9:24 AM

Trans-articular versus Retro-articular Drilling of Stable Osteochondritis Dissecans of the Knee: A Prospective Randomized Controlled Trial by the ROCK Multicenter Study Group

*Benton Heyworth, MD; Kevin Shea, MD; Elizabeth Liotta; Katelyn Hergott; Eric Wall, MD; Gregory Myer; Carl Nissen, MD; Eric Edmonds, MD; Roger Lyon, MD; Henry Chambers, MD; Matthew Milewski, MD; Daniel Green, MD; Jennifer Weiss, MD; Rick Wright; James Carey; John Polousky, MD; Jeffrey Nepple, MD; Mininder Kocher, MD, MPH; Theodore Ganley, MD
Boston Children's Hospital, Boston, MA*

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9:25 AM–9:30 AM



Operative Versus Non-Operative Treatment of Severely Shortened or Comminuted Clavicle Fractures in Older Adolescent Athletes: Results from A Prospective, Multicenter, Level 2 Cohort Study

*David Spence, MD; Philip Wilson, MD; Donald Bae, MD; Michael Busch, MD; Eric Edmonds, MD; Henry Ellis, MD; Katelyn Hergott; Mininder Kocher, MD, MPH; G Li, MD; Elizabeth Liotta; Jeffrey Nepple, MD; Nirav Pandya, MD; Andrew Pennock, MD; Crystal Perkins, MD; Coleen Sabatini, MD, MPH; David Williams PhD; Samuel Willimon, MD; Benton Heyworth, MD
Campbell Clinic/University of Tennessee, Germantown, TN*



SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

AWARDS PART 2

Moderator: *Todd Milbrandt, MD*

Co-Moderator: *Michelle Caird, MD*

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10:18 AM–10:23 AM **Nonoperative Management of Femoroacetabular Impingement: Clinical Outcomes at 5-years – A Prospective Study**

Andrew Zogby; James Bomar, MPH; Kristina Johnson;

Vidyadhar Upasani, MD; Andrew Pennock, MD

Rady Children's Hospital, San Diego, San Diego, California

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10:24 AM–10:29 AM **Acetabular remodeling after closed and open reduction for the treatment of developmental dysplasia of the hip**

Pedro Justo; William Morris, MD; Patricia Miller, MS;

Eduardo Novais, MD

Boston Childrens Hospital, Boston, MA

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10:40 AM–10:44 AM



Activation of A Central Immunosuppressive Cascade Prevents Ischemia Reperfusion Injury after Acute Compartment Syndrome in a Murine Model

Austin Hester; Nazanin Omidj; Daniel Casella;

Matthew Oetgen MD, MBA

Children's National Hospital, Washington, DC

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10:45 AM–10:49 AM **Hematopoietic Cells Regulate Fracture Healing in Neurofibromatosis**

Benjamin Alman, MD; Puvindran Nadesan

Duke, Durham, NC

Effectiveness of Various Cast Covers in the Pediatric Population

Amit Parekh; John Y. Moon; David W. Roberts MD; Verena M. Schreiber MD
NorthShore University HealthSystem, Evanston, IL

LOE-Economic-Level IV

Purpose: We explore the efficacy of different options as well as their cost across growing age cohorts encountered in a pediatric practice.

Methods: Short arm casts were applied to mannequin models representing the arms of pediatric patients ages 3, 6, and 12 years old. The mass of each cast was then measured in grams. Casts were then completely submerged in water for 1 minute and the difference in mass was calculated. This was repeated 6 times per cast cover group across for all three age groups. There was a control group without a cast cover and 8 additional groups of various cast cover types. Effectiveness of a cast was subjectively determined based on amount of absorption compared to the starting mass, and this was compared among the various groups using a non-parametric statistical test.

Results: For the different cast cover types across all age groups, the Kruskal-Wallis test was used to analyze the entire dataset. A single plastic bag with duct tape was the most effective in reducing absorption (mean of 3.2 g absorption, 4.4 g SD). The results for the remaining cast covers were as follows. Many, but not all, of the eight groups had less absorption than the control with statistical significance at an alpha level of 0.05. These groups included the double plastic bag rubber band cover ($p=0.0112$), single plastic bag with duct tape cover ($p<0.0001$), DryPro ($p<0.0001$), Bloccs ($p<0.0001$), Walgreens ($p=0.0010$), and Freedom covers ($p<0.0001$). The plastic bag with duct tape cover additionally had significantly less absorption than the Press N Seal. ($p=0.0045$). The Curad group was found to not be statistically different from the control, and in addition, the DryPro ($p=0.0049$), Bloccs ($p<0.0001$), Freedom ($p=0.0031$), and plastic bag with duct tape ($p<0.0001$) covers had significantly less absorption than this cover.. Finally, a cost analysis was performed and demonstrated that a single plastic bag with duct tape was found to be the most cost efficient in theory, but the Walgreens cast cover was least expensive in actual cost.

Conclusions: Our study indicated that a single plastic bag with duct tape was both one of the most effective cast covers at reducing absorption as well as one of the most cost effective across all age groups.

Significance: The use of a single plastic bag with duct tape was both, one of the most effective cast covers at reducing absorption as well as one of the most cost effective across all age groups

Table 1 - Mean Absorption for Various Cast Covers Across All Pediatric Age Groups

Group	Mean Absorption (grams)
Control	138.6±25.6 g
Double Plastic Bag with Rubber Band	34.0±48.5 g
Single Plastic Bag with Duct Tape	3.2±4.4 g
Press N Seal	57.4±44.9 g
DryPro	9.2 ± 9.1 g
Curad	108.0±57.0 g
Bloccs	7.1±5.3 g
Walgreens	22.5±28.7 g
Freedom	10.4±14.7 g

Pediatric Back Pain: A Scoring System to Guide Use of Magnetic Resonance Imaging

*Michael T. Nolte; Garrett Harada; Ryan LeDuc; Arash J. Sayari; Bryce Basques; Philip K. Louie; Ethan Benjamin Gordon; Dino Samartzis; Howard An; **Monica Kogan***
Rush University Medical Center, Chicago, IL

LOE-Economic-Level III

Purpose: The prevalence of back pain in the pediatric population is increasing. Although many cases are self-limited, failure to diagnose a pathology that requires clinical intervention can carry severe repercussions. Oftentimes the challenge with this population is determining when to order advanced imaging, such as magnetic resonance imaging (MRI). The aim of this study was to develop a predictive scoring system based on pediatric patient factors to help determine when an MRI will change clinical management.

Methods: This was a retrospective cohort review of consecutive pediatric patients (less than 21 years old) who presented to a single orthopaedic clinic with a chief complaint of back pain between 2010 and 2018. The primary outcome measured was whether or not an MRI directly contributed to a change in clinical management of the patient. Comprehensive demographic and presentation variables were collected. A physician reviewer determined whether or not an MRI, when performed, resulted in a change in clinical management. A predictive model of factors that influence whether MRI results in a change in management was then generated using cross-validation LASSO logistic regression analysis.

Results: A total of 729 patients were included, with a mean age of 15.1 years (range: 3 to 20 years). Of these, 344 (47.2%) had an MRI, and 224 (65.1%) were determined to have a change in clinical management as a result. The most common form was a change in the type or duration (by two weeks or greater) of conservative therapy. A predictive model was generated, with nocturnal symptoms (5 points), neurological deficit (10 points), age (0.7 points per year), lumbar pain (2 points), sudden onset of pain (3.25 points), and leg pain (3.75 points) identified as significant predictors (Table 1). A combined score of greater than 9.5 points for a given patient is highly suggestive that an MRI will result in a change in clinical management (specificity: 0.93; positive predictive value: 0.92).

Conclusions: In this study, we developed a scoring system to help guide the use of MRI based on the largest single-center series of pediatric patients with back pain to-date. These predictive factors included age, pain at the lumbar spine, pain radiating down the lower extremity, sudden onset of pain, nocturnal symptoms, and neurological deficit on physical exam.

Significance: Physicians can use this predictive model to help guide decision-making in their own practice, and to improve the quality of care provided while simultaneously limiting costs.

Table 1. N₂OLTE Criteria for Predicting Change in Pediatric Spine Clinical Management After MRI

Variable	Mean β Coefficient ^a	Assigned Point Total ^b
Night Pain	0.689	5
Neuro Deficit	1.394	10
Older Age (Range: 3 to 20 years)	0.095	0.7 (per year)
Lumbar Pain	0.286	2
Time of Onset	0.463	3.25 (sudden onset)
Extremity (Leg) Pain	0.517	3.75
Likelihood for Clinical Management Change After MRI	Stratification	Point Cutoff^c
	Indeterminate	≤ 9.5 points
	Highly Likely	> 9.5 points

^a Mean β coefficients are calculated using a penalized least absolute shrinkage and selection operator (LASSO) and can be interpreted similarly as β coefficients derived for maximum likelihood logit models. Positive β coefficients for a given variable suggest that, if present, the patient will have a greater likelihood of experiencing a change in clinical management after an MRI. Negative β coefficients suggest lower likelihood of this outcome.

^b Point totals were derived using whole number approximations based upon values for each respective mean β coefficient.

^c Point cutoffs were established empirically by identifying a threshold whereby specificity was ≥ 0.90 .

MSC exosomes enhance physal regeneration and reduce limb length discrepancy in a rat model of growth plate injury

*Si Heng Sharon Tan; Keng Lin Wong; Shipin Zhang; Shang Jiunn Chuah; Ruenn Chai Lai; Sai Kiang Lim; **James Hoi Po Hui**; Wei Seong Toh*

National University of Singapore, Singapore Singapore

LOE-Not Applicable-

Purpose: Mesenchymal stem/stromal cell (MSC) therapies have demonstrated regenerative potential for the treatment of growth plate injuries. Although the use of MSCs for tissue repair was first predicated on their differentiation potential, the therapeutic effects of MSCs have increasingly been attributed to its paracrine secretion, particularly exosomes. Here, we examine the therapeutic effects of MSC exosomes in an immunocompetent rat model of growth plate injury.

Methods: Exosomes were purified from conditioned medium of human MSCs by size fractionation. In 40 Sprague-Dawley rats, growth plate defect was surgically created on the right distal femur via a drill-hole method. Single intra-articular injection of 100 μ g exosomes in 100 μ l phosphate-buffered saline (PBS) or equivalent volume of PBS was given to the right knee immediately after the surgery. At 4 and 8 weeks, analyses were performed by micro-computed tomography for limb length measurement and histology, immunohistochemistry and histomorphometric analyses for assessment of tissue repair.

Results: MSC exosomes displayed a modal size of 100 nm and expressed exosome markers such as CD81, TSG101 and ALIX. Growth plate injury resulted in significant shortening of the right limb compared to the contralateral normal limb as early as week 4 ($P < 0.001$). We showed that single injection of MSC exosomes could significantly improve the limb length from 3.29 ± 0.07 cm at 4 weeks to 3.37 ± 0.108 cm at 8 weeks ($P = 0.047$) as compared to a lack of improvement in the control group ($p = 0.025$). The limb length discrepancy (expressed as percentage difference from the contralateral normal limb) in exosome-treated group was significantly lesser than that of PBS-treated group at both 4 weeks ($2.52 \pm 1.3\%$ vs. $4.11 \pm 0.93\%$; $P = 0.006$) and 8 weeks ($5.27 \pm 2.11\%$ vs. $8.06 \pm 2.56\%$; $P = 0.016$). Consistent with the reduced limb length discrepancy, the exosome-treated group displayed higher percentage areal deposition of glycosaminoglycan ($P < 0.05$) and type II collagen ($P < 0.05$) than PBS-treated group at both 4 and 8 weeks, reflective of enhanced physal regeneration with exosome treatment.

Conclusions: Our findings demonstrate for the first time that MSC exosomes enhance physal regeneration and reduce limb length discrepancy following growth plate injury.

Significance: Our study suggests the potential use of MSC exosomes as a cell-free MSC therapeutic for growth plate injuries to significantly reduce limb length discrepancy, potentially avoiding surgery or necessitating a less invasive surgery for growth plate injuries.

Sirt6 overexpression improves bone properties in the mouse model of osteogenesis imperfecta

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LOE-Not Applicable-

Purpose: Osteogenesis imperfecta (OI) is a genetic disorder caused by a mutation in genes that encode collagen type I. This defect stresses osteoblasts and adversely affects bone homeostasis leading to low bone mass, fracture, and bone deformity. Because bisphosphonates (BPs) positively affect bone mass and vertebral geometry, these are widely administered to individuals with OI. Still, long-term administration of BPs results in a decline of bone material quality. Sirtuin6 (Sirt6) is one of the genes known to regulate cellular stresses and apoptosis. Furthermore, Sirt6 prevents bone loss by inhibiting osteoclast-mediated bone resorption without impairing osteoblast function. We hypothesized that Sirt6 has a protective role in the OI bone phenotype.

Methods: To address this issue, we mated OI mice (Col1a2oim/oim), a widely accepted mouse model of moderate to severe OI, with Sirt6Tg (overexpression of Sirt6) mice. These transgenic mice (called “oim-Sirt6Tg”) overexpressed Sirt6 in bone tissue allowed us to understand the contribution of Sirt6 to the bone phenotype of the osteogenesis imperfecta (OI) mouse model. To confirm the effect of Sirt6 on OI, OI mice were administered fucoidan, which is a Sirt6 activator, via oral gavage.

Results: The oim-Sirt6Tg mice dramatically increased trabecular bone mass and bone mineral density of the cortical bone in the femur compared to OI mice. Conversely, osteoclast numbers, and osteoclast activity using TRAP staining and serum CTX levels were significantly suppressed in oim-Sirt6Tg compare with OI mice. Furthermore, osteocyte architecture determined by scanning electron microscopy in oim-Sirt6Tg was well organized, and lacunae were connected with each other. On the other hand, osteocytes in OI mice were markedly deformed with a rough, lysed, and rounded appearance. The pharmacological Sirt6 activity using fucoidan showed the same effect as oim-Sirt6Tg in improving bone loss in OI mice. Fucodian administration also effectively reduced the number and activity of osteoclasts in OI mice.

Conclusions: Our results indicate that Sirt6 overexpression preserved bone mass and bone quality in the osteogenesis imperfect mice model, and it may provide a new therapeutic approach in osteogenesis imperfecta.

Significance: This study presents a new biologic treatment for osteogenesis imperfecta, which still has limited treatment options.

Impact of Spinal Deformity and Surgery on Health-Related Quality of Life in Cerebral Palsy: A Multicenter Prospective Controlled Trial

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LOE-Therapeutic-Level II

Purpose: Spinal fusion for scoliosis associated with cerebral palsy (CP) is associated with high costs and complications, but evidence that surgery leads to meaningful benefits has not been established with any rigor. The aim of this study was to determine if corrective spinal fusion improves health related quality of life (HRQoL) in children with CP scoliosis.

Methods: In a prospective longitudinal cohort study of scoliosis associated with CP, HRQoL was recorded using the CPCHILD questionnaire. Children with CP (All GMFCS levels) & scoliosis that met criteria for posterior spinal fusion were enrolled at 10 centers in the US & Canada. Participants families selected the operative intervention group (OP) or the non-operatively treated (NON) group. Demographic, clinical data (GMFCS level, magnitude of deformity, co-morbidities), and HRQoL (CPCHILD Questionnaire) were collected at baseline and 2 years. Change (from baseline) in total CPCHILD scores was the primary outcome.

Results: 301 OP and 34 NON subjects had complete baseline and 2yr data. At baseline, both groups were comparable in GMFCS level, co-morbid status, and CPCHILD scores (52.1 ± 15.3 SD v. 53.4 ± 14.5 SD; $p=0.66$). However, the OP group had larger deformity magnitude ($84.5^\circ \pm 21.8^\circ$ v. $66.3^\circ \pm 18.1^\circ$; $p=0.001$). Total CPCHILD score improved in OP group by 6.6 points ($p<0.001$). NON scores were unchanged ($+1.2$; $p=0.65$) during follow up. There were also significant score increases in the OP group for all six CPCHILD subdomains. The change in CPCHILD scores from enrollment to 2 years was more significant in the OP group ($p=0.054$) including the subdomains of positioning, transferring, mobility (PTM) (OP 8.8 v NON -0.6; $p=0.009$), comfort and emotions (CE) (OP 8.6 v NON -2.1; $p=0.021$), and overall health (OH) (OP 6.7 v NON -3.8; $p=0.005$).

Conclusions: For children with CP who undergo spinal fusion, HRQoL improved, but remained unchanged in the non-operative control group. The improvement in HRQoL is achieved through improvements in the expected subdomains of a) PTM, b) CE, and c) OH. Children with scoliosis associated with CP benefit from spinal fusion.

Significance: This is the first multicenter, prospective, controlled study demonstrating benefits of spinal fusion surgery in CP patients using a validated measure of HRQoL.

Table 1: Change in CPCHILD scores from baseline to two years

	OP	NON	p value
Subjects meeting inclusion criteria	301	34	-
GMFCS levels: No. (%)	I: 3 (1%) II: 6 (2%) III: 11 (3.7%) IV: 56 (18.6%) V: 209 (69.4%) Null: 16 (5.3%)	I: 0 (0%) II: 2 (5.9%) III: 2 (5.9%) IV: 4 (11.8%) V: 24 (70.6%) Null: 2 (5.9%)	0.625
Baseline CPCHILD scores	52.1	53.4	0.659
Pre to 2y Cobb change (degrees)	- 52.1	+ 11.5	<0.001
Change in Total CPCHILD (pre-op to 2y)	6.6, $p<0.001$	1.2, $p=0.65$	0.054
Change in positioning, transferring, mobility (pre-op to 2y)	8.8, $p<0.001$	-0.6, $p=0.87$	0.009
Change in comfort and emotions (pre-op to 2y)	8.6, $p<0.001$	-2.1, $p=0.62$	0.021
Change in health (pre-op to 2y)	6.7, $p<0.001$	-3.8, $p=0.30$	0.005

Anterior Vertebral Body Tethering in Idiopathic Scoliosis: a Prospective, Multicenter Analysis

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LOE-Therapeutic-Level II

Purpose: AVBT is being increasingly explored, however majority of studies to date are small, single center series with limited f/u limiting our understanding on its efficacy and complication rate. Our aim was to evaluate the clinical and radiographic outcomes as well as the complication rates in a large multicenter cohort to determine the efficacy and safety profile of AVBT in the treatment of IS.

Methods: A prospective, multicenter database was used to identify consecutive patients with IS treated with AVBT at 2 centers with ≥ 2 yr f/u. Clinical success was defined a priori as major coronal Cobb $\leq 35^\circ$ and no fusion performed at most recent f/u(MRF).

Results: 124 patients with 130 tethers had mean age of 12.7yrs and mean f/u of 35months(24-64). 115 females and 9 males had mean preop Risser 0.5(0-3) and mean Sanders score 3.3 ± 1.2 .Risser at MRF was 3.9(0-5).There were 114 thoracic tethers,4 lumbar and 6 double tethers. Mean OR time was 248min(110-760) and mean EBL was 5.2(0.5-18)ml/kg with no allogeneic blood transfusions. Mean preop thoracic major curve of 50.1° (31-81) corrected to 22.7° (3-57°) on first erect(FE) xray with significant further correction of the instrumented curve to 15.7° (-12-55°,p<0.01) at 1 yr f/u. At MRF loss of correction to mean 18.2° (-18-57) was noted. Lumbar tethers corrected from mean preop of 51.2° (45-65°) to mean 10.9° (3-20°) on FE with significant improvement at 1 yr(8.4° (-6-32°)) and MRF(5.2° (-29-32°)p<0.01).There were 32 complications (24.6%) in 17 patients requiring 21 reops(16.1%):6 conversion to fusion and 1 revision;5 for overcorrection;4 for adding-on;2 tether replacements;2 screw malposition with CSF leak;and 1 hemothorax.29 tether failures were suspected (22%) with associated loss of correction on average of 14.9 ± 9.5 all of which occurred greater than 1 yr postop.

Conclusions: AVBT appears effective in maintaining major coronal cobb $\leq 35^\circ$ in 88% of skeletally immature patients with IS. There is an associated 24.6% complication rate and 16.1% reop rate highlighting the importance of patient selection and long term f/u.

Significance: AVBT appears to modulate spinal growth with 88% success rate of maintaining major coronal Cobb $\leq 35^\circ$ at final f/u. Complications and tether failures are not infrequent and may compromise outcomes.

Patient Demographics (N=124; 130 Tethers)				
Mean Age at Surgery (yrs)	12.7 ± 1.4			
Gender	M=7.3%; F= 92.7%			
Mean Sanders	3.3 ±1.2			
Risser Grade	0.5(0-3)			
Outcome Variables				
Mean Follow-up (mnths)	35(24-64)			
Mean OR Time (min)	248 ±(110-760)			
Mean Blood Loss (mL/kg)	5.2 (0.5-18)			
Length of Stay (days)	4.9(3-16)			
Clinical Success (Major Cobb curve $\leq 35^\circ$) (%)	88			
Radiographic Measures				
	Pre-op	First Erect	MRF	p-value
Mean Major Thoracic Cobb (°)	50.1(31-81)	22.7(3-57)	18.2(-18-57)	<0.001*
Mean Major Lumbar Cobb (°)	51.2(45-65)	10.9(3-20)	5.2(-29-32)	<0.001*
T2-T12 Kyphosis (°)	18.6± 11.5	15.3±11.5	21.4± 12.3	0.709
Tether Failure	29	Avg 14.9°±9.5° deformity progression		
Complications Requiring Reoperations (N=21)				
Conversion to Fusion	7			
Over-correction	5			
Adding-on	4			
Hardware Malposition	2			
Recurrent Hemothorax	1			
Tether Replacement	2			

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

Who Will Need a Second Surgery?- A Study of Cases of Isolated Septic Arthritis from the CORTICES

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LOE-Therapeutic-Level III

Purpose: Septic Arthritis (SA) is considered a surgical urgency/emergency by physicians around the world. As our understanding grows, and improved diagnostic algorithms are developed, it has become apparent that competing interests in terms of accurately diagnosing concurrent osteomyelitis may supercede rapid surgical intervention when the imaging is timely. Nevertheless, even in cases of isolated SA, many patients will require repeat surgery. We aimed to assess factors which could predict multiple surgeries.

Methods: A multicenter retrospective database was created involving 18 pediatric centers from the CORTICES study group with the goal of better understanding pediatric musculoskeletal infection (PMSKI). All patients who met inclusion for the database were considered, surgeons for each site determined through imaging and chart review which patients met the diagnosis of isolated SA. Patients with concomitant abscesses or osteomyelitis were expressly excluded. Appropriate non parametric statistics were used to assess univariate significance. Multivariable logistic regression was used to assess clinical factors associated with an increased likelihood of multiple surgeries. Receiver characteristics operating curve (ROC) analysis was used to determine optimal cutoffs to discriminate between children who required more than one surgery compared to those who required only one surgery. A probability algorithm was developed for the number of clinical factors present and the likelihood requiring multiple surgeries following SA diagnosis.

Results: Four hundred and fifty-four patients with isolated SA were analyzed from 18 US hospitals. Patients were 5.4 +/- 4.8 years old at admission, and the cohort was 56% male. Of the 454 patients, 47 (10.4%) needed more than one surgery. Bivariate comparisons across surgery groups found significant differences in minimum platelet count ($p<0.01$), peak CRP ($p<0.01$), and admission temperature ($p<0.030$). Multivariate logistic regression analysis found that for each additional platelet, a patient has a 0.3% reduction in the odds of needing more than one surgery (OR=.997; $p=0.04$). For each additional ten units of CRP, a patient has a 8% increase in the odds of needing more than one surgery (OR=1.08; $p<0.001$). Our predictive algorithm found that children with both risk factors had a 64% chance of requiring multiple surgeries (Table 1).

Conclusions: Higher CRP values and lower platelet values indicate more severe disease in isolated SA with a greater likelihood of repeat surgery.

Significance: Higher CRP values and lower platelet values indicate more severe disease in isolated SA with a greater likelihood of repeat surgery.

Table. Cutoffs and probability algorithm for the likelihood of requiring additional washout(s) following an MSKI diagnosis of isolated septic arthritis.

Characteristic	Cutoff	AUC	(95% CI)	P	Sens	Spec	PPV	NPV
Platelets	<203	0.62	(0.53-0.72)	0.006	29%	93%	37%	90%
CRP	>97	0.63	(0.52-0.74)	0.004	22%	94%	57%	78%

Number of factors that exceed cutoff value	Probability of additional washout
0	4%
1	17%
2	46%

AUC, area under the receiver operating characteristic curve; CI, confidence interval; CRP, C-reactive protein.

Intramedullary Kirschner-wires are equivalent to titanium elastic nails for pediatric femur fractures: Results from a randomized clinical trial in Dar es Salaam, Tanzania

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LOE-Therapeutic-Level I

Purpose: Femur fractures in children are common injuries in the developing world. In children age 5-14, these fractures have historically been treated with skeletal traction. The introduction of flexible intramedullary elastic nails has revolutionized the care these injuries but can be price prohibitive. Recently, use of intramedullary Kirschner wire (K-wire) fixation has been proposed as a low-cost alternative treatment option. The purpose of this study is to compare intramedullary K-wire to titanium elastic nail (TEN) for pediatric femur fractures in a resource-limited setting.

Methods: All children age 5-14 presenting to Muhimbili Orthopaedic Institute (MOI) in Dar es Salaam, Tanzania with acute diaphyseal fracture of the femur were considered for inclusion. Participants were randomized to receive surgical treatment with either intramedullary K-wire or TEN. Participants returned at 2 weeks, 6 weeks, 3 months, 6 months and 12 months postoperatively. The primary outcome measure for this study was acceptable fracture union (modified RUST score) or any complication requiring unplanned surgery (eg. deep infection, hardware failure, malunion) at one year after the surgery. Secondary outcomes will include the Pediatric Quality of Life Inventory (PedsQL) and recovery milestones (time to independent walking, return to school, time until full activity allowed).

Results: Sixty patients (28 TEN, 32 K-wire) were enrolled. Injuries were sustained in road traffic accidents (31), falls (19), and crush injuries (10). The k-wire group was younger (7.9 vs 9.2 years). There was no other differences between groups in patient demographics or fracture pattern. Similar rates of fracture union were observed between study groups at each measured time point by the RUST score. Recovery milestones were similar between groups. There was no difference in rates of complication. There was a positive correlation between RUST score and Squat & Smile score. The PedsQL demonstrated improvement over the course of follow-up and there was no significant difference between the TEN and K-wire groups. The K-wires (\$10) were significantly less costly than TEN (\$260).

Conclusions: This study demonstrates equivalence of a K-wire to TEN for fixation of pediatric femoral shaft fractures. Furthermore, this study demonstrates the feasibility of implementing a randomized clinical trial for pediatric orthopaedic disorders in resource-limited settings.

Significance: This study demonstrates the equivalence of a low-cost alternative to titanium elastic nails for surgical treatment of pediatric femoral shaft fractures in resource-limited settings.

Molecules in Necrotic Femoral Head Inhibit Osteogenesis and Promote Fibrogenesis and Adipogenesis of Mesenchymal Stem Cells

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LOE-Not Applicable-

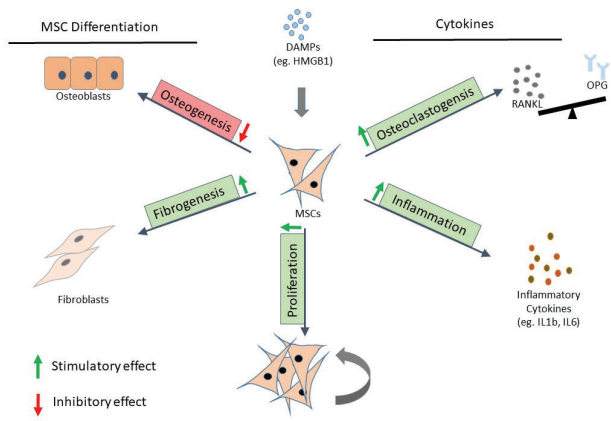
Purpose: In Legg-Calvé-Perthes disease (LCPD), loss of blood supply leads to necrotic cell death and damage-associated molecular patterns (DAMPs) release, which triggers chronic inflammatory response as the disease progresses with bone loss and increased fibrous tissue and adipose tissue in the bone marrow. However, little is known about the components of DAMPs, and its effects on bone mesenchymal stem cell (BMSC) differentiation during bone repair in osteonecrosis. The purpose of this study was to characterize the components of DAMPs in osteonecrosis, and investigate its function on BMSC differentiation.

Methods: DAMPs-containing pig necrotic bone fluid (NBF) was collected from the femoral head after the induction of osteonecrosis in piglets at 48 hours, 2 weeks and 4 weeks. Western-blot and ELISA (enzyme-linked immunosorbent assay) were used to characterize the molecular components of DAMPs in NBF. RNA analysis and cell differentiation assays were performed using pig primary cells.

Results: Using western-blot and ELISA, we identified the presence of DAMP proteins including HMGB1 and Cyclophilin A in NBF. Moreover, we found an increase of inflammatory cytokines such as IL-1 β , IL-6 and TNF α in NBF with the progression of osteonecrosis. To investigate the role of NBF on BMSC osteogenesis, we induced osteogenic differentiation of primary piglet bone marrow cells. We found that NBF inhibited BMSC osteogenesis with decreased expression of osteogenic genes (OSX, Col1a1) and decreased mineralization staining (Von Kossa/Alizarin Red). NBF also markedly enhanced the expression of cell proliferation markers (Ki67/PCNA), fibrogenic genes (Vimentin/Fibronectin) and adipogenic genes (FABP4/Adiponectin) of BMSCs. To specifically study the roles of DAMPS in promoting fibrogenesis, we treated pig fibrotic cells with NBF. We observed increased cell proliferation of fibrotic cells in a NBF dose-dependent manner. Additionally, NBF treated BMSC cells also show elevated RANKL/OPG secretion and increased expression of inflammatory cytokines including IL-1 β and IL-6. Lastly, we studied the effect of HMGB1, a prototypic molecule in the DAMPs family, and showed that HMGB1 promoted cell proliferation and fibrogenesis of BMSC.

Conclusions: Our study showed that DAMPs and the inflammatory cytokines present in the necrotic environment skews the differentiation of BMSC from osteogenesis to fibrogenesis and adipogenesis (figure below), potentially contributing to poor bone regeneration in ischemic osteonecrosis as observed in LCPD patients.

Significance: This study investigated the effects of DAMPs on BMSC differentiation in a necrotic bone environment which promotes our understanding of the disease process and may hint for future therapies targeting DAMPs as treatment.



Does NRG/ErbB Signaling Modulate Contractures after Neonatal Brachial Plexus Injuries?

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LOE-Not Applicable-

Purpose: Neonatal brachial plexus injury (NBPI) causes disabling and incurable muscle contractures, caused primarily by impaired growth of denervated muscles. However, the mechanism by which denervation impairs muscle growth is unknown. A rare form of NBPI, characterized by preganglionic nerve root avulsion, does not cause contractures. This injury maintains afferent muscle innervation despite motor denervation, in contrast to postganglionic injury that causes complete muscle denervation, suggesting a potential regulatory role of afferent innervation in contracture formation. Afferent innervation regulates various aspects of skeletal muscle development through NRG/ErbB signaling. Therefore, our current study used mouse models of pre- and postganglionic NBPI to investigate whether the protective effect of preganglionic injury against contractures is modulated by NRG/ErbB signaling, and if restoration of NRG/ErbB signaling in postganglionic injury could prevent contractures.

Methods: Preganglionic NBPI (Fig 1a) was generated in postnatal day (P)5 mice by unilateral intraforaminal nerve root transection. These mice were subsequently treated with saline or canertinib, an ErbB antagonist, to inhibit ErbB activity. Postganglionic NBPI (Fig 2a) was generated in separate groups of P5 mice by unilateral extraforaminal nerve root excision. These mice were treated with Dulbecco's phosphate-buffered saline (DPBS) or different isoforms of neuregulin-1 (NRG1), the ErbB receptor ligand, to activate ErbB signaling. At P33, following 4 weeks of daily treatments, bilateral elbow ranges of motion were assessed immediately post-sacrifice and brachialis size measurements were subsequently analyzed with MicroCT.

Results: After preganglionic NBPI, ErbB inhibition with Canertinib did not induce elbow contractures (Fig 1b). However, Canertinib impeded cross-sectional and volumetric growth of non-denervated muscles (Figs 1c, 1d). Likewise, ErbB activation with NRG1 isoforms did not prevent elbow contractures after postganglionic NBPI (Fig 2b). Despite this, the β 1-EDF and SMDF isoforms exacerbated reductions in cross-sectional area and volume of denervated muscles (Figs 2c, 2d).

Conclusions: Our findings reveal that NRG/ErbB signaling does not directly modulate contracture development, indicating that the protective effect of preganglionic NBPI against contractures is either not conferred by afferent innervation alone or is conferred through an alternative molecular cross-talk pathway between afferent neurons and skeletal muscle. Despite the lack of involvement in contracture development, we discovered that intricate regulation of NRG/ErbB signaling is required to facilitate neonatal muscle development and limit muscle loss following denervation.

Significance: Our results rule out NRG/ErbB signaling as a potential mechanism and thus pharmacologic target for modulating contractures following NBPI, but identify its importance in muscle mass regulation during neonatal development.

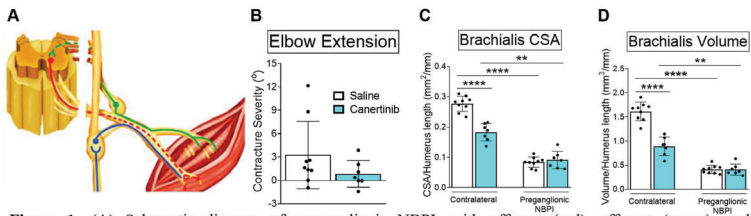


Figure 1: (A) Schematic diagram of preganglionic NBPI, with efferent (red), afferent (green), and sympathetic (blue) neurons depicted. Dashed lines indicate Wallerian degeneration of axons (denervation). (B) Canertinib treatment does not induce contractures after preganglionic NBPI. (C,D) Canertinib treatment attenuates whole muscle cross-sectional area and volume at 4 weeks post-NBPI in control arms. All data are presented as mean \pm s.d. ** $P < 0.01$, **** $P < 0.0001$.

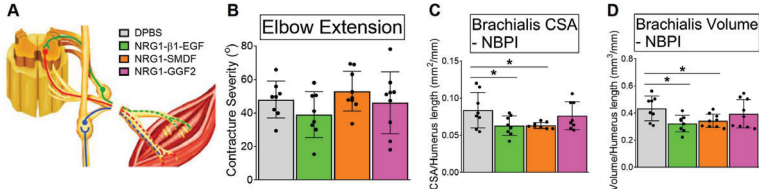


Figure 2: (A) Schematic diagram of postganglionic NBPI, with efferent (red), afferent (green), and sympathetic (blue) neurons depicted. Dashed lines indicate Wallerian degeneration of axons (denervation). (B) Exogenous administration of different NRG1 isoforms does not prevent contractures after postganglionic NBPI. (C,D) Treatment with the β 1-EDF and SMDF diminishes whole muscle cross-sectional area and volume at 4 weeks post-NBPI in denervated arms. All data are presented as mean \pm s.d. * $P < 0.05$.

Trans-articular versus Retro-articular Drilling of Stable Osteochondritis Dissecans of the Knee: A Prospective Randomized Controlled Trial by the ROCK Multicenter Study Group

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LOE-Not Applicable-Level I

Purpose: Knee osteochondritis dissecans (OCD) most commonly presents as a stable lesion on the lateral aspect of the medial femoral condyle (MFC) in an adolescent or pre-adolescent athlete. When non-operative treatment fails, two different drilling techniques are predominantly utilized, but no prospective studies have compared their relative effectiveness. The study hypothesis was that retro-articular drilling (RAD), would not be inferior to trans-articular drilling (TAD), with regard to rate of healing, time to return to sports (RTS), and patient-reported outcome scores (PROs).

Methods: Skeletally immature (n=113) patients presenting with MRI-confirmed stable OCD of the MFC who demonstrated no/minimal healing after ≥ 3 months of non-operative treatment were prospectively enrolled by one of seventeen surgeon-investigators (14 North American centers) and randomized to TAD or RAD. Post-operatively, serial radiographs were obtained every 6 weeks to assess healing, and PROs were obtained at 6, 12, and 24 months. Twelve patients were closed out at time of surgery due to intra-operative lesion instability. Power analysis determined that 37 subjects per group were required to detect a difference in 2-year IKDC scores between both groups with 80% power, if the true standard deviation were 15, using independent samples Student's t-test with alpha at 5%.

Results: Ninety-one study subjects were included, consisting of 51 TAD and 40 RAD patients, respectively, which were similar in age (12.6 years vs. 11.9 years), sex (45% vs. 27% female, $p=0.081$), and 2-year PRO response rate (both 90%). There were no significant differences between TAD and RAD in post-operative Pedi-IKDC, Lysholm, Marx knee activity score, or KOOS QOL scores (Table 1). Revision OCD surgery occurred in similar rates of RAD (10%) and TAD (4%, $p=0.40$). 73% of TAD patients reached a 'completely healed' status at a mean of 1.15 years, compared with 60% RAD patients at a mean of 1.21 years.

Conclusions: Both OCD drilling techniques demonstrated high rates of clinical improvement, PROs approximating normative values, and RTS around 7 months post-operatively despite 'healed' status taking >1 year. Higher powered studies are needed to potentially differentiate revision surgery rates, but overall risk is low and absolute risk only 6%.

Significance: For stable OCD, the current data supports use of either TAD, which may be technically simpler, without the need for fluoroscopy, or RAD, which may be more protective of the chondral articular surface.

	Trans-Articular (n=51)	Retro-articular (n=40)	p-value
Radiographic 'Healed' OCD Lesion (n,%)	36 (70.6%)	24 (60.0%)	0.37
Time to 'healed' (years)	1.15	1.21	0.82
Returned to running sports (RTS) (years)	0.61	0.64	0.85
Revision OCD Surgery (n, %)	2 (3.9%)	4 (10.0%)	0.40
Mean 2-Year Post-Operative PRO/Activity Score			
Pedi-IKDC	90.1	87.3	0.43
Lysholm	90.6	87.6	0.42
Marx Knee Activity Score	12.6	11.8	0.45
KOOS Quality of Life	81.8	73.7	0.17

Operative Versus Non-Operative Treatment of Severely Shortened or Comminuted Clavicle Fractures in Older Adolescent Athletes: Results from A Prospective, Multicenter, Level 2 Cohort Study

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LOE-Therapeutic-Level II

Purpose: Operative management of clavicle fractures is increasingly advocated for athletes and young adults. Surgical indications and optimal treatment for comminuted or severely shortened clavicle fractures in adolescent athletes remain unclear. The purpose of this study was to evaluate the outcomes of non-operatively and operatively treated comminuted and/or severely shortened (>25mm) clavicle fractures in older adolescent athletes.

Methods: Athletes aged 14 to 18 years with mid-shaft clavicle fractures who had non-operative (NONOP) or operative (OP) treatment at one of eight participating centers between 2013 and 2017 were screened for the presence of comminution and/or fracture shortening >25mm. Demographics, injury mechanism, fracture characteristics and treatment (NONOP vs. OP) were prospectively recorded and patients followed for a minimum of two years. Complications, rates and timing of return to sport (RTS), and patient reported outcomes (PROs: ASES, QuickDASH, MARX shoulder activity, EQ-5D, EQ-VAS, and patient satisfaction) were analyzed.

Results: The two groups included 137 patients (70 NONOP, 67 OP), with a similar distribution among various sports—most commonly football—and rates of competitive athletic participation (NONOP: 81%, OP: 85%) (Figure 1). Of the 137 patients, 100 [NONOP n=52, 15.3 years, 44 males (84.6%); OP n= 48, 15.5 years, 40 males (83.3%)] provided PROs at > 2 years. Comminution (C) and shortening (S) were not different between groups [NONOP C=24 (46.2%), S=28mm (24.5, 33.2); OP C=35 (72.9%), S=28mm (25.0, 36.5)], but the OP group demonstrated 3 mm greater vertical displacement [NONOP 13.0 (9.6, 18.0) mm, OP 16.0 (11.8, 21.0) mm; $p<0.05$], which was therefore controlled for as a statistical confounder in the comparative PRO analysis. There was no difference in nonunion, delayed union, symptomatic malunion, re-fracture, or clinically significant complications between treatment groups (Table 1). Two years after injury, 75% of NONOP and 79% of OP patients reported RTS, with 61% and 57%, respectively, reporting achievement of same sport-level and similar RTS timing (OP=10 weeks, NONOP= 11.6 weeks). When controlling for minor differences in superior displacement, regression and matching analyses demonstrated no difference in mean and dichotomized PRO scores between the NONOP and OP groups (Table 2).

Conclusions: In this prospective multi-center cohort of comminuted and/or severely shortened (>25mm) clavicle fractures in adolescent athletes, there was no difference in complications, RTS, or PROs between non-operatively and operatively treated patients at 2 years. Despite several studies suggesting the contrary in adult populations, comparably excellent outcomes of severe clavicle fractures in adolescent athletes can be achieved with non-operative treatment.

Significance: This study represents the largest cohort of adolescent athletes with displaced clavicle fractures and suggests that more research is necessary to determine which patients might benefit from surgical fixation of clavicle fractures.

FIGURE 1A:

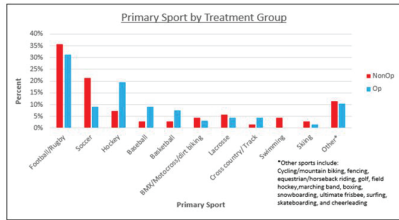


FIGURE 1B:

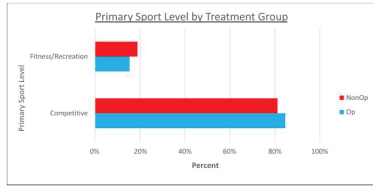


Table 1 - Outcome: Objective Criteria

	Nonoperative treatment	Operative treatment
Nonunion	0	0
Delayed union	2%	2%
Symptomatic malunion	2%	0
Re-fracture	0	2%
Clinically significant complication*	4%	13%

*based on the modified **Clayton-Dixie** classification

TABLE 2 - Distribution of PROs, by Treatment Groups

Variable	Non-Operative (n=52)	Operative (n=48)	p-value
ASES Score			
Patients (%) with Suboptimal (<80) Score	4 (8.0%)	3 (6.2%)	1.0
Mean (SD)*	97.5 (7.5)	97.1 (7.7)	
QuickDASH Score			
Patients (%) with Suboptimal (>10) Score	3 (5.9%)	3 (6.4%)	1.0
Mean (SD)*	23 (7.7)	27 (7.4)	
EQ-VAS Score			
Patients (%) with Suboptimal (<80) Score	3 (5.9%)	1 (2.1%)	1.0
Mean (SD)*	83.4 (8.6)	84.5 (8.9)	
EQ-5D Score			
Patients (%) with Suboptimal (<0.80) Score	3 (5.9%)	2 (4.3%)	1.0
Mean (SD)*	0.98 (0.06)	0.97 (0.08)	
Overall Satisfaction Score			
Patients (%) with Suboptimal (<2) Score	7 (13.7%)	3 (6.4%)	0.32
Mean (SD)*	1.4 (0.8)	1.3 (0.8)	
MARX Shoulder Activity			
Patients (%) with Suboptimal (<7) Score	6 (11.5%)	5 (10.4%)	1.0
Mean (SD)*	12 (6 (5.2)	14.6 (5.6)	

*All values are reported as the mean (SD). The p-value is reported as the p-value for the comparison between the two groups. The p-value is reported as the p-value for the comparison between the two groups. The p-value is reported as the p-value for the comparison between the two groups. The p-value is reported as the p-value for the comparison between the two groups.

Nonoperative Management of Femoroacetabular Impingement: Clinical Outcomes at 5-years – A Prospective Study

Andrew Zogby; James David Bomar MPH; Kristina Parvanta Johnson; Vidyadhar S V Upasani MD; Andrew Pennock MD
 Rady Children's Hospital, San Diego, San Diego, California

LOE-Therapeutic-Level II

Purpose: Our purpose is to present 5-year outcomes data utilizing a non-operative protocol on a consecutive series of patients with FAI syndrome.

Methods: Between 2013 and 2016, patients were prospectively recruited in a non-operative FAI study. The protocol consisted of an initial trial of rest, physical therapy, and activity modification. Patients who remained symptomatic were offered an intra-articular steroid injection. Patients with recurrent symptoms were offered arthroscopic treatment. Patient-reported outcomes including the modified Harris Hip Score (mHHS) and Non-arthritic Hip Score (NAHS) were collected 1-, 2-, and 5-years after enrollment. We present the 5-year data. Statistical analysis was performed to determine outcomes based on FAI type and treatment.

Results: 133 hips in 100 patients were enrolled. Sixty-seven hips in 50 patients were available for 5-year follow up. At enrollment, the mean mHHS and NAHS were 69.6±13.1 and 76.3±14.7 respectively. In total, 73% of the cohort was managed non-operatively. Of the 11 patients requiring surgery, six (55%) converted to surgery within one year of enrollment, 4 (36%) converted to surgery between one and 2 years, and one patient converted to surgery between 2 and 5 years. At final follow up, the mean mHHS and NAHS were 89.6±10.7 and 88.0±12.1 respectively. At 1-year follow up, only the activity modification group made a significant increase in mHHS and NAHS (p<0.03), by two year follow up, all three treatment groups had made statistically significant improvements in mHHS and NAHS (p<0.05), by 5-years follow up, the activity modification group and the scope group had maintained their statistically significant improvement in mHHS and NAHS (p<0.03). There was no significant difference in mHHS or NAHS between treatment groups at 5-year follow-up (p>0.4)(Table 1), and no difference in proportion of hips meeting the MCID for mHHS based on treatment course (p=0.961). There was no difference in mHHS or NAHS between FAI types at any time point (p>0.06)(Table 2), or in the proportion of hips that met MCID among FAI types (p=0.511). 72% of patients returned to the same or similar sport/activity level, and there was no difference in the proportion of patients that returned to sports/activities among treatment type (p=0.095) or FAI type (p=0.273).

Conclusions: Non-operative management of FAI syndrome is effective in a majority of adolescent patients, with robust improvements in patient-reported-outcomes persisting at 5-year follow-up.

Significance: Non-operative management can be successful for a large portion of adolescent patients with symptomatic FAI syndrome with durable outcomes at 5-year follow-up.

Table 1. All patient reported outcomes collected during the course of the study

		Initial Visit (IV)			1 year follow up			2 year follow up			5 year follow up					
		N	Mean	Std. Dev.	N	Mean	Std. Dev.	p-value	N	Mean	Std. Dev.	p-value	N	Mean	Std. Dev.	p-value
Modified Harris Hip Score	Activity Mod.	49	69.6±14.2	30	88.5±13.4	<0.001	42	90.5±11	<0.001	49	90.6±10.2	<0.001				
	Injection	7	69.9±8.3	3	93.9±10.8	0.109	6	93.3±4.4	0.042	7	86.6±15.3	0.091				
	Scope	11	69.3±11	8	74.4±16.5	0.752	11	88.5±6.8	0.008	11	87.1±10.1	0.008				
	p-value		0.999		0.066		0.648		0.43							
Non-Arthritic Hip Score	Activity Mod.	46	76.6±15.8	30	85.8±17.3	0.023	42	88.3±13.3	<0.001	49	88±12.8	<0.001				
	Injection	7	72.5±13.4	3	91.7±6.9	0.109	6	90.2±5.2	0.046	7	86.6±13	0.128				
	Scope	11	77.3±11.4	8	77.3±19.6	0.888	11	88.5±6.9	0.012	11	88.8±8.6	0.022				
	p-value		0.628		0.472		0.511		0.771							

Table 2. All patient reported outcomes collected during the course of the study by impingement type

		Initial Visit (IV)			1 year follow up			2 year follow up			5 year follow up					
		N	Mean	Std. Dev.	N	Mean	Std. Dev.	p-value	N	Mean	Std. Dev.	p-value	N	Mean	Std. Dev.	p-value
Modified Harris Hip Score	Cam	32	66.9±14.1	18	89.4±14.1	0.002	27	90.1±8.7	<0.001	32	86.4±11.3	<0.001				
	Pincer	9	74.6±5.5	7	83.0±11.6	0.225	9	84.7±13.4	0.092	9	94.0±10.8	0.011				
	Cam & Pincer	8	67.8±15.8	6	77.9±16.2	0.465	7	90.4±8.9	0.028	8	92.4±6.8	0.017				
	No radiographic signs of FAI	18	72.6±12.3	10	87.3±16.9	0.05	16	94.2±9.0	0.001	18	92.0±9.9	0.001				
p-value		0.26		0.205		0.171		0.066								
Non-Arthritic Hip Score	Cam	31	73.2±15.5	18	87.3±17.6	0.017	27	88.4±10.5	<0.001	32	84.7±13.2	0.001				
	Pincer	9	77.0±8.7	7	86.3±14.2	0.237	9	85.1±14.4	0.135	9	91.1±11.9	0.012				
	Cam & Pincer	7	81.6±14.1	6	79.2±15.2	0.752	7	85.2±12.7	0.786	8	90.8±8.9	0.173				
	No radiographic signs of FAI	17	79.2±15.9	10	81.6±21.1	0.721	16	92.2±11.4	0.005	18	91.0±10.6	0.008				
p-value		0.454		0.316		0.226		0.114								

Acetabular remodeling after closed and open reduction for the treatment of developmental dysplasia of the hip

*Pedro Gaspar Soares Justo; William Zachary Morris MD; Patricia E. Miller MS; Eduardo V. Novais MD
Boston Childrens Hospital , Boston MA*

LOE-Therapeutic-Level III

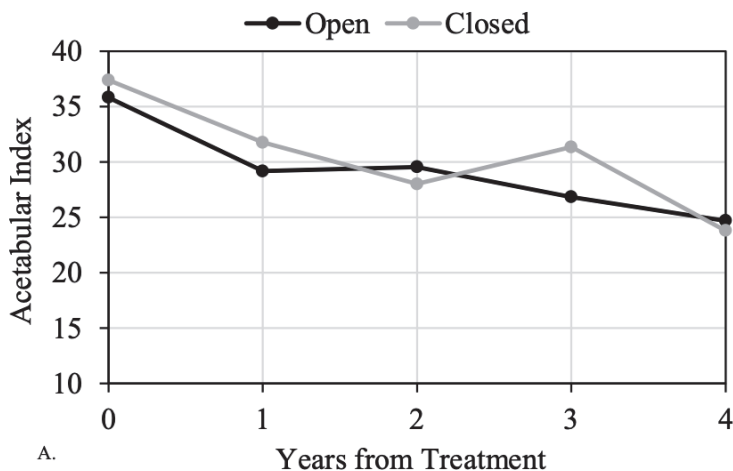
Purpose: The purpose of this study was to compare the remodeling of the acetabulum after closed versus open reduction of developmental dysplasia of the hip (DDH).

Methods: Two hundred thirty-five patients between the ages of 0 and 24 months who underwent closed or open reduction for the treatment of DDH t between 2000 and 2018 were identified. Fourteen subjects did not have a record of the type of treatment they underwent, and 45 did not have initial IHDI class, and so were excluded. Of the 176 remaining subjects, 99 underwent closed reduction and 76 underwent open reduction. Because of the significant difference in the IHDI grading and age of the subject at the time of the reduction, a propensity score matching was conducted to match open and closed reduction subjects on the basis of IHDI class, age at treatment, and patient sex. A 1:1 ratio matching was achieved by utilizing a logistic regression model with a nearest neighbor algorithm using a caliper of 0.1 of the standard deviation of the propensity score. The final match included 56 subjects who underwent open reduction and 56 who underwent closed reduction. The acetabular index (AI) was measured at every clinic visit after reduction. Patient, condition, and treatment characteristics were summarized for patients stratified by treatment group. Comparisons across treatment group were conducted using general linear regression analysis to adjust for propensity score.

Results: We found no differences across treatment groups concerning any demographic, condition, or treatment characteristics at base line. There was a slightly higher mean acetabular index for closed reduction patients at one (p=0.03) and three (p=0.02) years of follow-up. However, linear mixed modeling found no difference in the change in AI over time across treatment groups (p=0.10). (Figure 1)

Conclusions: Despite a slightly higher acetabular index and one and three years of followup in hips treated by closed reduction, we found no differences in the rate of AI improvement during the first four years post-surgery between hips undergoing closed versus open reduction.

Significance: The acetabulum remodels at a similar rate following closed and open reduction during the first 4 years following reduction. However, given the developmental nature of DDH further studies should investigate whether the remodeling of the acetabulum continues in a similar fashion after 4 years postoperative.



A.

Activation of A Central Immunosuppressive Cascade Prevents Ischemia Reperfusion Injury after Acute Compartment Syndrome in a Murine Model

Austin Grayce Hester; Nazanin Omid; Daniel Paul Casella; **Matthew E. Oetgen MD**
Children's National Hospital, Washington, DC

LOE-Not Applicable-

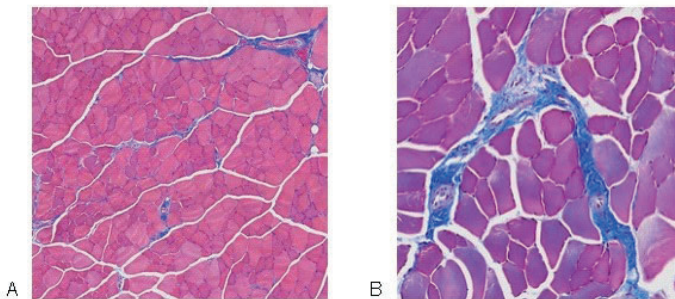
Purpose: Occurring when interstitial pressure exceeds perfusion pressure, acute compartment syndrome (ACS) results in warm ischemia and cell death due to impaired aerobic metabolism. Following surgical decompression and reperfusion of the extremity, there is a robust innate inflammatory response that results in further tissue injury due to the production of reactive oxygen species and local capillary dysfunction. In addition to prompt diagnosis and reperfusion of the compartment, therapies which limit the secondary ischemia reperfusion injury (IRI) may be helpful to improve outcomes in patients with ACS. Varenicline (Chantix™) activates a novel immunosuppressive cascade and is effective at reducing IRI in following testicular torsion and pyelonephritis. We hypothesized that varenicline administration would reduce IRI following a compartment syndrome model in a mouse.

Methods: Using an established model, warm hindlimb ischemia was induced in mature CD-1 mice by placing and orthodontic rubber band around the hindlimb for 90 minutes. In the treatment group, varenicline (1µg/gram) was administered as an intraperitoneal injection 60 minutes after the onset of ischemia. The degree of acute inflammation was quantified using Fluorescent Activated Cell Sorting, 24 hours following reperfusion. The expression of pro-fibrotic genes in the gastrocnemius muscle were evaluated 7 days following reperfusion and histologic evaluation of fibrosis with trichrome staining was performed 14 days following reperfusion of the limb.

Results: Treatment with varenicline reduced the acute leukocyte infiltrate 24 hours after reperfusion (3.08% vs 0.86%, $P \leq 0.01$, $n=16$). Treatment with varenicline reduced the expression of the pro-fibrotic genes (measured in relative expression) (Collagen1a1 (1.73 vs 0.31), Collagen1a3 (1.85 vs 0.42), Vimentin (2.11 vs 0.38) and Actin (1.82 vs 0.56) $P \leq 0.05$, $n=16$ 7 days following reperfusion. Histologic evidence of collagen deposition was also significantly reduced (3.45% vs 1.89%, $P \leq 0.005$, $n=20$) 14 days following reperfusion in animals treated with varenicline.

Conclusions: Varenicline administration reduces acute inflammation and long-term fibrosis of the gastrocnemius muscle following warm hindlimb ischemia in a mouse.

Significance: Varenicline represents a potentially novel FDA approved adjunct to the current management of acute compartment syndrome and extremity ischemia. Administration of this medication appears to have the potential to mitigate post-injury inflammation and fibrosis which may lead to improved functional outcomes following this condition. Further studies are needed to define the optimal dosing and administration regimens.



Trichrome staining of muscle fibers 14 days following limb ischemia in animals treated with varenicline (A), N=10 and untreated controls (B), N=10 demonstrated a significant decrease in collagen deposition in animals treated with varenicline, $P \leq 0.005$.

Hematopoietic Cells Regulate Fracture Healing in Neurofibromatosis

*Benjamin A. Alman MD; Puvindran Nadesan
duke, durham, NC*

LOE-Not Applicable-

Purpose: Recent data shows that macrophage cells are critical for bone fracture healing. In addition, this cell type regulates the pace of fracture repair. Neurofibromatosis is associated with a slowed pace of fracture repair and inhibited osteogenesis, and this contributes to conditions such as tibial pseudoarthrosis. Here we determined the contribution of hematopoietic cells in fracture repair in NF1.

Methods: Mice in which the *Nf1* gene is conditionally deleted by injection of an adenovirus expressing cre-recombinase (*Nf1f/f*) were used for the study. Tibia fractures were generated and fixed with an intramedullary pin. The quality of the repair was assessed 21 days after fracture using micro-CT and histomorphometry. Bone marrow transplantations were performed on these animals using donor bone marrow from *Nf1f/f* or wild type mice of the same background. All of the mice were of the same age, and half were male and half female in each cohort. All were treated with an adenovirus. 12 mice were examined in each group: recipient *Nf1f/f* mice with wild type donor; recipient *Nf1f/f* mice with *Nf1f/f* donor; *Nf1f/f* mice without a bone marrow transplantation; and wild type mice without a transplantation.

Results: *Nf1f/f* mice without a bone marrow transplantation had a 27% lower bone density at the tibia fracture site and a 35% increase in the proportion of fibrous tissue (both $p < 0.01$ by t-test). Recipient *Nf1f/f* mice with *Nf1f/f* donor marrow showed a bone density at the fracture site and a proportion of fibrous tissue at the fracture site the same as for control *Nf1f/f* mice. Recipient *Nf1f/f* mice with wild type donor marrow had a 19% increase in bone density and a 29% decrease in the percent of fibrous tissue at the fracture site (both $p < 0.01$ by t-test). There were no mesenchymal or bone cells found in the recipient animals from the donor animals, showing that the effect is from the hematopoietic cell population.

Conclusions: This data shows that hematopoietic cells regulate the quality of fracture repair in NF1 in mice. A role for hematopoietic cells was previously demonstrated in other conditions, such as in aging, and this data extends the notion that these cell types orchestrate bone repair to a genetic condition influencing bone repair.

Significance: Taken together, this suggests that an approach to target hematopoietic cells, such as macrophage cells, could be developed into a therapy to improve bone healing in neurofibromatosis. Pharmacologic and cell therapy approaches are being investigated to achieve this goal

SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

CONCURRENT SESSION 1 : SPINE

Moderator: Lindsay Andras, MD

Co-Moderator: Jeffrey Sawyer, MD

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2:05 PM–2:09 PM



10 year follow up of Lenke V curves in patients with adolescent idiopathic scoliosis

Nicholas Fletcher, MD; Tracey Bastrom, MA;

Noelle A. Larson, MD; Mark Erickson, MD; Baron Lonner, MD;

Stefan Parent, MD; Burt Yaszay, MD

Children's Healthcare of Atlanta, Atlanta, GA

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2:10 PM–2:14 PM

Adolescent Athletes Return To Sports Rapidly After Posterior Spine Fusion (PSF) For Idiopathic Scoliosis (AIS): A Prospective Cohort Study

Tyler Tetreault; Hannah Darland; Thien Thanh Angela Vu;

Patrick Carry; Sumeet Garg, MD

Children's Hospital Colorado, Aurora, CO

115

2:15 PM–2:19 PM

Discordant Lowest Instrumented Vertebra in Adolescent Idiopathic Scoliosis: When Coronal and Sagittal Parameters Conflict

Michael Vitale, MD, MPH ; Dale Segal; Jacob Ball;

Nicholas Fletcher, MD; Tracey Bastrom, MA; Eric Yoon

Children's Healthcare of Atlanta, Atlanta, GA



SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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2:29 PM–2:33 PM

Unplanned Return to the Operating Room (UPROR) after AIS Surgery

Nishank Mehta; Divya Talwar; Harms Study Group;

John (Jack) Flynn, MD

Children's Hospital of Philadelphia, Philadelphia, PA

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2:34 PM–2:38 PM

Complications Following Surgical Treatment of Adolescent Idiopathic Scoliosis: 10- year Prospective Follow-up Study

Arun Hariharan, MD; Suken Shah, MD; Margaret Baldwin;

Joseph Petfield; Baron Lonner, MD; Firoz Miyanji, MD;

Peter Newton, MD; Amer Samdani, MD;

Paul Sponseller, MD; Burt Yaszay, MD

Nemours/A.I. DuPont Hospital for Children, Wilmington, DE

118

2:39 PM–2:43 PM

Digital Skeletal Age and Curve Acceleration Phase in Male Adolescent Idiopathic Scoliosis

Alexander Kuzma; Michael Stevens; John King, MD;

Kevin Cronin; Olivia Grothaus; Jonathan Grabau;

Cale Jacobs; Vishwas Talwalkar, MD; Ryan Muchow, MD

University of Kentucky, Lexington, KY

SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

CONCURRENT SESSION 1: SPINE PART II

Moderator: Ying Li, MD

Co-Moderator: Pat Cahill, MD

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3:28 PM–3:32 PM

Outcomes of Magnetically Controlled Growing Rods in Severe Early Onset Scoliosis

Ilkka Helenius; Antti Saarinen; Paul Sponseller, MD; Lindsay Andras, MD; David Skaggs, MD, MMM; John Emans, MD; George Thompson, MD; Pediatric Spine Study Group University of Turku and Turku University Hospital, Turku, Finland

120

3:33 PM–3:37 PM

Early Outcomes of Magnetically Controlled Growing Rods (MCGRs), Posterior Final Fusion (PSF) and Vertebral Body Tethers (VBT) in Older Patients with Early Onset Scoliosis (EOS)

Catherine Mackey; Regina Hanstein; Majella Vaughan; Tricia St Hilaire; Scott Luhmann, MD; Michael Vitale, MD, MPH; Michael Glotzbecker, MD; Amer Samdani, MD; Stefan Parent, MD; Jaime Gomez, MD Montefiore Medical Center, Bronx, NY

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3:38 PM–3:42 PM

Half of Magnetic Controlled Growing Rods (MCGR) “stall” 3 years after implantation

Amy McIntosh, MD; Brandon Ramo, MD; Charles Johnston, MD; Anna McClung; David Thornberg Texas Scottish Rite Hospital, Dallas, TX

122

3:52 PM–3:56 PM

Matched Comparison of Growing Rods versus Primary Posterior Spinal Fusion in “Tweeners” with Early Onset Scoliosis

Craig Louer, MD; Lukas Keil; Til Stürmer; Alysa Nash; Yvonne Golightly; FENG-CHANG LIN; Joseph Stone, MD; James Sanders, MD UNC Orthopaedics, Chapel Hill, NC

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3:57 PM–4:01 PM

Vertebral Body Tethering Compared to the Spinal Fusion Gold Standard: A Matched Analysis 2 Years Post-Operatively

Lily Eaker; Jonahtan Markowitz; Baron Lonner, MD Mount Sinai Hospital, New York, NY



SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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4:02 PM–4:06 PM

Does Body Mass Index Affect Outcomes after Vertebral Body Tethering Surgery?

*Amir Mishreky; Stefan Parent, MD; Firoz Miyanji, MD; Joshua Murphy, MD; Ron El-Hawary, MD
IWK Health Centre, Halifax, Nova Scotia, Canada*

125

4:16 PM–4:20 PM

The effect of scoliosis on audio-visual and socio-emotional processing and the use of adaptive communicative equipment in children with severely involved cerebral palsy

*Amanda Whitaker, MD; Stephanie Burkhardt; Kaleigh Hague; Lindsay Pietruszewski; Julia Less; Nathalie Maitre
Nationwide Children's Hospital, Columbus, Ohio*

126

4:21 PM–4:25 PM

Definitive Fusions are Better than Growth Friendly Procedures for Juvenile Patients with Cerebral Palsy and Scoliosis: A Prospective Comparative Cohort Study

*Arun Hariharan, MD; Suken Shah, MD; Joseph Petfield; Margaret Baldwin; Paul Sponseller, MD; Burt Yaszay, MD; Michael Glotzbecker, MD; Patrick Cahill, MD; Tracey Bastrom, MA
Nemours/A.I. DuPont Hospital for Children, Wilmington, DE*

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4:26 PM–4:30 PM

Functional Outcomes of Spinal Orthoses in Spinal Muscular Atrophy

*Mitchell Johnson; Carina Lott; Patrick Cahill, MD; Jason Anari, MD
Children's Hospital of Philadelphia, Philadelphia, PA*

CONCURRENT SESSION 2: SPORTS

Moderator: *Phil Wilson, MD*

Co-Moderator: *Melissa Christino, MD*

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2:05 PM–2:09 PM

Compared to Repair or No Treatment, Medial patellofemoral Ligament Reconstruction Results in Increased Stability in Adolescents with Acute First-time Patellar Dislocation with an Associated Loose Body

*Eric Edmonds, MD; Preet Gurusamy; Jason Pedowitz; Alyssa Carroll; Kristina Johnson; Henry Chambers, MD; Andrew Pennock, MD
Rady Children's Hospital, San Diego, CA*

SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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2:10 PM–2:14 PM

Isolated MPFL Reconstruction vs. Tibial Tubercle Osteotomy Plus Medial Retinacular Plication for Recurrent Patellar Instability: A Matched, Cohort Analysis

*Benton Heyworth, MD; Evan Zheng; Zaamin Hussain; Benjamin Wilson, MD; Kianna Nunally; Mininder Kocher, MD, MPH; Yi-Meng Yen, MD; Dennis Kramer, MD; Lyle Micheli, MD
Boston Children's Hospital, Boston, MA*

130

2:15 PM–2:19 PM

Predictors of Arthrofibrosis after Pediatric Anterior Cruciate Ligament Reconstruction: What is the Impact of Quadriceps Autograft?

*Abraham Ouweleen; Tyler Hall; Craig Finlayson, MD; Neeraj Patel, MD
Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL*

131

2:29 PM–2:33 PM

Functional recovery in Adolescent Athletes following ACL Reconstruction: A Matched Cohort Analysis of Patellar Tendon vs. Hamstring Autograft

*Nikolaos Paschos; Dai Sugimoto; Elizabeth Liotta; Patricia Miller, MS; Lyle Micheli, MD; Mininder Kocher, MD, MPH; Benton Heyworth, MD
Boston Children's Hospital, Boston, MA*

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2:34 PM–2:38 PM

Anterior Cruciate Ligament Tear Following Operative Treatment of Pediatric Tibial Eminence Fractures in a Multicenter Cohort

*Ryan O'Donnell; Steven Bokshan; Kelsey Brown; Julien Aoyama, BA; Theodore Ganley, MD; Peter Fabricant, MD; Neeraj Patel, MD; Henry Ellis, MD; Daniel Green, MD; Indranil Kushare, MD; R Lee, MD; Scott McKay, MD; Jason Rhodes, MD; Brant Sachleben, MD; Mary Sargent, MD; Gregory Schmale, MD; Yi-Meng Yen, MD; R Mistovich, MD; Aristides Cruz, MD
Brown University/Rhode Island Hospital, Providence, RI*



SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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2:39 PM–2:43 PM

A Multicenter Comparison of Open versus Arthroscopic Reduction and Internal Fixation for Tibial Spine Fractures
R. Justin Mistovich, MD; Jilan Shimberg; Tomasina Leska; Julien Aoyama, BA; Aristides Cruz, MD; Henry Ellis, MD; Peter Fabricant, MD; Theodore Ganley, MD; Daniel Green, MD; Jason Jagodzinski, MD; Indranil Kushare, MD; R Lee, MD; Scott McKay, MD; Neeraj Patel, MD; Jason Rhodes, MD; Brant Sachleben, MD; Mary Sargent, MD; Gregory Schmale, MD; Yi-Meng Yen, MD
Rainbow Babies and Children's Hospital, Cleveland, OH

CONCURRENT SESSION 2: FOOT/NM/LE

Moderator: Steve Frick, MD

Co-Moderator: L. Reid Nichols, MD

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3:28 PM–3:32 PM

Comparison of Rigid and Dynamic Foot Abduction Orthoses in Children with Clubfoot: A Randomized Trial
Vincent Prusick, MD; Michael Stevens; Cale Jacobs; Vishwas Talwalkar, MD; Janet Walker, MD; Ryan Muchow, MD; Henry Iwinski, MD; Elizabeth Hubbard, MD
Shriners Hospital for Children, Lexington, KY

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3:33 PM–3:37 PM

Radiographic and Histologic Evaluation of Three Common Tendon Transfer Techniques in an Un-ossified Bone Porcine Model: Implications for Early Anterior Tibialis Tendon Transfers in Children with Clubfeet
Maegen Wallace, MD; Matthew Halanski, MD; Kyle Korth; Scott Bolam; Ellen Leiferman; Tom Crenshaw; Michael Dray; Haemish Crawford, MD
University of Wisconsin, Madison, WI

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3:38 PM–3:42 PM

Ponseti versus surgery, the 15 year outcomes of prospectively enrolled cohorts.
James Recordon; Matthew Halanski, MD; N Susan Stott, MD; Mark Boocock; Peter McNair; Haemish Crawford, MD
Starship Children's Hospital, Auckland, New Zealand

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3:52 PM–3:56 PM

Calcaneal Sliding Osteotomy is Superior to Calcaneal Lengthening Osteotomy in Children with Cerebral Palsy
Robert Kay, MD; Susan Rethlefsen, PT; Alison Hanson; Tishya Wren, PhD
Children's Hospital Los Angeles, Los Angeles, CA

SCIENTIFIC PROGRAM

FRIDAY, MAY 14 CONTINUED

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3:57 PM–4:01 PM

The Impact of Preoperative Factors and Surgical Burden on Postoperative Recovery of Walking Activity in Children with Cerebral Palsy

*M Shrader, MD; Chris Church; Isabel Biermann; Nancy Lennon MS; John Henley; Stephanie Butler; Timothy Niiler; Freeman Miller, MD; Jason Howard, MD
Nemours duPont Hospital for Children, Wilmington, DE*

139

4:02 PM–4:06 PM

Fassier-Duval Telescoping Rodding in Osteogenesis Imperfecta: Rod Revision and Survivorship

*Jirawat Saengsin; Patricia Miller, MS; Nicholas Sullivan; Blair Stewig; Collin May, MD; Carley Vuillermin FRACS; Susan Mahan, MD; James Kasser, MD; Samantha Spencer, MD
Department of Orthopaedic Surgery, Boston Children's Hospital, Harvard Medical School, Boston, MA*

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4:16 PM–4:20 PM

Prediction of Varus Deformity Correction by Lateral Tension Band Plating at the Knee in Late-Onset Blount Disease- A Multi-Center Study

*Janet Walker, MD; David Dueber; Kenneth Powell, MD; Lindsay Stephenson, MD; Allison Scott, MD; Joel Lerman, MD; Sarah Nossov, MD; Corinna Franklin, MD; David Westberry, MD
Shriners Hospitals for Children, Multiple Centers- Lead Site, Lexington, KY*

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4:21 PM–4:25 PM

Correction of Leg Length Discrepancy (LLD): Tension-Band Plating versus Percutaneous Trans-epiphyseal Screws

*Manaf Younis, MD; Regina Hanstein; Yungtai Lo; Kainaat Javed; Eric Fornari, MD; Jaime Gomez, MD; Melinda Sharkey, MD; Jacob Schulz, MD
Montefiore Medical Center, Bronx, NY*

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4:26 PM–4:30 PM

Total Joint Arthroplasties before 25: Functional Outcomes and Quality of Life

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10 year follow up of Lenke V curves in patients with adolescent idiopathic scoliosis

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LOE-Therapeutic-Level IV

Purpose: Patients with surgically treated Lenke V curves require at least partial fusion of the lumbar spine. Longer term outcomes evaluating clinical and radiographic results are lacking.

Methods: A retrospective review of a multicenter prospectively collected database of patients with Lenke V curves treated with spinal fusion was performed. Clinical and radiographic outcomes as well as SRS-22 scores were collected at 2-and-10 year follow up.

Results: 54 patients (26 treated with posterior spinal fusion (PSF) and 28 with anterior spinal fusion (ASF)) met inclusion criteria. 33% were treated with longer fusion (above T9) and 67% with shorter fusion (T9 and below). 72% were fused to L3 distally and 17% to L4. Preoperative lumbar curve magnitude was $45\pm 8^\circ$ and corrected to $14\pm 7^\circ$ ($p<0.001$). A $3\pm 7^\circ$ increase in curve size was noted at final follow up ($p<0.008$) with 20% of patients having a loss of correction (LOC) of 10° or more. LOC did not vary with approach ($p=0.38$), disc angulation below LIV ($p=0.89$), or non-selective fusion ($p=0.96$). Thoracic curve correction and T5-T12 kyphosis were stable at 10 year follow up. End vertebrae angulation improved from $11\pm 23^\circ$ to $1\pm 6^\circ$ ($p=0.004$) and translation improved from $2.5\pm 2.9\text{cm}$ to $0.92\pm 1.5\text{cm}$ ($p=0.008$) with no LOC. Similarly, C7-CSVL and both apical and apical lumbar translation improved significantly on first erect radiograph with no LOC at final follow up. Disc wedging below the lower instrumented vertebrae increased from $0.3\pm 4.9^\circ$ to $2.8\pm 4.4^\circ$ ($p<0.001$) with no subsequent change at 10 years. SRS-22 self-image and satisfaction improved from post-operative to final follow up. There was no increase in pain scores (4.3 ± 0.7 preop vs 4.2 ± 0.6 10-year, $p=0.53$). Using normative data for adults aged 20-40, there was no correlation between pain scores 2-standard deviations below normal and LOC $>10^\circ$ ($p=0.99$), L3 vs L4 as LIV ($p=0.34$), or thoracic vs lumbar fusion ($p=0.14$). There were three complications using the Clavien-Dindo classification greater than grade II (2 CDS III and 1 CDS IVa) in the ASF group and none in the PSF group. No patient required a second operation.

Conclusions: Both ASF and PSF showed durable results at 10 year follow up. 20% of patients had a loss of correction $>10^\circ$; this did not correlate with worse pain or need for revision surgery. Disc wedging was stable. Selection of LIV did not correlate with pain scores.

Significance: Surgeons can counsel patients that results of spinal fusion at ten-year follow up are typically excellent and outcomes are stable without a high risk of revision .

Adolescent Athletes Return To Sports Rapidly After Posterior Spine Fusion (PSF) For Idiopathic Scoliosis (AIS): A Prospective Cohort Study

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LOE-Therapeutic-Level II

Purpose: No consensus exists regarding return to sports for patients with AIS treated with PSF. Our program allows unrestricted return to sports after a 6-week post-operative appointment. The purpose of this study was to determine how rapidly athletes return to baseline sports activity following PSF for AIS using validated patient reported outcome measures.

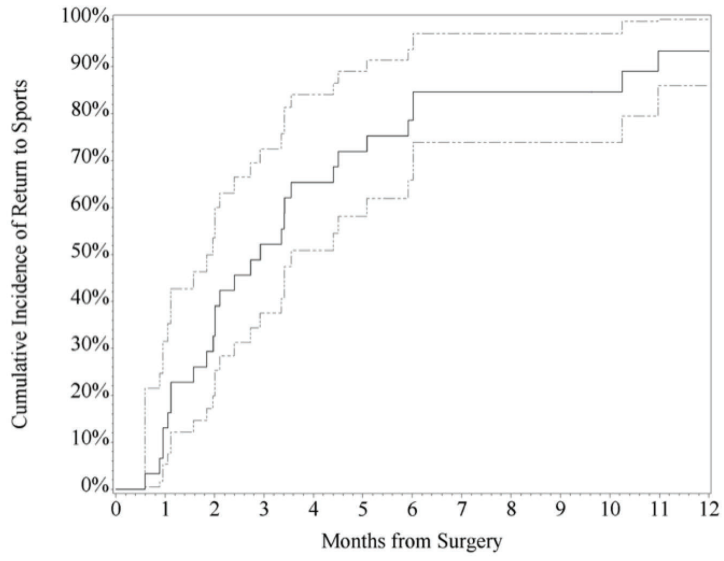
Methods: After IRB approval, 30 patients were consecutively enrolled from April 2018 to August 2019. Inclusion criteria included competition at a junior varsity level or greater for > 3 months yearly, diagnosis of AIS, major Cobb angle 40-75°, and age 10-18 years. Subjects completed preoperative sports performance and Patient Reported Outcomes Measurement Information System (PROMIS) physical activity (PA), pain interference (PI), and depressive symptoms (DS) questionnaires. At six weeks post-op all patients were cleared to return to sports without restrictions and completed the same self-assessments, which were repeated monthly until one year after PSF.

Results: Median follow-up was 12 months (range: 4-20). Median time to return to play among the 28/30 athletes who returned to their pre-surgery level of play or better was 2.6 months (range: 0.6 -11). At three months, 52.2% [95% CI: 37.6 to 72.5%], at six months 78.5% [95% CI: 65.9 to 93.6%], and at 12 months, 93.3% [95% CI: 86.0 to 100%] of athletes self-reported a return to pre-surgical level of play. Athletes in contact sports returned to play later than athletes in non-contact/limited contact sports [Hazard Ratio: 0.37, 95% CI: 0.15 to 0.90, p=0.0277]. There was a significant increase in physical function during the first 12 months following surgery [change in PA per 1 month increase in time: 0.81, CI: 0.39 to 0.1.23, p = 0.0002]. Similarly, there was a significant decrease in the odds of symptomatic pain interference during the first post-operative year [Odds Ratio per 1 month increase in time: 0.74, 95% CI: 0.57 to 0.95, p=0.0179]. There was no change in the odds of symptomatic depression scores across the post-operative period [OR per 1 month increase in time: 1.13, 95% CI: 0.98 to 1.31, p = 0.0884]. One athlete (1/30, 3.3%) developed a superficial infection. No athletes required a return to the operating room.

Conclusions: Adolescent athletes return to pre-surgical level of sports rapidly following PSF for AIS without any apparent associated complications during the first year post-op.

Significance: Early unrestricted return to sports should be permitted for adolescent athletes after PSF For AIS.

Cumulative Incidence of Return to Sports During the First Post-Operative Year



Discordant Lowest Instrumented Vertebra in Adolescent Idiopathic Scoliosis: When Coronal and Sagittal Parameters Conflict

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LOE-Prognostic-Level II

Purpose: Typically selection of lowest instrumented vertebra (LIV) in Adolescent Idiopathic Scoliosis (AIS) is based on the coronal radiograph. Fusion often extends to the last touched vertebrae (LTV). Increasing evidence suggests that fusions proximal the the stable sagittal vertebrae (SSV) on the lateral radiograph can result in distal junctional kyphosis (DJK). No studies have evaluated the situation when LTV and SSV are not the same. The purpose of this study is to compare patients with AIS that have a discordance between the LTV and the SSV. Additionally, we sought to identify risk factors for developing DJK.

Methods: A multi-center database of prospectively enrolled subjects was reviewed for patients with adolescent idiopathic scoliosis that had Lenke type 1, 2 and 3 curves treated with a selective thoracic posterior instrumented fusion. Patients were separated into two groups, I and II. Group I had a SSV that was proximal to the LTV whereas group II had an SSV that was distal to the LTV. Comparisons were made for patients that were fused to the SSV(a), LTV(b) or between(c). Distal junctional angle (DJA) >5° and increasing kyphosis at the end of the fusion construct were evaluated as risk factors for DJK. Spinopelvic parameters were evaluated as risk factors for the development of DJK.

Results: Group I included 293 patients and the rate of DJK was 0.0% in group Ia, Ib, and Ic. Group II included 205 patients and the rate of DJK was 4.3%, 18.5% and 10.0% in groups IIa, IIb and IIc, respectively (p<0.001). The rate of DJK was 22.9° when the DJA > 5° versus 1.4% when the DJA<5° (p<0.001). Patients who developed DJK had an average preoperative thoracic kyphosis of 40.4° compared with 30.7° in those who did not (p<0.001)

Conclusions: There was a low risk for progression of DJK when the SSV was proximal to the LTV however those with SSV distal to the LTV represent a high-risk group. Furthermore, having a distal junctional angle 5° or greater increased the risk of developing DJK by roughly 16-fold. An elevated preoperative thoracic kyphosis was identified as a risk factor for developing DJK as well.

Significance: These findings suggest that attention to be paid to patients with an SSV distal to the LTV, particularly if the plan is to fuse to the LTV. Careful consideration should be given when instrumenting patients with hyperkyphosis, particularly when ending the construct at a disc space with an increased distal junctional angle.

DJK in Discordant Subgroups

Group	No DJK	DJK	P-Value
1a: SSV above LTV fused to SSV	19 (100.0%)	0 (0.0%)	
1b: SSV above LTV fused to LTV	186 (100.0%)	0 (0.0%)	
1c: SSV above LTV fused between	88 (100.0%)	0 (0.0%)	
2a: SSV below LTV fused to SSV	67 (95.7%)	3 (4.3%)	
2b: SSV below LTV fused to LTV	53 (81.5%)	12 (18.5%)	
2c: SSV below LTV fused between	63 (90.0%)	7 (10.0%)	<0.001

Unplanned Return to the Operating Room (UPROR) after AIS Surgery

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LOE-Therapeutic-Level III

Purpose: UPROR is an inclusive metric for unexpected surgery after the index procedure and a central focus of each pre-operative informed consent discussion. Families ask “how many are ‘one and done’?”. Given the many quality and safety improvements in AIS surgery over the past 20 years, it is useful for spine deformity surgeons to understand the current rate of UPROR, the etiologies, and trends over time. A report from a very large data set, including multiple surgeons and centers, with longer follow-up, would provide the clearest picture.

Methods: A retrospective review of a prospective multi-center database was analyzed for patients with AIS deformity correction surgery. Preoperative, intraoperative, follow-up visit, and complication data was collected for all patients. Univariate linear regression models, survival analysis, and descriptive statistics were utilized to summarize UPROR findings.

Results: Among 3464 patients who had surgery (ASF, PSF, or ASF+PSF) for AIS from 1995-2017, 4.8% had an UPROR event in one of the following categories: surgical-site related (43.3%), instrument failures (34.3%), revisions (8.4%), neurologic (5.1%), pulmonary (5.1%), medical (0.6%), and “other” (3.4%). The most common reasons for UPROR in our cohort were infections (1.7%), instrument failures (1.7%), revisions (0.43%), and neurological injury (0.26%). The average time from initial surgery to UPROR was 734.4 days. 45.5% of UPRORs occurred within 1 year, 12.4% between 1-2 years, 30.9% between 2-5 years, and 11.2% between 5-10 years. In patients with at least 2 year, 5 year, and 10 year follow-up, the UPROR rates were 6.6%, 7.3%, and 9.2%, respectively. Figure 1A shows the survival plot for the group with at least 10 years of follow-up. Between 1997-2013, the overall UPROR rate decreased by 0.46% per year (95% CI: 0.25-0.68, $p < .001$) (Figure 1B), and the instrument failure rate decreased by 0.26% per year (95% CI: 0.02-0.49, $p = .03$).

Conclusions: UPROR rates are decreasing significantly over time. UPROR rates vary from 6.6% in the 2 year follow-up cohort to 9.2% in the 10 year follow-up cohort. UPROR likely rises with increased follow-up for several reasons: techniques have improved over the past decade, complications may take time to manifest, and patients with a problem are more likely to return for follow-up.

Significance: UPROR, an inclusive metric for unexpected surgery, has decreased over time, but increases with increased follow-up. The 10-year follow-up rate was 9.2%. 45.5% of UPRORs happen in the 1st year.

Figure 1A)

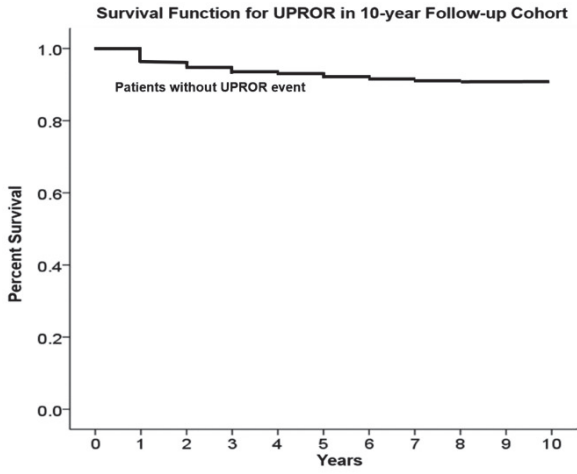


Figure 1B)

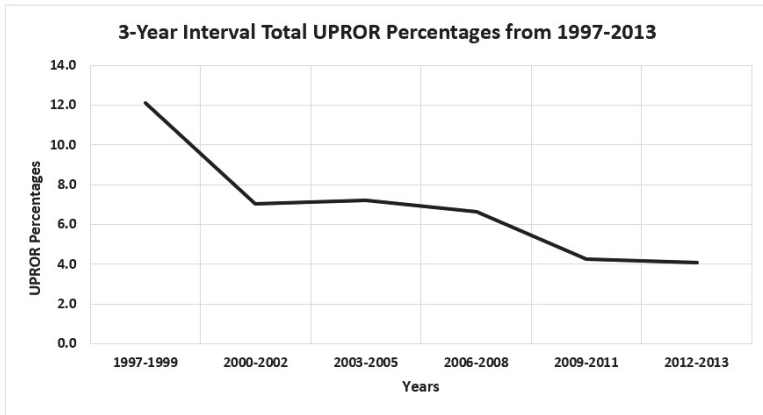


Figure: 1A. Kaplan Meier Curve for UPROR after AIS Spinal Fusion in the 10-year Follow-up Cohort. At the 10th year, 90.8% of patients have not had an UPROR. 1B. Total UPROR trend graph demonstrating a decrease of 0.46% per year (95% CI: 0.25-0.68, $p < .001$)

Complications Following Surgical Treatment of Adolescent Idiopathic Scoliosis: 10- year Prospective Follow-up Study

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LOE-Therapeutic-Level II

Purpose: Accurate reporting of long-term complications of surgical treatment of AIS is critical, but lacking. The purpose of this study is to report on the rate of complications following surgical treatment of AIS among patients with at least 10 years of follow-up.

Methods: This was a retrospective review of prospectively collected data from a multicenter registry of patients who underwent surgical treatment for AIS with minimum 10-year follow-up. A complication was defined as major if it resulted in reoperation, prolonged hospital stay, neurological injury, or was considered life-threatening. Rates and causes of re-operations were also reviewed.

Results: 284 patients were identified who had a mean age at surgery of 14.6. The mean follow up period was 10.6 years (9.5-14 years). The overall major complication rate was 12.3% (n= 35) in 30 patients. When analyzed by system, 23% (n=8) were SSI, 23% (n=8) were pulmonary, 17% (n=6) were adding-on, 11% (n=4) were malpositioned implants, 11% (n=4) were neurologic, 9% (n=3) pseudarthrosis, and 6% (n=2) gastrointestinal. When separated to looking at posterior spinal fusions (PSF) only, there were 24 complications in 19 patients for an overall major complication rate was 12.2%. When analyzed by system, 33% (n=8) were SSI, 21% (n=5) were adding-on, 17% (n=4) were malpositioned implants, 13% (n=3) were pulmonary, 8% (n=2) were neurologic, 4% (n=1) pseudarthrosis, and 4% (n=1) gastrointestinal. The re-operation rate was 6.7% (n=19) in 18 patients; 42% (n=8) for SSI, 32% (n=6) for adding on, 16% (n=3) for malpositioned implants, and 11% (n=2) for pseudarthrosis. When analyzed by those undergoing PSF only the re-operation rate was 8.6% (n=17) in 16 patients; 47% (n=8) for SSI, 29% (n=4) for adding on, 17% (n=3) for malpositioned implants, and 6% (n=1) for pseudoarthrosis. Complications presented throughout the post-operative period; SSI and adding on were seen even late into the 10-year period.

Conclusions: The overall rate of major complications following surgery for AIS is 12% and the overall rate of re-operations is 6%. It should be noted that long-term follow-up is critical as 35% of complications presented after the 2-year mark and 18% after the 5-year mark.

Significance: This is the largest study with at least 10-year follow up of complications and re-operations following spinal fusion for AIS. It is vital to have an accurate understanding of complication and re-operation profiles with patients and caregivers who are preparing for surgical intervention for AIS.

Table 1 Patient Characteristics	
Number of Cases	284
Age (years)	14.6 +/- 2.1
Follow-up period	10.6 (9.5-14)
Gender	
Female	238 (83.8%)
Male	46 (16.2%)
Surgical Approach	
Anterior	87 (30.6%)
Posterior	197 (69.4%)
Combined	13 (4.5%)
Instrumentation	
Anterior	87 (30.6%)
Posterior	
All Screw	82 (41.6%)
>80% Screw	90 (45.7%)
Hybrid	23 (11.7%)
All Hook	2 (1.0%)

Figure 1. Major Complications

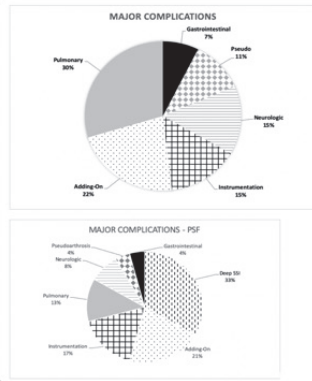
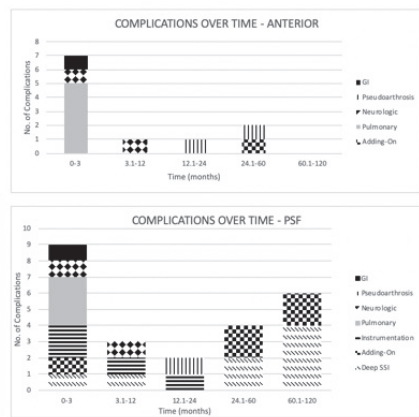


Figure 2. Causes of Re-Operations



Figure 3. Complications Over Time



Digital Skeletal Age and Curve Acceleration Phase in Male Adolescent Idiopathic Scoliosis

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LOE-Prognostic-Level III

Purpose: Understanding a patient’s individual risk of curve progression helps to guide treatment decisions in adolescent idiopathic scoliosis (AIS). Digital skeletal age (DSA) has been shown by Sanders et al. to closely correlate with curve acceleration phase (CAP) in female with AIS patients. Male AIS patients present at later chronological age and may have curve progression at more advanced stages of skeletal maturity. The purpose of this study is to assess the ability of DSA to predict CAP in comparison to other markers of skeletal maturity in male AIS patients.

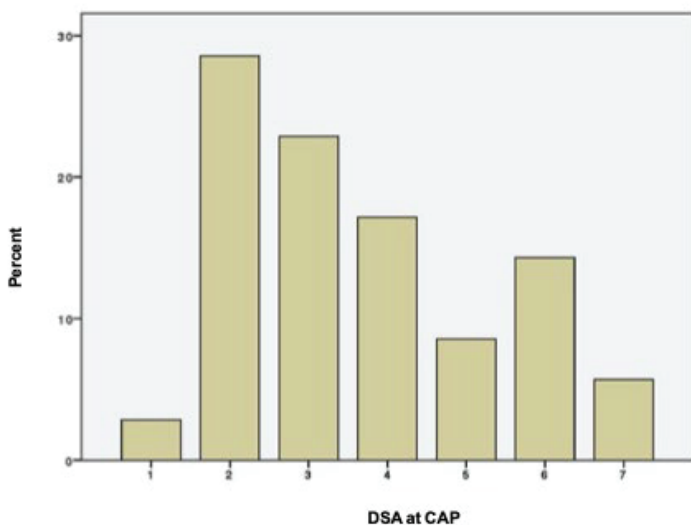
Methods: After IRB approval, a retrospective chart review of all male AIS patients at a single tertiary care institution between April 2006 and April 2017 was performed. Male AIS patients with open triradiate cartilage at presentation and minimum DSA stage of 7 at final follow up were included. Each patient had a minimum of four consecutive office visits at least 6 months separated. At each visit upright PA spine and left hand bone age radiographs were obtained. Change in curve magnitude over time was used to identify the CAP for each patient. Spearman’s rho was used to calculate correlation coefficients between CAP and the aforementioned variables. The Shapiro-Wilk test was used to assess the distribution of DSA at CAP.

Results: Twenty-six patients met inclusion criteria. Mean follow up time was 4.1 years with a mean of 8.2 clinic visits. The CAP began at mean chronological age of 13.7 years and mean DSA of 3.3. The correlation coefficient with CAP were: DSA (rs = 0.66), Risser stage (rs = 0.68), triradiate cartilage status (rs = 0.61), chronological age (rs = 0.67), and height (rs = 0.59). DSA at CAP did not correspond with a normal distribution (p < 0.01); a subset of patients had their CAP at late DSA stages (Figure 1).

Conclusions: DSA correlates with CAP in male patients with AIS, however, the strength of the correlation is not superior when compared to other maturity indices studied. Male AIS patients begin CAP at a comparatively broad range of DSA stages, including late stages such as 6 or 7. Monitoring for curve progression should continue through later stages of skeletal development for male AIS patients.

Significance: Curve acceleration phase in male AIS patients can occur even in late skeletal maturity stages. Monitoring for curve progression should continue through later stages of skeletal development for male AIS patients.

Figure 1. Distribution of digital skeletal age at curve acceleration phase.



Outcomes of Magnetically Controlled Growing Rods in Severe Early Onset Scoliosis

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LOE-Therapeutic-Level III

Purpose: Traditional growing rods (TGRs) are effective in controlling spinal deformity in early-onset scoliosis (EOS). However, repeated surgical lengthenings of TGRs expose patients to increased risk of complications. Magnetically controlled growing rods (MCGRs) allow outpatient based lengthenings and may reduce the risk of deep surgical site infection. In this study we compare MCGR and TGR in pediatric patients with severe ($\geq 90^\circ$) EOS. We hypothesize that MCGR and TGR instrumentations present with similar deformity correction and spinal growth, and MCGR to have a reduced rate of complications in patients with severe EOS.

Methods: This study was conducted as a retrospective review of prospectively collected international database. Inclusion criteria for the study were age less than 10 years at the time of surgery, diagnosis of EOS according to the definition of Scoliosis Research Society, minimum of two-year follow-up with at least three lengthenings, primary intervention using MCGR or TGR, and major curve of 90 degrees or more. Different lengths of follow-up between the groups were taken into account and analyzed using the Kaplan-Meier curves.

Results: The mean preoperative major curve was 102° in the MCGR (n=29) and 105° in the TGR group (n=28, p=0.204). This decreased to 52° and 62° after the index operation (p=0.009). At the final follow-up, the major curves were 52° and 63° , respectively (p=0.011). The annual thoracic height increase during the distraction period was 5.1 mm and 7.4 mm (p=0.295) and the annual spinal height increase was 8.9 mm and 9.7 mm (p=0.426), respectively. Instrumentation survival was analyzed using Kaplan-Meier estimator. Implant related complications (rod fracture, pullout, malfunction, migration) and deep surgical infections requiring revision surgery were considered as survival endpoints. Patients without revision surgery were considered as positive outcomes. There were statistically significantly less complications requiring revision in the MCGR group (p=0.0013). The 2 year survival rate was 79% (95%CI 68–93) in the MCGR and 55% (44–68) in the TGR group. The median survival time was 3.8 and 2.1 years respectively.

Conclusions: MCGR instrumentation provided similar deformity correction compared to the TGRs. Thoracic height improvement was slightly better in the TGR group. There were significantly fewer complications in the MCGR group. MCGR provides an effective and safe treatment option for children with severe EOS.

Significance: This study is a retrospective review of prospectively collected international database with largest patient sample so far.

	MCGR (n=29)	TGR (n=28)	P-value
Age at surgery (years)	7.1 (1.8 – 9.9)	5.6 (1.9 – 9.9)	0.007
Female	22 (76%)	16 (58%)	0.134
Etiology: Neuromuscular	18 (62%)	9 (32%)	0.024
Syndromic	3 (10%)	9 (32%)	0.044
Idiopathic	4 (14%)	6 (21%)	0.449
Congenital	4 (14%)	4 (14%)	0.957
Follow-up (years)	3.7 (2.2 – 5.6)	8.6 (2.3 – 15)	<0.005
Bilateral instrumentation	24 (83%)	19 (68%)	0.191
Major curve (°) Preoperative	102 (90 – 130)	105 (90 – 139)	0.204
Index	52 (21 – 85)	62 (34 – 94)	0.009
2-year follow-up	52 (22 – 98)	63 (23 – 103)	0.011
Thoracic height (mm), Preoperative	151 (84 – 202)	135 (80 – 203)	0.027
Index	185 (138 – 257)	170 (105 – 301)	0.082
2-year follow-up	195 (151 – 289)	186 (112 – 277)	0.185
Annual increase	5.1	7.4	0.295
Surgeries per year (range)	0.46 (0.21 – 1.1)	1.4 (0.51 – 2.7)	<0.005
Lengthenings per year (range)	2.8 (1.8 – 4.9)	0.75 (0.29 – 1.9)	<0.005
Unplanned surgeries per year (range)	0.09 (0 – 0.83)	0.09 (0 – 0.70)	0.486
Implant related complication	15	43	<0.005
Rod fracture	7	21	<0.005
Anchor pull out	4	11	0.029
Connector failure	0	3	0.070
Failure of distraction	1	0	0.322
Misplacement	3	8	0.081
Wound related	4	15	<0.005
Superficial infection	2	3	0.610
Deep wound infection	1	5	0.076
Dehiscence	1	7	0.019
New neurologic deficit (motor / other)	2 (0 / 2)	2 (1 / 2)	0.971

Early Outcomes of Magnetically Controlled Growing Rods (MCGRs), Posterior Final Fusion (PSF) and Vertebral Body Tethers (VBT) in Older Patients with Early Onset Scoliosis (EOS)

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LOE-Therapeutic-Level III

Purpose: MCGRs, PSF and VBTs control scoliosis curves in older EOS patients. While MCGRs and VBT allow for spinal growth and preserve motion, respectively, their outcomes compared to PSF have not yet been evaluated. This study compared outcomes of MCGRs and VBTs versus primary PSF in 8-11year old patients with idiopathic EOS.

Methods: 130 ambulatory idiopathic EOS patients from a multicenter registry, 81% female, aged 8-11 at index surgery (mean 10.5yrs) were included. Scoliosis curve, Kyphosis, T1-S1 length, complications and Quality of Life (QoL) were assessed pre-operatively and at most recent FU (mean 3.4yrs±1.5).

Results: 51 MCGR, 42 PSF and 37 VBT patients were included (Table1 Comparison of groups). Pre-operatively, VBT patients were older, had smaller curves and less kyphosis compared to PSF or MCGR patients ($p<0.005$). At FU, scoliosis curve decreased in all groups ($p<0.0005$), but curves were smaller in VBT and PSF compared to MCGR patients ($p<0.0005$). Kyphosis changed with VBT and PSF ($p\leq 0.005$) but was similar between groups at FU. Although pre-operative T1-S1 length was smaller in MCGRs compared to the other groups ($p=0.025$), it had increased in all groups by 5cm at last FU. 15 complications occurred in 10 VBT patients (27%), 9 in 6 PSF patients (13%), and 43 in 30 (59%) MCGR patients ($p<0.0001$; Table1). More MCGR patients experienced complications due to hardware compared to VBT and PSF patients ($p=0.023$). Complications that required planned revision surgery occurred in 6 VBT and 15 MCGR patients, but not in PSF patients ($p<0.0005$). Unplanned revisions were required in 6 VBT, 3 PSF and 10 MCGR patients ($p=0.227$). Regression analysis adjusted for age, gender, and pre-operative scoliosis curve revealed that MCGR patients had 5.59 times higher risk of an unplanned revision than PSF patients (MCGR: HR=5.59, 95%CI: 1.10-28.43, $p=0.038$; VBT: HR=2.99, 95%CI: 0.82-24.54, $p=0.084$; PSF reference). At recent FU, 16 MCGR had definitive fusions and 2 VBTs required fusion. QoL improved for VBT patients in the domains of Pain/Discomfort, Emotion and Parental Impact and for PSF patients in Parental Impact ($p<0.05$). QOL did not improve for MCGR patients.

Conclusions: MCGRs, PSF and VBTs control curves effectively and increase spinal height in EOS patients. PSF had significantly less unplanned revisions compared to MCGR. Fewer VBT and PSF patients required revisions and both techniques resulted in improved QOL.

Significance: In ambulatory older idiopathic EOS patients, MCGR, PSF and VBT are appropriate options to control scoliosis. PSF reduced the risk of unplanned revisions compared to MCGRs.

Table 1 Demographic and Radiographic Parameters of 130 idiopathic EOS Patients

Demographics	VBT N=37	MCGR N=51	PSF N=42	p-value
Female, n (%)	36 (97%)	35 (69%)	34 (81%)	0.002
Age, median (IQR)	11.3 (10.9, 11.8)	9.6 (8.8, 10.2)	10.9 (10.3, 11.5)	<0.005
Follow-Up, median (IQR)	3.0 (2.1, 3.6)	2.9 (2.4, 3.9)	3.6 (2.2, 5.1)	0.052
BMI % for age pre-op, median (IQR)	45 (16.5, 69.5)	45 (27, 76)	64.5 (20, 91)	0.312
BMI % for age post-op, median (IQR)	59 (35, 82)	57 (17.5, 76.5)	68.5 (36, 88)	0.503
Scoliosis curve				
Major Scoliosis angle pre-op (°), median (IQR)	50 (43.5, 58)	64.5 (55, 75)	63 (57, 72)	<0.0005
Major Scoliosis angle post-op (°), median (IQR)	27 (21, 32)	40 (31, 50.5)	29 (22, 36)	<0.0005
Major scoliosis angle pre- vs. post-op within Surgery group, p-value	<0.0005	<0.0005	<0.0005	
Δ Scoliosis angle pre to post (°), mean ± SD	41.1 ±22.4	28.7 ±24.4	52.2 ±19.9	<0.0005
Kyphosis (maximum)				
Kyphosis pre-op (°), median (IQR)	26 (20.5, 32)	39 (33, 49)	49 (34, 60)	<0.0005
Kyphosis post-op (°), median (IQR)	40 (29, 50)	37.6 (25.5, 52)	47 (35.0, 64.0)	0.366
Kyphosis pre-op vs. post-op within Surgery group, p-value	0.005	0.420	<0.0005	
Δ Kyphosis pre to post (°), mean ± SD	8.6 ±15.9	-2.0 ±22.8	-13.6 ±17.0	<0.0005
Spinal height (T1-S1)				
T1-S1 pre-op (cm), median (IQR)	34.2 (31.8, 35.6)	31.5 (29.7, 35.7)	35.4 (32.6, 37.3)	0.025
T1-S1 post-op (cm), median (IQR)	39.6 (36.8, 40.7)	35.9 (33.8, 39.5)	36.9.8 (36.9, 43)	0.003
T1-S1 pre-op vs. post-op within Surgery group, p-value	<0.0005	<0.0005	<0.0005	
Δ T1-S1 pre to post-op (cm), mean ± SD	5.0 ±2.0	5.0 ±5.0	5.8 ±6.8	0.827
Complications				
Complications, n (%)	10 (27)	30 (58.8)	6 (13)	<.0001
Minor complications, n (%)	4 (10.8)	9 (17.6)	2 (4.8)	0.151
Planned Surgeries, n (%)	3 (8.1)	15 (29.4)	0	<0.0005
Unplanned Surgeries, n (%)	6 (16.2)	10 (19.6)	3 (7.1)	0.227
Hardware Issue	5 (13.5)	10 (19.6)	1 (2.4)	0.023
n=number of patients; IQR: interquartile range				
Statistics: Fisher's exact test, Kruskal Wallis test or Anova				

Half of Magnetic Controlled Growing Rods (MCGR) “stall”3 years after implantation

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LOE-Therapeutic-Level IV

Purpose: Since 2014, the surgical correction of Early Onset Scoliosis (EOS) has been dominated by one specific implant, the Magnetically Controlled Growing Rod (MCGR). The MCGR has many known advantages over Traditional Growing Rods (TGR) and Vertical Expandable Prosthetic Titanium Rib (VEPTR). However, in time, issues with the MCGR failing to lengthen or obtain its intended length (aka: stalling) has arisen. We sought to quantify our institution's MCGR stall rate.

Methods: This is a single institution's retrospective review of consecutive prospective data included MCGR patients who had undergone least one lengthening. Age at placement, preop cobb, preop diagnosis, lengthening duration, and total attempted lengthenings were analyzed.

Results: 10 syndromic, 12 congenital, 16 idiopathic, 19 neuromuscular EOS patients were included (n=57). 6 were converted from TGR to MCGR (mean 6.8yrs) while 51 had index placement of MCGR (mean 6.5yrs). Mean preop cobb was 79° (47°-128°) in the 51 patients. 27/57 (47%) had suspected/definite rod stalling while 30/57 (53%) had no indication of stalling. Patients with stalling had been treated longer (3.3 vs 2.3 yr, p=.003) with more attempted lengthenings (9.3 vs 6.5 attempts, p=.009). There were no differences between age at insertion (6.4 vs 6.6 yr, p=.7), preop cobb (81° vs 77°, p=.7), or underlying diagnosis (50%, 50%, 47%, 40%). 11/57 (19%) had their MGR removed. 8 of those patients went on to definitive fusion, 2 patients were converted to TGR, and 1 patient had a new MCGR placed.

Conclusions: Half (27/57) 47% of MCGR “stall” after an average of 9 attempted lengthenings and by an average of 3.3 years post implantation.

Significance: This information should be used by the provider to educate MCGR patients and families to help set realistic expectations in regards to expected duration of the implant viability. Half of MCGR “stall” after an average of 9 attempted lengthenings and by an average of 3.3 years post implantation.

Matched Comparison of Growing Rods versus Primary Posterior Spinal Fusion in “Tweeners” with Early Onset Scoliosis

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LOE-Therapeutic-Level III

Purpose: In 7 to 11-year-old “tweeners” with early onset scoliosis (EOS) in whom bracing fails, the optimal surgical option remains uncertain. Growing rods (GRs) minimize progression while allowing further growth but are fraught with numerous, often severe complications. Primary PSF prevents spinal growth, potentially limiting thoracic cavity growth. This study compares GRs followed by definitive PSF versus primary PSF in this population. We hypothesized that the increased thoracic height afforded by GRs would be offset by increased rigidity (decreased deformity correction), more complications, and more total operations.

Methods: This retrospective comparative study included EOS patients aged 7.0-11.9 years at index surgery treated with GR→PSF or primary PSF between 2013 and 2020. Primary outcomes were thoracic height (T1-12H) and coronal deformity (Cobb angle). Secondary outcomes included other measures of spinal length and deformity, complications, and total operations. Primary PSFs were manually matched with replacement 1:n to GR→PSFs by age at index, etiology, and Cobb angle. Data were analyzed using a linear mixed effects model.

Results: Twenty-eight GR→PSFs met criteria, including 19 magnetically controlled GRs (MCGRs) and 9 traditional GRs (TGRs). Three MCGRs were definitively explanted without PSF due to complications. The remaining 25 GR→PSFs were matched to 17 primary PSFs with 100% etiology match, mean Δ Cobb of 1°, and mean Δ age at index of 0.5 years (PSFs older). Median Δ T1-12H pre-GR to post-PSF was 4.7 cm with median deformity correction of 37%. Median Δ T1-12H among primary PSFs was 1.9 cm with median deformity correction of 62%. GR→PSFs had median 2 complications and 2 operations. Primary PSFs had median 0 complications and 1 operation. Matched analysis showed adjusted mean differences of 2.3 cm greater Δ T1-12H among GR→PSFs than their matched primary PSFs, with 25% less overall coronal deformity correction, 1.2 additional complications, and 2.2 additional operations per patient. There was a trend towards decreasing benefit of GRs over primary PSF as pre-index age and Cobb angle increased. Subgroup analysis showed similar outcomes from MCGRs and TGRs.

Conclusions: In “tweeners” aged 7 to 11 with EOS, GRs afford ~2 cm of thoracic height over primary PSF at the cost of 25% loss of deformity correction and an additional 1 complication and 2 operations per patient.

Significance: GRs remain a viable option for severe EOS in very young patients. However, in “tweeners” the height gained may not warrant the iatrogenic stiffness, complications, and additional operations. Surgeons and families should weigh these concerns when choosing a treatment plan.

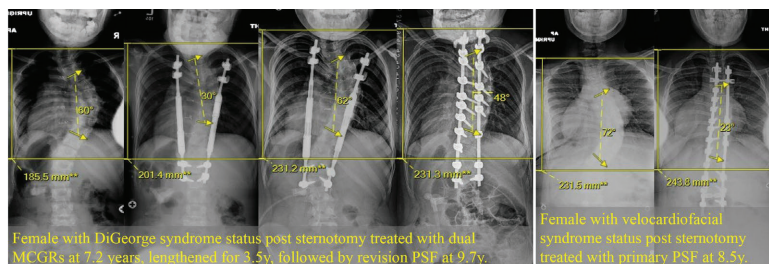


Figure 1. Matched pair with characteristic outcomes. GRs afforded ~3cm of additional thoracic height (4.4 vs 1.3 cm) at the cost of 48% worse deformity correction (20% vs 68% correction). Overall change in coronal balance was ≤ 1 cm in both patients.

Vertebral Body Tethering Compared to the Spinal Fusion Gold Standard: A Matched Analysis 2 Years Post-Operatively

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LOE-Therapeutic-Level II

Purpose: VBT is a motion-sparing alternative to the gold standard spinal arthrodesis for correction of AIS. There is a paucity of data comparing outcomes of VBT with the gold standard PSF. We planned to compare outcomes of the two procedures.

Methods: 50 consecutive AIS patients treated by a single surgeon with VBT or PSF were matched by Lenke type, major curve $\pm 8^\circ$, age ± 1 year, and T5-T12 kyphosis $\pm 10^\circ$. Radiographic, clinical, and SRS-22 outcomes were assessed pre-operatively, at first postoperative visit and 2-year follow up. Continuous variables were compared using student t-tests and categorical variables were compared using chi-square.

Results: Patients in each group had similar baseline characteristics (Table). In the VBT group there were 6 thoracic (T) tethers, 7 thoracolumbar (TL), and 12 both. The VBT group had 12 patients whose major and minor curves were instrumented and the PSF group had 8 ($p=0.2482$). In the VBT group, 10 patients had minor non-structural curves instrumented and the PSF group had 5. Major curve correction was similar overall ($p=0.0506$), however, TL major curve correction was greater for VBT than PSF ($p=0.0172$). 3-D kyphosis restoration was greater for VBT. Overall minor curve correction was comparable ($p=0.2417$); but, T minor curve correction was greater in VBT ($p=0.0463$), 5/9 had T curve instrumented vs. 3/9 in PSF. There was no difference in T inclinometer improvement ($p=0.7440$), but TL inclinometer improvement was greater in PSF ($p=0.0296$) (Figure 1). Operative time (223.5 PSF vs. 191.8 VBT) and number of levels instrumented (8.6 PSF vs. 7.4 VBT) did not differ ($p=0.0992$ and $p=0.1248$ respectively). VBT had less EBL than PSF (173.0 ± 83.8 vs. 1068.0 ± 740.3 , respectively [$p<0.0001$]). The VBT group had 3 patients who underwent thoracoplasty and the PSF group had 0. SRS-22 outcomes in all domains were similar at final FU ($p>0.05$). PSF had 2 major complications (1 misplaced screw requiring reoperation; 1 wound infection) and 3 VBT patients had cord breakage with no regional loss of correction at 2 years post-operatively.

Conclusions: VBT and PSF patients can expect comparable curve correction at 2 YR FU. No differences in SRS-22 outcomes were found. 2 major complications occurred in the PSF group and there were 3 VBT cord breakages without significant loss of correction.

Significance: Patients who undergo VBT can expect comparable curve correction, clinical outcomes and improved kyphosis restoration to those who undergo PSF without increased complications.

Table. PSF and VBT radiographic and clinical outcomes.

Demographics						
Age						
PSF	13.7±1.1					
VBT	13.8±1.1					
Gender						
PSF	21 F 4 M					
VBT	21 F 4 M					
Lenke Curve Type Per Group						
Lenke 1	14					
Lenke 3	1					
Lenke 5	9					
Lenke 6	1					
	Baseline	P-Value	1 st Erect	P-Value	2 YR FU	P-Value
Major Curve						
PSF	50.8±5.7	0.7253	20.7±8.0 (59.3±16.3%)	0.5136	24.1±6.4 (56.5±17.5%)	0.0506
VBT	50.2±7.0		18.9±10.7 (63.4±19.2%)		18.8±11.2 (63.1±21.2%)	
Thoracic Major Curve						
PSF	52.4±6.1	0.8662	18.4±6.0	0.1446	22.9±6.7	0.5042
VBT	51.9±7.2		22.9±9.7		20.4±11.8	
Thoracolumbar Major Curve						
PSF	48.9±4.7	0.4513	23.6±9.5	0.0110	26.1±5.9	0.0172
VBT	47.1±5.8		11.9±8.8		15.8±10.1	
Minor Curve						
PSF	37.4±8.3	0.3301	20.6±10.4	0.1894	20.32±10.7	0.2417
VBT	40.0±9.5		16.3±12.0		16.4±12.6	
Thoracic Minor Curve						
PSF	38.4±7.2	0.8914	25.5±10.8	0.1164	25.7±10.6	0.0463
VBT	37.8±11.6		18.0±7.9		16.0±9.4	
Thoracolumbar Minor Curve						
PSF	36.6±9.4	0.1733	16.8±8.6	0.7656	16.1±8.9	0.9019
VBT	41.3±8.2		15.5±13.8		16.6±14.4	
3-D T5-T12 Kyphosis						
PSF	7.6±10.1	0.9288	-	-	20.9±8.2	0.0199
VBT	7.3±11.4		-		27.7±11.4	
Thoracic Inclinator Measurements						
PSF	13.4±5.6	0.9806	-	-	5.9±2.9	0.7440
VBT	13.3±4.3		-		6.4±3.7	
Thoracolumbar Inclinator Measurements						
PSF	14.4±5.7	0.8581	-	-	3.0±2.1	0.0296
VBT	14.9±7.3		-		6.0±3.3	

Does Body Mass Index Affect Outcomes after Vertebral Body Tethering Surgery?

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LOE-Prognostic-Level III

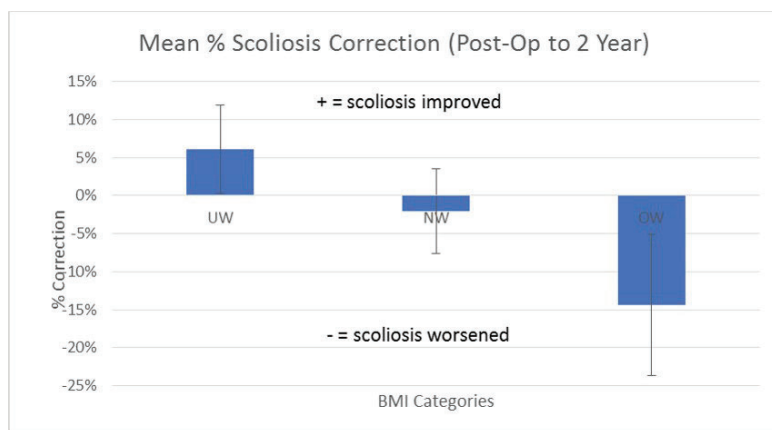
Purpose: To determine the effect of body weight and BMI on curve correction and on risk of post-operative complications after Vertebral Body Tethering (VBT) surgery.

Methods: BMI in children has been defined as: Underweight (<5thile for age), normal (5- 85%ile), and overweight (>85%ile). This was a retrospective review of prospectively collected study group data. AIS/JIS patients with VBT with 2 yr f/u from a multi-center EOS database were evaluated pre-op, 1 st erect, and 2 yr post-op. ANOVA was used to compare the 3 categories of BMI with significance as per Tukey-Kramer HSD post hoc test. Risk of scoliosis progression was analysed with Mid-P exact test

Results: 121 patients (51 underweight, 58 normal, 12 overweight; mean age 12.5 ±1.6 yr; BMI 18.8 ±4.6) were identified. After VBT, scoliosis improved over time (51 o pre-op, 29o 1 st Erect, 28o 2 yr post-op; p<0.05). Comparing underweight, normal, and overweight groups: Mean preop age (13 yr, 13 yr, 12 yr), pre-op scoliosis (52o , 50o , 52o), pre-op kyphosis (29o , 28o , 33o), periop scoliosis correction (44%, 42%, 46%), and complications by 2 yr f/u (23%, 24%, 17%) were similar between groups. There was one broken tether in each of the underweight and normal weight groups. Change in scoliosis % correction from 1st erect to 2 yr post-op was not significantly different between groups (Fig 1); however, risk ratio for scoliosis progression during this period was 4.74 (1.02- 22.02; p=0.04) for overweight patients.

Conclusions: Overweight patients treated with VBT had similar peri-op scoliosis correction and similar risk of complication as compared to underweight and normal weight patients. As compared to other patients, overweight patients had a risk ratio of 4.7 for progression of scoliosis during the first two years post-op

Significance: For overweight patients with idiopathic scoliosis, VBT does not appear to be effective as a means of further correcting scoliosis between 1st Erect and 2 years post-operative



The effect of scoliosis on audio-visual and socio-emotional processing and the use of adaptive communicative equipment in children with severely involved cerebral palsy

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LOE-Therapeutic-Level II

Purpose: Children severely affected by cerebral palsy (CP) often develop scoliosis. Many are non-verbal, unable to communicate their needs or demonstrate interaction with their surroundings. Non-invasive event-related potentials (ERPs) can assess cognitive and neural processing in children who cannot communicate and changes how children view their surroundings. Our objective was to determine if changing a child’s postural control through spine fusion would improve body and brain function in social-emotional interactions and facilitate use of assistive communication devices.

Methods: Prospective case-control study of children (9-18 years) with GMFCS IV/V CP. We collected baseline audio-visual and socio-emotional ERP with an electroencephalogram (EEG), adaptive communication and postural assessments, and CPCHILD scores at baseline, 6 months and 1 year. For brain-based measures, we performed ANCOVA analyses to determine effect size of the intervention at 1 year, controlling for baseline EEG measures. Similar analyses examined behaviorally-based assessments.

Results: Of 24 subjects included, 8 underwent spine surgery and 16 matched controls did not. At one year post spine surgery, there was an increased level of sitting balance seen in all domains, while the control group lost balance (p<0.05). The quality of eye gaze calibration improved (p<0.05) in the surgical group (29-52%), but not in the controls (39-39%) . For the ERP, children had more usable trials after fusion, and three controls lost the ability to participate (p=0.02). Overall, there was a significant effect of the surgery on both brain-based recognition of human face (social-emotional measure) and of matched picture-word vs non-matched sets (receptive language) at one year, that was NOT explained by time alone. (Table 1) CPCHILD scores increased for the fusion group compared with the controls(p<0.05) in total score (10.8 vs 0.6), personal care/ADLs (14.3 vs -0.9), positioning/transfers and mobility (20.9 vs -7), and communication and social interaction (14.9 vs 3.6).

Conclusions: Children with GMFCS IV/V CP after spine fusion have improved sitting balance, eye gaze, ability to use a communication device, receptive language, socioemotional processing, and health-related quality of life (HRQoL) compared to a matched group of children during the same time period.

Significance: Children with GMFCS IV/V CP undergoing spine surgery have postural changes associated with neuroplastic brain changes characteristic of improved social interactions, language learning, use of eye gaze devices, independent sitting balance, and HRQoL. This is the first to demonstrate both body and brain systems changes after spine fusion in children with CP.

ERP Paradigm	6 month (adjusted R-squared; ANCOVA p value)	1 year (adjusted R-squared; ANCOVA p value)
Human Face Recognition	0.100; p=0.491	0.277; p<0.001
Picture-Word Matching	0.334; p=0.007	0.144; p<0.001

Definitive Fusions are Better than Growth Friendly Procedures for Juvenile Patients with Cerebral Palsy and Scoliosis: A Prospective Comparative Cohort Study

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LOE-Therapeutic-Level II

Purpose: In juvenile patients with CP and scoliosis, there is controversy regarding surgical treatment with posterior fusion (PSF) versus allowing for potential truncal growth with growing rod (GR) constructs. This study compared the outcomes of juvenile CP patients with scoliosis who underwent PSF versus GR.

Methods: Two prospective registries were queried for patients 8-10yrs old with minimum 2yrs follow-up who underwent PSF or GR surgery. Demographics, radiographs, complications and outcomes scores were recorded.

Results: There were 41 patients in the PSF group and 15 in the GR group. The mean age at initial surgery was 10 yrs (8.1-10.9) and 9.3 yrs (8-10.9) in the PSF and GR groups, respectively ($p=0.01$). In the PSF group, the mean preop curve was 86° (50-144) and 80° (30-133) in the GR group ($p=0.20$). “Definitive” surgery in the GR group consisted of PSF in 10, implant retention in 3, and implant removal in 2. At 2 yr follow-up, the PSF group had 62% curve correction and the GR group had 40% correction following “definitive” surgery ($p=0.04$). In the PSF group, 27% had complications ($n=11$) and in the GR group, 73% had complications ($n=11$) ($p=0.02$) (see Table). In the PSF group, 2 patients had re-ops for infection while 8 patients in the GR group had re-ops for infection and implant complications ($p<0.01$). In the PSF group, 26/35 parents (75%) noted that the child’s life “improved a lot”. In the GR group, 3/7 parents (43%) noted they were “neutral” about their child’s ability to do things and 3/7 (43%) were “very dissatisfied”.

Conclusions: Our study shows that PSF in juvenile CP patients with scoliosis results in fewer complications and reoperations and better radiographic outcomes compared to GR. Quality of life improvements were better in the PSF group.

Significance: In this prospective comparative cohort study of PSF versus growth friendly surgery with minimum 2 year follow up from “definitive” surgery for juvenile CP scoliosis, we have shown that radiographic results were better in the PSF group and the complication rate and number of unplanned reoperations were higher in the GR group. Caregiver reported outcomes also rated PSF surgery with greater satisfaction.

PSF Complications	Rate (n)
Infection	7% (n=3)
Respiratory	17% (n=7)
GI	7% (n=3)
Medical	2% (n=1)

GR Complications	Rate (n)
Infection	46% (n=7)
Hardware	13% (n=2)
PJK	13% (n=2)
Respiratory	20% (n=3)
Decubitus Ulcer	13% (n=2)

Functional Outcomes of Spinal Orthoses in Spinal Muscular Atrophy

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LOE-Therapeutic-Level III

Purpose: Spinal Muscular Atrophy (SMA) is a neuromuscular disorder characterized by atrophy and weakness of the skeletal muscles of the limbs and trunk, often leading to scoliosis development. The Hammersmith Functional Motor Scale-Expanded (HFMSSE) is a validated tool shown to correlate with established measures of function and strength in patients with SMA type 2 and 3. Understanding the effects that bracing therapy has on preventing functional decline in patients with SMA can help clarify the potential benefits of nonoperative therapy.

Methods: A retrospective review of all patients with SMA treated at an urban tertiary care institution was performed to identify patients with at least two recorded HFMSSE assessments by trained clinical evaluators. Patients treated with Thoracic Lumbar Sacral Orthosis (TLSO) bracing with HFMSSE scores before and after initiation of bracing were compared to patients without bracing treatment. Change in HFMSSE was defined as the difference between the first recorded HFMSSE score and the score at most recent follow up.

Results: 29 patients were included with an average age of 4.6 ± 3.4 years at first HFMSSE assessment. There were 9 patients treated with TLSO bracing with an average brace initiation age of 7.2 ± 3.8 years. There were no differences between the bracing and non-bracing cohorts in regard to baseline characteristics including initial age ($p=0.849$), gender ($p=0.978$), SMA type ($p=0.599$), or baseline HFMSSE score ($p=0.639$). Additionally, no differences in the proportion of patients treated with Nusinersen ($p=0.548$) or the total time of follow up ($p=0.177$) were observed between treatment groups. Patients treated with bracing experienced less decline in functional motor skills as measured by the HFMSSE compared to patients not braced (0.1 ± 2.8 vs -7.15 ± 14.5 , $p=0.043$).

Conclusions: Traditionally, scoliosis bracing has been thought of as a method for preventing progression of spinal deformity. However, here we demonstrate that despite comparable baseline characteristics, SMA patients treated with bracing for scoliosis experienced a slower decline in functional status than those not treated with bracing. This may be the result of improved postural stability.

Significance: The use of bracing for scoliosis in children with Spinal Muscular Atrophy can be a useful non-operative therapy for preserving functional motor skills and strength.

Table 1. Demographic and functional information for patients with spinal muscular atrophy treated with bracing versus non-bracing

	Bracing (n=9)	Non-Bracing (n=20)	p-value
Age of First HFMSSE (years)	4.4 \pm 3.6	4.7 \pm 3.4	0.849
Time of Follow Up	5.8 \pm 3.0	7.3 \pm 2.3	0.177
Gender Distribution			0.978
Male	4 (44.4)	9 (45.0)	
Female	5 (55.6)	11 (55.0)	
SMA Type			0.599
Type 2	5 (55.6)	9 (45.0)	
Type 3	4 (44.4)	11 (55.0)	
Nusinersen Treatment	8 (88.9)	19 (95.0)	0.548
Initial HFMSSE Score	24.2 \pm 24.4	28.6 \pm 22.3	0.639
Change in HFMSSE	0.1 \pm 2.8	-7.15 \pm 14.5	0.043

All values shown as number (%) or average \pm standard deviation

Compared to Repair or No Treatment, Medial patellofemoral Ligament Reconstruction Results in Increased Stability in Adolescents with Acute First-time Patellar Dislocation with an Associated Loose Body

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LOE-Therapeutic-Level II

Purpose: The management of acute first-time patellar dislocations with a loose body remains a debated topic. To our knowledge, a prospective evaluation of medial patellofemoral ligament (MPFL) reconstruction for adolescents with acute first-time patellar dislocation with an associated chondral or osteochondral loose body has not been previously performed. The purpose of this study was to analyze patients with a patellar dislocation requiring surgery for a loose body, and to compare those who underwent MPFL repair or no treatment versus those that underwent reconstruction at the time of surgery. The hypothesis was that performing MPFL reconstruction would reduce the rate of recurrent instability and improve patient reported outcomes when compared to MPFL repair or no treatment.

Methods: This was a prospective analysis of adolescents treated with MPFL reconstruction for acute first-time patellar dislocation with associated loose bodies between 2015 and 2017 at a single pediatric level 1 trauma center with minimum 2-year follow up. Retrospective analysis was previously performed for a similar cohort of adolescents treated with MPFL repair or no treatment. Patient demographic data, radiographic measurements, and surgical variables were compared. Primary outcome measures included recurrent subluxation or dislocation and the need for further stabilization procedures. Secondary outcomes included Kujala score, SANE score, patient satisfaction, and ability to return to sport.

Results: Seventy-six patients were included, 30 in the MPFL reconstruction cohort and 46 in the MPFL repair or no treatment cohort. The only difference noted in demographic, radiographic, or surgical variables was a smaller Insall-Salvati ratio in the reconstruction group compared to the neglect/repair group (1.29 versus 1.42; $p = .011$). Compared to MPFL repair or no treatment, MPFL reconstruction was associated with less recurrent instability (10.0% versus 58.7%; $p < .001$), fewer secondary procedures (6.7% versus 47.8%; $p < .001$), and more frequent return to sports (66.7% versus 39.1%; $p = .003$). No differences in patient reported outcomes were noted.

Conclusions: Performing concomitant MPFL reconstruction in adolescents with first-time patellar dislocation and an intra-articular loose body results in a five-fold reduction in recurrent instability, reduces the need for subsequent surgery, and improves patients' ability to return to sports compared to repairing or not treating the MPFL.

Significance: Reconstructing the MPFL (as opposed to repair or neglect) should be strongly considered when a patient requires surgical intervention for a loose body after a first time dislocation.

Isolated MPFL Reconstruction vs. Tibial Tubercle Osteotomy Plus Medial Retinacular Plication for Recurrent Patellar Instability: A Matched, Cohort Analysis

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LOE-Economic-Level III

Purpose: The combined proximal/distal realignment technique of tibial tubercle osteotomy (TTO) and proximal medial retinacular plication/reefing/advancement/repair (MRP) represents one of the most commonly utilized techniques to address recurrent patellofemoral instability (PFI). Rising interest in the medial patellofemoral ligament reconstruction (MPFLR) over the last decade has prompted debate over the optimal technique to treat PFI. The purpose of this study was to compare rates of recurrent PFI and revision PFI surgery between comparable cohorts who underwent TTO+MRP vs. MPFLR.

Methods: A large, single-center PFI database of 492 patients (556 knees) who underwent a variety of stabilization procedures by one of 5 different surgeons was used to identify 114 MPFLR patients, who were similar to 109 TTO+MRP patients, in terms of on age, gender, BMI, and TT-TG distance. Propensity score matching then utilized logistic regression models to produce 1:1 matching, and a caliper of 0.2 standard deviations of the estimated propensity score was used for the nearest-neighbor matching algorithm. This process yielded 84 MPFLR and 84 TTO+MRP patients, who were comparable based on the 4 matching criteria. The cohorts were compared on demographic and radiologic characteristics, as well as post-operative clinical results, with a mean clinical follow up time of 2.6 and 3.0 years ($p=0.009$), respectively.

Results: Demographic and radiologic comparisons of the cohorts are shown in Table 1, with the only difference between groups being an expectedly higher rate of open physes in the MPFLR cohort, despite no significant difference in age. The two groups had comparable rates of return to sports. Despite having shorter follow-up times, the MPFLR group had a higher rate of recurrent instability, though not to a significant degree, and significantly more revision patellar stabilization surgeries ($p<0.001$). The TTO+MRP group had a higher rate of subsequent non-PFI knee surgeries, the majority of which were implant removal for TTO screws performed by a single surgeon, who also used a washer.

Conclusions: In the current comparison of cohorts matched based on common surgical selection criteria, TTO+MRP shows equivalent or superior results to isolated MPFLR, in terms of maintaining patellar stability and avoiding revision stabilization. While implant removal may be common with TTO, this may be somewhat technique or surgeon-dependent.

Significance: In the current landscape of increasing interest and utilization of isolated MPFLR as an all-encompassing PFI surgery, the influence of distal bony realignment procedures to minimize recurrent PFI should not be underappreciated.

Table 1. Clinical Summary (N=168).

Characteristic	MPFLR (n=84)		TTO (n=84)		P
	Freq	(%)/sd/IQR	Freq	(%)/sd/IQR	
Age (years)	15.8	± 2.5	16.1	± 2.5	0.48
BMI (kg/m ²)	22.0	± 3.4	22.1	± 3.3	0.80
Sex (% male)	23	(27%)	22	(26%)	1.00
Athlete (yes, n=165)	76	(94%)	72	(86%)	0.15
Laterality (% right)	35	(42%)	46	(55%)	0.12
Mechanism of injury (n=112)					0.67
Contact (direct blow)	9	(15%)	10	(20%)	
Non-contact (twisting)	52	(85%)	41	(80%)	
TT-TG (mm)	16.8	± 4.0	16.9	± 4.8	0.85
Sulcus angle (degrees)	161.2	± 10.2	160.6	± 9.7	0.70
Patella inclination angle (degrees)	25.4	± 10.3	26.3	± 10.0	0.61
Caton-Deschamps index	1.3	(21%)	1.2	(18%)	0.57
Dejour classification					0.30
A	23	(27%)	33	(39%)	
B	24	(29%)	24	(29%)	
C	23	(27%)	14	(17%)	
D	5	(6%)	7	(8%)	
No dysplasia	9	(11%)	6	(7%)	
Patella dysplasia (Wiberg)					0.23
A	11	(13%)	8	(10%)	
B	54	(64%)	64	(76%)	
C	19	(23%)	12	(14%)	
Physcal status					<0.001
Open	39	(46%)	17	(20%)	
Closing	20	(24%)	40	(48%)	
Closed	25	(30%)	27	(32%)	
Follow-up time (years)	2.6	(1.0 - 3.9)	3.0	(1.5 - 5.8)	0.009
Return to sport (yes)	66	(90%)	67	(91%)	0.98
Return to sport time (months)	4.9	(3.6 - 6.7)	5.7	(4.1 - 7.5)	0.41
Recurrent instability (any type)	14	(17%)	8	(10%)	0.18
Dislocation	6	(7%)	4	(5%)	0.72
Subluxation	6	(7%)	1	(1%)	0.19
Subjective instability	2	(2%)	3	(4%)	0.31
Revision patellar stabilization surgery*	8	(10%)	0	(0%)	<0.001
'Other' secondary ipsilateral knee surgery#	2	(2%)	27	(32%)	<0.001
Removal of hardware			24	(89%)	

*Revision PFI surgery included either MPFLR + TTO (4), TTO (2), revision MPFLR (1), or MRP alone (1)

#Other procedures in the MPFLR cohort included an open foreign body removal for a painful subcutaneous suture/knot and an arthroscopic loose body removal. Other procedures in the TTO cohort included an irrigation and drainage for a wound infection, an osteochondral autologous grafting (OATS) procedure, and a lysis of adhesions for arthrofibrosis.

Predictors of Arthrofibrosis after Pediatric Anterior Cruciate Ligament Reconstruction: What is the Impact of Quadriceps Autograft?

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LOE-Prognostic-Level III

Purpose: Previous studies suggest that children and adolescents undergoing anterior cruciate ligament reconstruction (ACLR) with patellar tendon (PT) autograft may be at higher risk than with hamstrings tendon (HT), but there is little data regarding this complication in patients receiving quadriceps tendon (QT) autograft. The purpose of this study is to identify risk factors for arthrofibrosis following pediatric ACLR with attention to graft type.

Methods: Patients that underwent primary ACLR at a single tertiary children's hospital were reviewed for this retrospective cohort study. Those with multiligament reconstructions, lateral extra-articular tenodesis procedures, or a modified MacIntosh reconstruction were excluded. Arthrofibrosis was defined as a deficit of 10 degrees of extension and/or 20 degrees of flexion at 3 months after ACLR. Demographic data, intra-operative findings and techniques, and post-operative motion and complications were recorded. Univariate analysis was followed by purposeful entry logistic regression to control for confounding factors.

Results: A total of 378 patients (mean age 15.9±1.7 years, 49.7% female) were included in the analysis, of which there were 180 PT, 103 HT, and 95 QT grafts. The rate of arthrofibrosis was 1.9% for HT, 6.3% for QT, and 10.0% for PT (p=0.04). Females developed arthrofibrosis more frequently than males (10.6% vs. 3.2%, p=0.004). Additionally, those that ultimately experienced this complication had lower median flexion at 6 weeks after ACLR (88 vs. 110 degrees, p<0.001). In multivariate analysis, PT graft raised the odds of arthrofibrosis 6.2 times compared to HT (95% CI 1.4-27.6, p=0.02), but there were no significant differences between QT and other graft types. Females were at 4.2 times higher odds than males (95% CI 1.6-10.8; p=0.003). Patients that were unable to attain 90 degrees of flexion 6 weeks after ACLR had 14.7 times higher odds of eventually developing arthrofibrosis (95% CI 5.4-39.8; p<0.001). Finally, those with an extension deficit of ≥5 degrees 6 weeks after ACLR had 4.7 times higher odds of experiencing this complication (95% CI 1.8-12.2, p=0.001).

Conclusions: The rate of arthrofibrosis with QT autograft is 6.3% after pediatric ACLR. After adjusting for multiple covariates, PT autograft, female sex, and motion deficits at 6 weeks after ACLR (<90 degrees of flexion or extension deficit ≥5 degrees) were predictive of arthrofibrosis in children and adolescents.

Significance: There is little data on arthrofibrosis with QT autograft for pediatric ACLR. This study found the rate to 6.3% with QT. PT autograft, female sex, and motion deficits at 6 weeks were predictive of arthrofibrosis.

Functional recovery in Adolescent Athletes following ACL Reconstruction: A Matched Cohort Analysis of Patellar Tendon vs. Hamstring Autograft

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LOE-Therapeutic-Level III

Purpose: Adolescents who undergo anterior cruciate ligament reconstruction (ACLR) have the highest risks of graft rupture and contralateral ACL injury, with recent data suggesting poor post-operative functional recovery as a contributing factor. The purpose of this study was to assess the recovery of strength, balance, and hopping performance amongst adolescent ACLR patients 6 months post-operatively and compare the two most common autograft types in a matched cohort analysis.

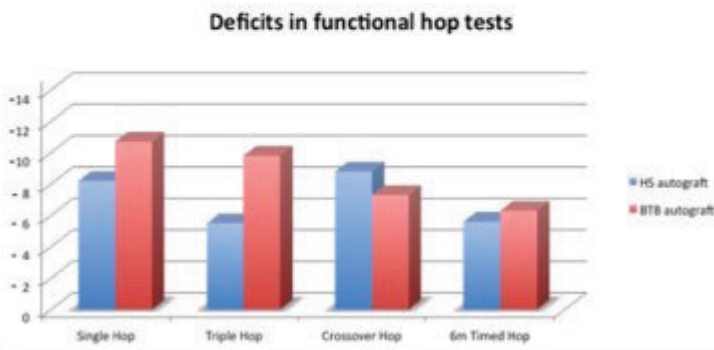
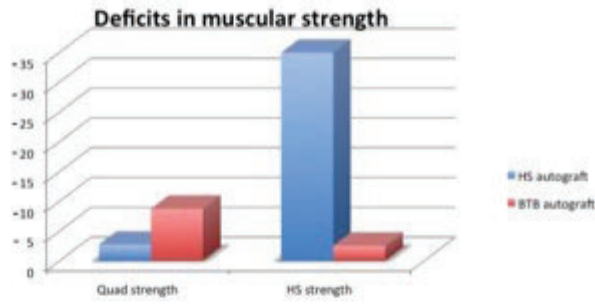
Methods: Prospectively collected data evaluating functional recovery and readiness for return to sports (RTS) in adolescent patients 6-months following ACLR were retrospectively analyzed. In all cases, ACLR was performed with either bone-patellar tendon-bone (BTB) autograft or doubled semitendinosus/gracilis hamstring (HS) autograft. A matched cohort analysis, based on age, sex, and body mass index (BMI), was performed with a logistic regression model to produce comparable cohorts of BTB:HS patients with a 1:2 ratio. Analyses included comparisons of demographic features, injury data and RTS metrics of lower extremity strength (quadriceps, hamstring, hip abductors, and hip extensors), dynamic Y-balance test, and functional hop tests (single, triple, cross-over and 6-meter timed hop). The operative side was compared to the non-operative side to generate standard limb symmetry indices (LSI) for all metrics.

Results: The study cohort included 170 patients (111 HS, 59 BTB). BTB patients demonstrated significantly greater quadriceps strength deficits than HS patients, respectively (-8.7 ± 15.9 vs. -2.7 ± 13.4 , $p=0.01$), while HS patients demonstrated significantly greater hamstring strength deficits than BTB patients (-34.9 ± 23.4 vs. -2.5 ± 12.2 , $p=0.01$), respectively. No difference between graft cohorts was detected in dynamic balance tests. BTB patients demonstrated a significantly greater triple hop performance deficit compared to HS patients (-9.8 ± 10.5 vs. -5.5 ± 8.7 , $p=0.02$), while no significant difference between graft cohorts was seen in the other 3 hop tests. However, deficits greater than 5% were seen in all 4 functional hop tests in both graft cohorts, when compared to the non-operative limb.

Conclusions: Adolescent patients demonstrate significant functional deficits 6 months following ACLR, regardless of autograft type utilized. However, HS patients demonstrated hamstring strength deficits of approximately 35%, while BTB patients showed quadriceps strength deficits of approximately 9%.

Significance: The study findings suggest that: 1) RTS at 6 months may not be safe for the adolescent age group. 2) Significant deficits to the primary dynamic knee stabilizers in HS patients may contribute to a higher re-tear rate. 3) Functional deficits after ACLR are relatively graft-specific, suggesting a role for individualized rehabilitation protocols tailored to graft type.

Demographics	HS autograft (N=111)	BTB autograft (N=59)	P-value
Age (y)	16.9±1.6	17.1±1.2	0.47
BMI	24.8±4.1	24.7±3.8	0.94
Female %	38.7%	37.3%	0.85
Concomitant meniscus repair	45.9%	37.3%	0.28
RTS assessment time (mo)	6.1±0.5	6.1±0.8	0.76



Anterior Cruciate Ligament Tear Following Operative Treatment of Pediatric Tibial Eminence Fractures in a Multicenter Cohort

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LOE-Prognostic-Level III

Purpose: The phenomenon of postoperative ipsilateral ACL tears after tibial eminence fracture fixation has been noted in the literature previously. This study aims to describe the prevalence of and risk factors for post-operative ACL tears in a cohort of patients surgically treated for tibial eminence fracture.

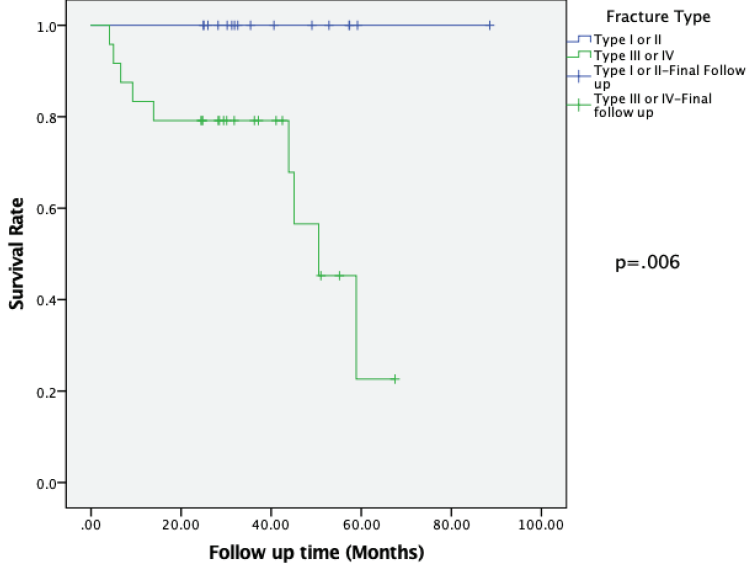
Methods: We performed a retrospective review of children undergoing treatment of a tibial eminence fracture at 10 tertiary care children's hospitals. The primary outcome was subsequent ACL rupture. Incidence rates of ACL tear were recorded for the entire cohort. Patients with minimum 2-year follow up data or those that had met the primary outcome within the 2-year period, were analyzed for demographics, risk factors and survival analyses in a sub-analysis of the original cohort.

Results: 385 pediatric patients were reviewed. A 2.6% incidence rate of entire cohort experienced a subsequent ACL tear. The overall median follow up time was 6.5 months (SD 6.4 months). 46 patients had either 2-year follow up data or met the primary outcome measure of an ACL tear prior to the 2-year mark. Mean age these patients was 11.2 years old (SD 2.8), and the median follow time was 36.4 months (SD 17.7 months). There was a 21.7% incidence of subsequent ACL tear in this cohort analyzed. Subsequent ACL tears occurred at a median of 10.2 months (SD 19.5 months) postoperatively. There was a statistically significant association with higher Myers & McKeever grade tibial spine fractures (Type III and IV) and subsequent ACL rupture ($p=0.006$). Subsequent ACL tears occurred in patients who were older when they had their original tibial eminence fracture (13.4 years old vs. 11.3 years old, $p=0.035$).

Conclusions: Subsequent ipsilateral ACL tears following operatively treated pediatric tibial eminence fractures in a large multicenter cohort occurred at a rate of 2.6%. However, in those with adequate follow up the incidence was 21.7%. They were associated with completely displaced (Type III or IV) tibial eminence fractures, and older patients.

Significance: ACL tears follow operative treatment of tibial eminence fracture fixation occurred at a high rate in relatively older patients and those with higher energy fracture patterns. They were found more often in patients with long term follow up. It is important for clinicians to counsel patients on the potential for this risk and long term follow up is advised.

Subsequent ACL tear versus Fracture Type



A Multicenter Comparison of Open versus Arthroscopic Reduction and Internal Fixation for Tibial Spine Fractures

R Justin Mistovich MD; Jilan Shimberg; Tomasina Leska; Julien Aoyama BA; Aristides I. Cruz MD; Henry Bone Ellis MD; Peter D. Fabricant MD; Theodore J. Ganley MD; Daniel W. Green MD; Jason E. Jagodzinski MD; Indranil Kushare MD; R Jay Lee MD; Scott D. McKay MD; Neeraj Patel MD; Jason Rhodes MD; Brant Sachleben MD; Mary Catherine Sargent MD; Gregory A. Schmale MD; Yi-Meng Yen MD; Tibial Spine Research Interest Group Rainbow Babies and Children's Hospital, Cleveland, OH

LOE-Therapeutic-Level III

Purpose: Trends in the management of tibial spine fractures have shifted to an arthroscopic approach. However, the optimal surgical approach has not yet been defined.

Methods: We performed a retrospective review of tibial spine fractures occurring between January 1, 2000 and January 31, 2019 at 10 institutions. Patients less than age 25 with at least 1-year follow-up with tibial spine fractures were included. Data was collected on demographics, injury, treatment details, and surgical outcomes. We compared rates of concomitant injury and treatment complications in patients treated with arthroscopically assisted reduction and internal fixation (ARIF) to those of open reduction and internal fixation (ORIF). We also compared demographics of surgeons treating tibial spine fractures with ORIF versus ARIF.

Results: 387 tibial spine fracture patients met inclusion criteria, 345 of whom (89%) were treated with ARIF, while 42 (11%) were treated with ORIF. Demographics were similar between the treatment groups. The relative distribution of fracture type differed between treatment groups: of patients treated with ARIF, 3.2% had type I, 42.9% had type II, and 53.9% had type III fractures. Of ORIF patients, 2.4% had type I, 23.8% had type II, and 73.8% had type III fractures ($p=0.048$). Rates of concomitant injury differed between the treatment groups. 163 of 345 (47.2%) ARIF patients presented with concomitant injuries, whereas only 12 of 42 (28.6%) ORIF patients had a reported concomitant injury ($p=0.033$). Rates of arthrofibrosis, return to operating room, and achieving normal range of motion at final follow-up were similar between groups ($p=0.987$, $p=0.447$, $p=0.411$). Almost all surgeons performing both ORIF (97.4%) and ARIF (98.2%) completed pediatric fellowship. 84.6% surgeons performing ARIF had further sports training, compared to only 35.7% of those performing ORIF ($p<0.001$). 31% of surgeons performing ORIF had trauma training, compared to none performing ARIF ($p<0.001$).

Conclusions: To our knowledge, this is the largest cohort comparing ORIF and ARIF treatment outcomes in tibial spine patients. Our study demonstrated a higher rate of concomitant injury in patients treated with ARIF. Did patients with ARIF truly present with more concomitant injuries, or were some injuries missed in patients treated with ORIF? Further study is warranted. Patients undergoing ORIF were more likely treated by a surgeon with trauma training without additional sports training.

Significance: While both ARIF and ORIF may result in successful fracture healing, concomitant injuries may be missed with an open approach. Surgeon preference and training may impact treatment decision, identification and adequate treatment of concomitant injury.

Comparison of Rigid and Dynamic Foot Abduction Orthoses in Children with Clubfoot: A Randomized Trial

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LOE-Therapeutic-Level II

Purpose: The Ponseti Method is the standard for clubfoot treatment with previous studies suggesting dynamic FAOs (dFAOs) improve compliance over rigid FAOs (rFAOs). The goal of this study is to use temperature sensors to compare in-brace time and incidence of recurrence between different braces.

Methods: This is a randomized trial of clubfoot patients treated with casting randomized to rFAO or dFAO, and prescribed full time wear for 3 months with evaluation monthly. Recurrence defined as surgery, or repeat casting, and in-brace time measured by temperature and parent report were recorded. Sample size was calculated with a power of 80% to identify a difference in daily brace-wear of 5.25 hours/day. Continuous variables were compared using two-tailed independent t-tests, or Mann Whitney nonparametric tests based on normality. Categorical variables were compared using chi-squared, and Fisher’s tests.

Results: Forty-eight patients were enrolled. Age at first cast was 15.25 days with mean Dimeglio score of 12.4 and, an average of 4.35 casts. Mean age at initiation of bracing was 7.3 months, with 22 patients randomized to dFAO, and 25 to rFAO. Demographics were identical between groups ($p > 0.05$). Mean reported in-brace time at 1, 2 and 3 months was 20.1, 22.1, and 21.8 hours for dFAOs, and 23.0, 22.1, and 22.6 hours for rFAOs. P-values for difference in reported in-brace time, at 1, 2, and 3 months, were $p = 0.06$, $p = 0.98$, and $p = 0.30$. Mean monitored in-brace time was 21.1, 20.9, and 20.8 hours for dFAOs, and 22.0, 19.9, and 16.5 hours for rFAOs with p-values of $p = 0.49$, $p = 0.61$, and $p = 0.06$. P-values comparing actual vs. reported in-brace time were $p = 0.02$, $p = 0.20$, $p = 0.01$ at 1, 2, and 3 months for rFAOs, and $p = 0.57$, $p = 0.37$, and $p = 0.16$ for dFAOs. Recurrence at 3 months was 15.8% ($n=4$) for dFAOs, and 15.4% ($n=3$) for rFAOs ($p > 0.99$).

Conclusions: This study demonstrates that parents overestimate in-brace time for rFAOs, and dFAOs show improved compliance with an increased in-brace time of 4.3 hours at 3 months. There is a trend towards degradation of in-brace time in the rFAO group with no difference in recurrence at 3 months. Additional study is needed to clarify the relationship between brace type, compliance, and recurrence.

Significance: Parents overestimate FAO compliance following clubfoot casting. Dynamic FAOs have improved compliance at 3-months with further study needed regarding recurrence.

	N	Monitored brace-time 1 month	Monitored brace-time 2 months	Monitored brace-time 3 months	Recurrence at 3 months
rFAO	25	22.0	19.9	16.5	4
dFAO	22	21.1	20.9	20.8	3
P-value		0.49	0.61	0.06	>0.99

	N	Parent reported brace 1 month	Parent reported brace 2 month	Parent reported brace 3 months
rFAO	25	23.0	22.1	21.8
dFAO	22	20.1	22.1	22.6
P-value		0.06	0.98	0.30

Radiographic and Histologic Evaluation of Three Common Tendon Transfer Techniques in an Un-ossified Bone Porcine Model: Implications for Early Anterior Tibialis Tendon Transfers in Children with Clubfoot

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LOE-Therapeutic-

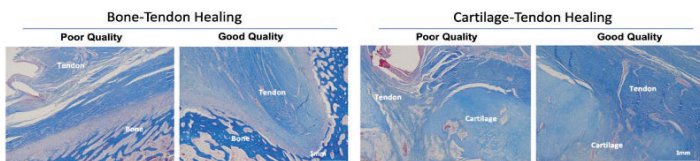
Purpose: In this study we compare the histologic and radiographic effects of tendons transferred to unossified bone using sutures, metallic suture anchors, and the classic tunnel technique.

Methods: Nine new-born piglets (eighteen calcanei) underwent one of the three surgical procedures. Suture fixation, metallic bone anchor, or classic tunnel transfer was performed to fix a single slip of the superficial digital flexor (FS) to either the ossified bony calcaneal body or cartilaginous unossified apophysis. At three weeks of age, high resolution Faxitron radiographic imaging was performed on the calcanei and the apophyseal ossification graded by five independent reviewers in triplicate using a modified (1-4) validated scoring system. Calcanei were harvested, prepared for histology, and a semi-quantitative aggregated scoring system with values ranging from 0 (poor) to 15 (excellent), was used to grade healing at the surgical entheses.

Results: Radiographically, all three of the transfer techniques to the unossified bone demonstrated at least minor alterations in ossification, with the most significant changes being observed in the apophyseal anchor samples (mean score=3 (range of modes 2-4)). The median scores for both the tunnel and suture techniques were 2 (range of modes 1-3). Histologically, the cartilaginous transfers utilizing the tunnel 10.3 (10-11) and suture 10.3 (8-12) techniques also demonstrated the best average aggregated scores of entheses healing. These scores were higher than those for the classic tunnel through bone technique 9.3 (8-11).

Conclusions: Suture or tunnel fixation techniques appear radiographically and histologically superior to suture anchors in the newborn unossified bone model.

Significance: Tendons fixed to the cartilaginous surface of the unossified apophysis with sutures heal similarly to those placed through the classic tunnel with minimal effects on subsequent ossification. These findings support current clinical scenarios in which suture fixation is used to fix the tibialis anterior tendon to talar cartilage surface, such as in the modified Dobbs technique for vertical talus, and appear a promising technique for further translational development in early clubfoot treatment.



Score	Collagen fiber Density	Collagen fiber Orientation	Bone-tendon interface	Vascularity	Inflammation	Group	Average Combined Histologic Score
0	None	None	0-24 % interdigitation	Abundant vascular network	Abundant inflammatory cells	Anchor-Bone (N=3)	5.7
1	Low	Disorganised fibers	25-49 % interdigitation	Moderate vascular network	Moderate inflammatory cells	Anchor-Cartilage (N=3)	5.7
2	Medium	Moderate alignment	50-75 % interdigitation	Minimal vascular network	Minimal inflammatory cells	Suture-Bone (N=3)	7.3
3	High	Highly aligned	>75 % interdigitation	No vascular network	No inflammatory cells	Suture-Cartilage (N=3)	10.3
						Tunnel-Bone (N=3)	9.3
						Tunnel- Cartilage (N=3)	10.3

Ponseti versus surgery, the 15 year outcomes of prospectively enrolled cohorts.

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Starship Children's Hospital, Auckland New Zealand

LOE-Therapeutic-Level III

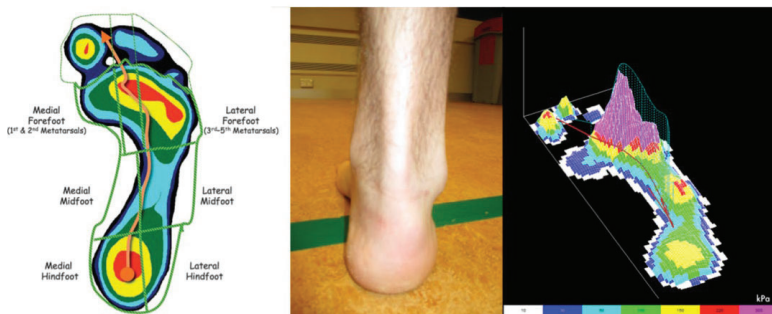
Purpose: To compare the mid-term (15 year) outcomes of prospectively enrolled patients that received either Ponseti casting or primary surgical release for idiopathic congenital talipes equinovarus (CTEV).

Methods: At average and median age of 15 years (range 13-17 years) following initial clubfoot treatment and study enrollment, the clinical records of subjects were assessed for additional surgical interventions following initial deformity correction. Participants were contacted and patient reported outcomes (PRO) [Royce Disease Specific Instrument (DSI) and Functional Disability Inventory (FDI)], clinical examination (range of motion and Dimeglio scoring), and 3D instrumented gait analysis (3D IGA) with plantar pressures were performed.

Results: The clinical records of the initial 26 Ponseti and 29 surgical patients demonstrated a re-intervention rate of 40% and 43% respectively, with a higher number of major re-interventions (intra-articular procedures or osteotomies) in the surgical group (15 vs 5 feet, $p < 0.05$). 33/55 (60%) of the initial patients (16 Ponseti, 17 Surgical) participated in the multimodal assessment and were similar in terms of numbers of bilateral cases, relapse rates (8/16 Ponseti and 7/17 surgical without re-interventions), initial pre-treatment Pirani scores [5(2.5-6) vs. 5 (4-6)], or final BMI. The Ponseti group demonstrated higher DSI (80 vs 65.6, $p < 0.05$), lower FDI (1.1 vs 5.0 $p < 0.05$), and Dimeglio (5.8 vs 7.0, $p < 0.05$) scores. 3D IGA revealed that the Ponseti cohort also had greater (1) total sagittal ankle range of motion during gait (23.4° vs 18.7°) $p < 0.005$, (2) ankle plantarflexion range at toe off (8.5° vs 5.2° , $p < 0.05$) and (3) calf power generation (2.5 vs 1.8 $p < 0.05$). Likewise, the Ponseti cohort demonstrated more normal plantar pressures while the surgical group (Figure below) displayed greater maximum force as % body weight in the lateral forefoot (52.4% vs 40.9%, $p < 0.05$), and increased pressure time integral (101.9 vs 59.6 Kpa, $p < 0.05$) in the lateral midfoot. There was an increase in the lateral center of pressure area (cm²) in the surgical feet, (14.9 vs 9.3, $p < 0.05$). Interestingly, the surgical feet were also significantly smaller, demonstrated by a 15% reduction in total area ($p < 0.05$).

Conclusions: At 15 years follow-up, relapses were similar between cohorts, but, the surgical cohort required more major re-operations and were found to have lower/worse PRO and functional outcomes than the Ponseti group.

Significance: This study is the most comprehensive evaluation of prospectively enrolled idiopathic CTEV cohorts near maturity and reinforces that the Ponseti Method is the initial treatment of choice for idiopathic clubfeet.



Calcaneal Sliding Osteotomy is Superior to Calcaneal Lengthening Osteotomy in Children with Cerebral Palsy

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LOE-Therapeutic-Level III

Purpose: Medial calcaneal sliding osteotomy (CS) and lateral column lengthening (LCL) are often performed to relieve pain, improve transverse plane alignment and functional ambulation for children with cerebral palsy (CP) with valgus foot deformities. The purpose of this study was to compare the effectiveness of these two procedures in this patient population.

Methods: Retrospective review was conducted of pre- and post-operative medical records (including 3D gait analysis data) for patients with CP who underwent LCL (26 subjects, 46 limbs) or CS (61 subjects, 100 limbs). Data extraction included complications (rated using the modified Clavien-Dindo system), change in standing foot position (rated using a modified Yoo system), and change in ankle kinematics and kinetics pre- to post-operatively. Groups were compared statistically using paired t-tests, Fisher's exact and logistic regression.

Results: Subjects were 60% male, average age at surgery 11.2 (SD 2.6) years, average length of follow-up 3.1 (SD 2.8) years. Complications were minor and the rate was similar between groups ($p=0.48$). Prolonged pain and plantar hypersensitivity occurred only in the CS group. Successful deformity correction was achieved in 71/100 limbs (71%) in the CS group and 16/44 limbs (36%) in the LCL group ($p<0.001$) (2 limbs could not be rated). Recurrent pes valgus was more common with LCL (33% vs. 13%, $p=0.007$), as was need for repeat foot surgery (30% vs. 11%, $p=0.008$). Recurrent valgus never occurred when talonavicular fusion was done concurrently with either LCL or CS. After adjusting for covariates, the odds of developing recurrent valgus were 10 times higher with LCL, 10-28 times higher at GMFCS levels I, III and IV versus level II, and 32 times higher when prior foot surgery had been performed. Odds of recurrent valgus decreased by 58% (OR 0.42, $p<0.0001$) with each year surgery was delayed. Length of follow-up did not affect the likelihood of recurrent valgus. None of the variables were predictive of development of pes varus post-operatively ($p>0.17$). Ankle kinematics and kinetics during gait were unchanged in both groups.

Conclusions: CS is a safe and effective alternative to LCL, resulting in longer lasting correction of pes valgus, especially if done with concomitant talonavicular fusion. LCL carries a risk of need for repeat foot surgery to correct recurrent pes valgus, especially if done before age 11-12 years.

Significance: CS is more effective than LCL in providing long-lasting correction of valgus foot deformities. Concomitant talonavicular fusion is key to success of both procedures.

The Impact of Preoperative Factors and Surgical Burden on Postoperative Recovery of Walking Activity in Children with Cerebral Palsy

*M Wade Shrader MD; Chris Church; Isabel Biermann; Nancy Lennon MS; John Henley; Stephanie Butler; Timothy Niiler; Freeman Miller MD; Jason Howard MD
Nemours duPont Hospital for Children, Wilmington, DE*

LOE-Therapeutic-Level III

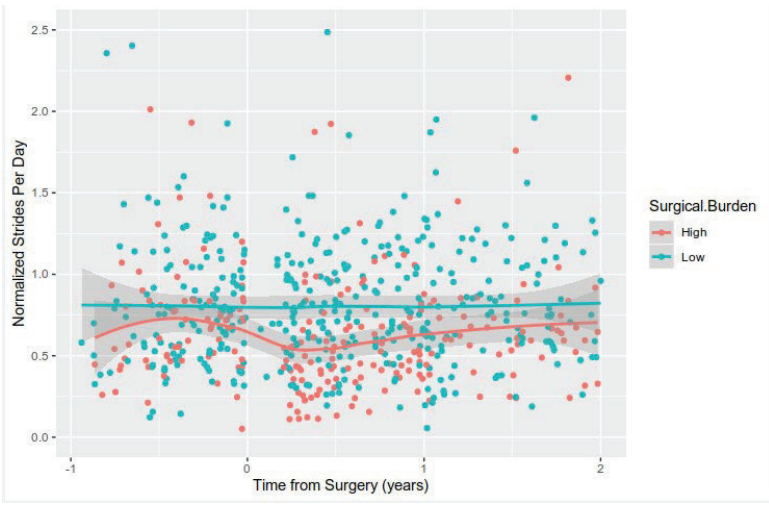
Purpose: Our previous work showed that 1-2 years after single-event multilevel surgery (SEMLS) ‘impairment-level’ gait outcomes, such as the Gait Deviation Index (GDI), were consistently improved, but ‘activity and participation-level’ outcomes, such as daily step counts were not. To fill a knowledge gap about recovery of function after SEMLS our specific aims were: To determine how the dose, or surgical burden, of orthopedic surgery affects the recovery of daily Walking Activity (WA) after SEMLS. To examine how preoperative factors affect surgical recovery.

Methods: In this IRB-approved retrospective study, inclusion criteria were a diagnosis of CP, gait related surgery, and WA monitoring using a StepWatch device within 12 months before and 24 months after surgery. The outcome measure was normalized strides per day, calculated by dividing total mean strides per day by reference values according to age and GMFCS level. A regression analysis was performed using multiple imputation with chained equations with surgical burden (low burden = soft tissue surgery and up to 1 osteotomy and high burden = 2 or more osteotomies), age at surgery, GMFCS level, and preoperative gait velocity, average GDI, FMS (5, 50, 500), GMFM-D, strength and O2 cost index as predictors.

Results: 178 children (Age 12.8 ± 8.6 , GMFCS I (22), II (110), III (39), IV (7)) with 613 StepWatch collection periods and 197 surgeries (127 low, 70 high burden) met the inclusion criteria. Children returned to baseline WA within 3 months after a low burden surgery and within 12 months after a high burden surgery (Figure). On average, children did not have significant improvement in WA within 2 years after surgery. However, there was significant variation in postoperative WA, with 41% improving, 18% having no change, and 41% declining. Lower surgical burden, younger age at surgery, and higher preoperative gait velocity, average GDI, and GMFM-D ($p < 0.001$), lower preoperative O2 cost index ($p < 0.01$), and higher preoperative muscle strength scores ($p < 0.05$) were significant predictors of higher postoperative WA.

Conclusions: Postoperative recovery of WA is prolonged after high burden SEMLS. Older children and those with more severe gait and gross motor impairments are less likely to improve WA after SEMLS.

Significance: Previous studies have demonstrated that SEMLS produces good technical gait outcomes in children with CP, but its effect on mobility function is inconsistent. This study demonstrates the feasibility of using WA as an objective measure of mobility function that could help providers to set expectations for families preparing for SEMLS.



Fassier-Duval Telescoping Rodding in Osteogenesis Imperfecta: Rod Revision and Survivorship

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Department of Orthopaedic Surgery, Boston Children's Hospital, Harvard Medical School, Boston, MA

LOE-Therapeutic-Level IV

Purpose: This study retrospectively examined telescoping Fassier-Duval (FD) rod survivorship and revision factors in osteogenesis imperfecta (OI) patients. We investigated risk factors associated with rod revision. Our goal was to show revision rates over a mid-term follow up period of 5-10 years after rodding surgery.

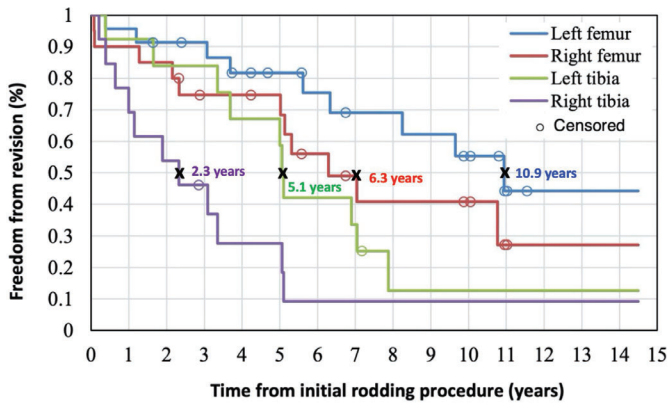
Methods: Between 2005 and 2019, 24 OI patients that underwent 69 FD rod placements were retrospectively reviewed and included for the analysis utilizing a combination of medical records, radiologic findings, and telemedicine reviews. Univariate logistic regression with a generalized estimating equations approach was used to assess the association between risk factors and the likelihood of rod revision; while multivariable Cox proportional hazards analysis was used to determine the association of bone location with the likelihood of revision while controlling for other patient and condition characteristics.

Results: The patient cohort was predominantly male (58%), and patients were an average of 5.5 years from the initial procedure (range 2.0-21.2 years). Forty-four rods (64%) required at least one revision procedure at an average of 4.4 years (range 0.1days-1.8years). The common indications for FD rod revision were rod bending, migration or cessation of telescoping (40.9%), recurrent fracture with progressive deformity (27.3%), and a combination of both causes (27.3%). Rods without revisions (36.2%) were followed for an average of 6.7 years (range 1.1-11.6years). Rod survivorship over time using logistic regression is shown in Figure 1. Tibial rods had nearly four times higher revision compared to femoral rods when controlling for the side of rodding (Hazard ratio (HR)=3.9; 95%CI=2.16-6.88); $p<0.001$). Right-sided rods had nearly two times higher revision rate (HR=1.9; 95%CI=1.21-3.08; $p=0.006$) while controlling for bone location. Additionally, for each subsequent rod, revision increased by 1.8 times (Incidence rate ratio (IRR)=1.83; 95%CI=1.48-2.26; $p<0.001$). Simultaneous rodding procedures decreased the incidence of revision by 43% (IRR=0.97; 95%CI=0.43-0.77; $p<0.001$) when controlling for the number of rodding procedures.

Conclusions: Telescoping rods perform well but have increasing revision rates over time. Tibial rods, right-sided rods, and additional rod placement have increased risk of revision. Simultaneous multi-bone rodding decreased the revision rate.

Significance: At 8.6-year average follow-up after Fassier-Duval rodding in OI, Kaplan-Meier survivorship ranged from 30-80% based on bony location and laterality. Patients can be better counseled regarding the risk of revision surgery over time.

Figure 1. Kaplan-Meier curve for freedom from revision following index rodding by side and bone location. The circle data points indicate censored rods.



Prediction of Varus Deformity Correction by Lateral Tension Band Plating at the Knee in Late-Onset Blount Disease- A Multi-Center Study

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 Shriners Hospitals for Children, Multiple Centers- Lead Site, Lexington KY

LOE-Prognostic-Level III

Purpose: Poor results are reported for guided growth by lateral tension band plating (LTBP) in Blount disease, compared to other conditions. The purpose of this study is to determine parameters that predict outcome of LTBP in late-onset Blount disease.

Methods: Five centers reviewed radiographic outcomes of LTBP in patients with Blount disease, onset ≥ 8 years. Outcomes measured were mechanical lateral distal femoral angle (mLDFA) and medial proximal tibial angle (mMPTA) for individual femoral and tibial TBP, respectively. Overall limb outcome was determined by mechanical axis zone (MAzone), axis deviation (MAD), and tibiofemoral angle (mTFA). Weight, severity of deformity and hip physal closure were assessed for prediction of outcomes using multivariate logistical regression. Success was defined as correction or overcorrection to normal range for radiographic parameters.

Results: Sixty-one patients with 84 involved limbs met inclusion criteria. Mean follow-up was 2.7yrs. There were 47 males:14 females. Overall, 123 LTBP's implanted, at a mean age 12.7yrs, included 31 femoral TBP, 7 revised tibial implants and 1 reimplantation for recurrence. Outcome results are presented in Table 1. Implants were removed in 34 limbs. Tibial LTBP (n=92) resulted in mean change of +7.1o (rate=0.3o/mo) in the mMPTA. While MAD was successfully corrected in only 43% of limbs, the mean=18.6mm correction results in 30% reduction of knee torsional forces. Of the 37 limbs with preop-mLDFA>90o, treated with tibial LTBP alone, only 6 limbs achieved post-mLDFA=85o-90o. The multivariate analyses are shown in Table 2. These analyses showed preop-mTFA was more important in predicting success than preop-MAD or preop-MAzone. Each 1o decrease in the preop-mMPTA or 1o increase in the preop-mTFA decreases the odds of success by 31% and 11%, respectively, when weight or hip physal closure remain constant. Holding preop-mMPTA or preop-mTFA constant, closure of the triradiate physis decreases the odds of post-mMPTA and final-mTFA success by 83% and 75%, respectively. Weighing ≥ 95 -100kg also decreases the odds of post-mMPTA and final-mTFA success by 86% and 78%, respectively, holding preop-mMPTA or preop-mTFA constant.

Conclusions: The rate of correction with LTBP in late-onset Blount is slower than reported for other diagnoses. Even partial correction, substantially reduces torsional forces at the knee. Femoral deformity rarely corrects with tibial LTPB alone. Correction/overcorrection of mMPTA and mTFA are impacted by deformity magnitude, hip physal closure, and weight >95-100kg.

Significance: First report of nomograms for predicting the chances of success of LTBP in late-onset Blount disease

Table 1. Outcome of Lateral Tension Band Plating for Late-Onset Blount Disease (61 Patients, 84 Limbs, and 123 LTBP's)

Limb Segments	Mean Pre-op	Mean Treatment End	Median Correction	Number Achieving Success*
Tibial mMPTA (degrees n=92)	76.5	83.6	+7.5	44 (47%)
Femoral mLDFa (degrees n=31)	95.3	87.2	-7.3	24 (77%)
Overall Limbs (n=84)	Mean Pre-op	Mean Study End	Median Correction	Number Achieving Success*
mTFA (degrees varus)	18.1	8.4	-11.0	38 (45%)
MAD (millimeters varus)	63.0	44.4	-23.5	36 (43%)
MAzone (n)				37 (44%)
I		35		
II varus	15	19		
III varus	70	28		
II valgus		2		
Mature/tibial epiphyseodesis (n)		45		

* success = correction or overcorrection, relative to normal limb parameters

Table 2. Predicting mMPTA and mTFA Correction/Overcorrection

Preoperative mMPTA levels needed for mMPTA success				
Chance of Success	20%	40%	60%	80%
Hip Physal Closure				
All open	67.8	71.2	74	77.4
Triradiate only	72.8	76.2	79	82.4
Femoral Head and/or Greater Trochanter	76.6	80	82.8	N/A
Weight				
< 100 kg	70.4	73.8	76.6	80
≥ 100 kg	77.2	80.6	83.4	N/A
Preoperative mTFA needed for Final-mTFA success				
Chance of Success	20%	40%	60%	80%
Hip Physal Closure				
All open	30.9	22.6	15.7	7.4
Triradiate only	31.9	23.6	16.9	8.4
Femoral Head and/or Greater Trochanter	15.6	7.3	N/A	N/A
Weight				
< 95 kg	37.4	27.4	19.1	9.2
≥ 95 kg	21.8	11.8	N/A	N/A

Correction of Leg Length Discrepancy (LLD): Tension-Band Plating versus Percutaneous Trans-epiphyseal Screws

Manaf H. Younis MD; Regina Hanstein; Yungtai Lo; Kainaat Javed; Eric Fornari MD; Jaime A. Gomez MD; Melinda Sharkey MD; **Jacob Schulz MD**

Montefiore Medical Center, Bronx, NY

LOE-Therapeutic-Level III

Purpose: This study compared the efficacy and outcomes between tension-band plating (TBP) and percutaneous epiphysiodesis using transphyseal screws (PETS) for correction of LLD.

Methods: Retrospective review of children who underwent epiphysiodesis with either TBP or PETS of the lower extremity from 2008 to 2018. LLD and complications were reviewed at treatment completion (defined as ROH or physis closure) and recent follow-up (FU). Statistical analysis included t-test, Wilcoxon rank-sum test, Fisher’s exact test or χ^2 test.

Results: 47 surgeries with either TBP (24 femur/tibia, 17 limbs) or PETS (23 femur/tibia, 15 limbs) were performed. TBP patients were younger at surgery compared to PETS (11 vs 13.1 years, $P < 0.005$). PETS had a shorter operative time ($P = 0.047$), length of hospital-stay ($P = 0.014$), and time to return to activities ($P = 0.043$). Length of epiphysiodesis treatment was similar between groups (TBP 23.5 vs PETS 24 months, $P = 0.132$), however, follow-up was significantly shorter in the PETS group (TBP 5.4 years vs PETS 2.5 years, $P = 0.001$). Other demographic and surgical parameters were similar between groups. LLD was determined pre-operatively, at completion of epiphysiodesis treatment and recent FU (Table 1). Overall, pre-operative LLD was 2.7 ± 1.6 cm and predicted LLD at maturity 3.2 ± 1.7 cm. At FU, LLD had corrected from 2.64 to 1.38 cm ($P = 0.005$) in TBPs and from 2.76 to 1.08 cm ($P < 0.001$) in PETS, achieving an average correction of 1.42 cm and 1.68 cm, respectively ($P = 0.666$). The rate of LLD correction during treatment was 0.49 ± 0.9 cm/year for TBPs and 1.0 ± 1.1 cm/year for PETS ($p = 0.185$). 11 TBP (65%) and 12 PETS cases (80%) achieved $LLD \leq 2$ cm at FU ($P = 0.444$). Non-operative complications occurred in 3 limbs treated with TBP and 2 limbs treated with PETS ($P = 1.000$). Revision surgery due to persistent LLD or angular deformity occurred in 11 TBPs and 3 PETS ($P = 0.016$). However, logistic regression adjusted for age at surgery did not reveal that TBP was significantly associated with revision surgery (OR=3.98, 95%CI 0.63-26.20; $P = 0.142$).

Conclusions: Both, TBP and PETS, decreased LLD at final follow up successfully; there were no significant differences in the length of the discrepancy corrected or need for revision surgeries. However, PETS was associated with shorter operative time, shorter hospital-stay and faster return to pre-operative function.

Significance: Both methods, PETS and TBP, are successful in controlling LLD with similar correction and low complication rates.

Table 1

	Pre-operative			Completion of treatment			Final follow-up		
	Tension-band plate	PETS	P-value	Tension-band plate	PETS	P-value	Tension-band plate	PETS	P-value
LLD*, cm	2.64 ± 1.7	2.76 ± 1.5	0.843	1.92 ± 2.5	1.29 ± 1.3	0.381	1.38 ± 1.7	1.08 ± 1.0	0.544
p-value pre to postop				0.139*	0.005*		0.005*	<0.001*	
Δ LLD*, cm pre to postop				0.67 ± 1.8	1.47 ± 1.7	0.243	1.42 ± 1.8	1.68 ± 1.34	0.666
Correction Rate, cm/year				0.49 ± 0.9	1.00 ± 1.1	0.185	0.26 ± 0.4	0.83 ± 0.8	0.035
LLD*			1.000^			0.429^			0.697 ^
≤ 1.5 cm	4 (23.5%)	3 (20%)		5 (29.4%)	8 (53%)		9 (52.9%)	9 (60%)	
1.5-2 cm	2 (11.8%)	1 (7%)		3 (17.6%)	1 (7%)		2 (11.8%)	3 (20%)	
> 2 cm	11 (64.7%)	11 (73%)		9 (52.9%)	6 (40%)		6 (35.3%)	3 (20%)	

analysis by limb: TBP N=17, PETS N=15
 Data is shown as mean ± SD or N (%)
 Statistics: Comparison TBP vs PETS: unpaired t-test
 Comparison pre to post-op within each treatment group: paired t-test
 Distribution of cases among LLD categories: Fisher’s exact test^

Total Joint Arthroplasties before 25: Functional Outcomes and Quality of Life

*Nathan Donaldson DO; John Colleran; Nathan Rogers MPH
Children's Hospital Colorado, Aurora, CO*

LOE-Therapeutic-Level II

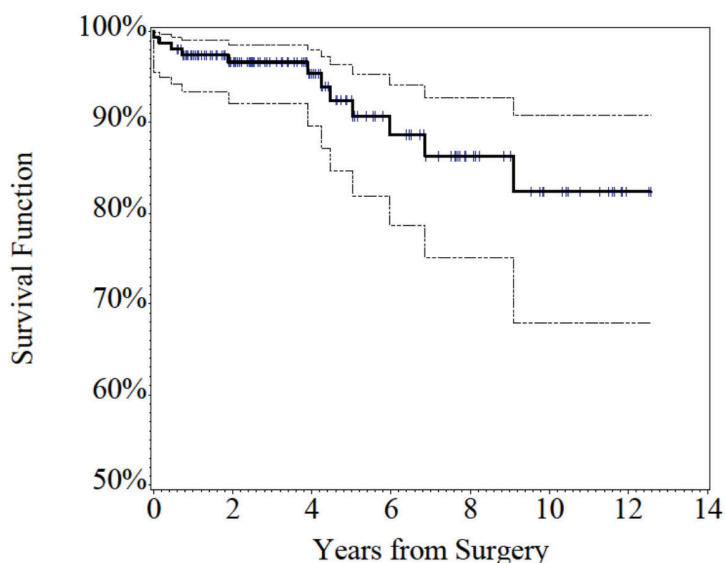
Purpose: Total Joint Arthroplasties (TJA) are done to treat painful or otherwise debilitated joints. Done most commonly in the adult population, the procedure is increasingly being used in a younger population to treat a variety of pathologies. These pathologies include avascular necrosis secondary to corticosteroid use (eg. treatment for leukemia), autoimmune disorders (eg. Juvenile Idiopathic Arthritis (JIA) and SLE), post traumatic arthritis, and hip dysplasia. If conservative therapies fail, the use of TJA may be warranted to restore function and relieve pain for these patients. Our study aimed to look at the long-term functional outcomes and quality of life for patients under the age of 25 years who underwent TJA at Children's Hospital Colorado.

Methods: We identified 142 patients who underwent a total knee (TKA) or total hip (THA) arthroplasty at Children's Hospital Colorado between 2003 and 2019. There were a total of 159 THAs, 28 TKAs and 6 Hemiarthroplasties. Patients who received a TJA for a primary diagnosis of solid tumor were excluded. Patients were contacted to assess quality of life and functional ability using the SF-36v2, the Oxford Knee score, and the modified Harris Hip Score.

Results: Of all the patients, 61 responded to the surveys. The average age at surgery for these patients was 17.33 years. Average time since surgery for each joint was 5.64 years. The mean Oxford Knee score for these patients was 35.69 ± 11.71 and the average Harris Hip Score was 77.84 ± 14.31 demonstrating only mild deficits in function. The average mental quality of life score was 50.64, similar to the general population. 11 joints underwent revision (7 for recalled implants, 3 for fracture, 1 for deep infection). Probable survival at 5 years was 94.22% for all joint replacements. When excluding patients with recalled implants, the 5 year survival was 97.01%.

Conclusions: Total Joint Arthroplasties can be an appropriate surgical intervention to restore function and decrease pain for patients who have failed conservative treatment and are not candidates for hip preservation surgery. Patients who underwent TJA reported good to excellent function with mild limitations. These results are consistent with older adults and indicate the success of this intervention in pediatric patients. These patients also reported their average quality of life was comparable to the general population.

Significance: Patients under the age of 25 who present with severe hip or knee pain should be considered candidates for TJA. Our experience demonstrates excellent functional results for these patients.



SCIENTIFIC PROGRAM

SATURDAY, MAY 15 CONTINUED

OSVI I

Moderator: Kevin Shea, MD

Co-Moderator: Kali Tileston, MD

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8:44 AM–8:48 AM

Looking Under the Hood: Factors that Drive Successful Study Group Participation and Publications in Pediatric Spine Programs

Sonya Levine; Bradley Hammor; Abby Morris; Sushrut Arora; Afrain Bobby; Hiroko Matsumoto, PhD; Michael Fields; Matthew Oetgen MD, MBA; Tricia St Hilaire; Brandon Ramo, MD; Richard Anderson; John Smith, MD; Michael Vitale, MD, MPH; David Skaggs, MD; Pediatric Spine Study Group
Columbia University Medical Center, New York, NY

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8:49 AM–8:53 AM

Improving Hip Surveillance across a Tertiary Children's Hospital: A Multi-Disciplinary Quality Improvement Initiative

Kathryn Milks; Jessica Holstine; Lynne Ruess; Alec McGinnis; Courtney Bishop, PA-C; Erin Mesj; Amanda Whitaker, MD
Nationwide Children's Hospital, Columbus, Ohio

145

8:54 AM–8:58 AM

How Much Will My Child's ACL Reconstruction Cost? Availability and Variability of Price Estimates for Anterior Cruciate Ligament Reconstruction in the United States

Julianna Lee; Ryan Guzek; Neal Shah; J Todd Lawrence, MD; Theodore Ganley, MD; Apurva Shah, MD
Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

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9:08 AM–9:12 AM

Disposal of Unused Opioids Using an At-home Disposal Method

De-An Zhang; Marilan Luong; Emmanuel Barragan; Robert Cho, MD; Selina Poon, MD
Shriners for Children Medical Center, Pasadena, CA

SCIENTIFIC PROGRAM

SATURDAY, MAY 15 CONTINUED

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9:13 AM–9:17 AM



Opioid Use in Children and Adolescents Following
Common Orthopaedic Surgeries

*Samuel Willimon, MD; Asahi Murata; Crystal Perkins, MD
Children's Healthcare of Atlanta, Atlanta, GA*

148

9:18 AM–9:22 AM

Perioperative steroid use in patients undergoing posterior spinal
fusion for adolescent idiopathic scoliosis

*Robert Bruce, MD; Nicholas Fletcher, MD; Tracy Ruska NP;
Ndeye Guisse; Thomas Austin; Joshua Murphy, MD
Children's Healthcare of Atlanta, Atlanta, GA*

149

9:32 AM–9:36 AM

Reducing Intraoperative Radiation Exposure During
Periacetabular Osteotomy: The Use of Flat Panel Detector
Fluoroscopy

*Rachael Martino, BA; Omar Samara; Sterling Lee;
Courtney Selberg, MD
Children's Hospital Colorado, Aurora, Colorado*

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9:37 AM–9:41 AM

Lowering radiation dose to children with hip dysplasia through a
change in radiograph technique

*Cheryl Lawing, MD; Rebecca Gorbe; Maureen Maciel, MD;
Joseph Khoury, MD
Shriners Hospitals for Children, Tampa, FL*

151

9:42 AM–9:46 AM



Does Surgical Experience Decrease Radiation Exposure in
the Operating Room?

*Lacey Magee, BA; Alexa Karkenny, MD; Jie Nguyen;
Faris Fazal, BS; Divya Talwar; Xiaowei Zhu; Apurva Shah, MD
Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*



SCIENTIFIC PROGRAM

SATURDAY, MAY 15 CONTINUED

QSVI II

Moderator: Julie Samora, MD

Co-Moderator: Brian Brighton, MD

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10:25 AM–10:29 AM **Methods for Reducing Intra-Operative Breast Radiation Exposure in Orthopaedic Surgeons**

Sara Van Nortwick, MD

Medical University of South Carolina, Charleston, SC

153

10:30 AM–10:34 AM **Healthcare disparities after implementation of standardized care pathway for adolescent idiopathic scoliosis patients undergoing spinal fusion**

Philip Dela Merced; Caroll Vazquez Colon; Jenhao Cheng;

Matthew Oetgen MD, MBA; Sophie Pestieau;

Benjamin Martin, MD; Shannon Kelly, MD;

Ariana Mirzada; Zsombor Gal; Jessica Cronin

Children's National Hospital, Washington, DC

154

10:35 AM–10:39 AM **Perceived physician empathy in pediatric orthopedics: a cross-sectional study**

Ian Singleton; Rachel Garfinkel; Jason Malone, DO;

M'hamed Temkit; Mohan Belthur, MD

Phoenix Children's Hospital, Phoenix, Arizona

155

10:49 AM–10:53 AM **Efficacy of Virtual Reality in Pain Reduction in Orthopedic Pediatric Patients Measured by Patient Feedback and Heart Rate Monitoring**

Sean Waldron, MD; Bhumit Desai; Michael Nammour;

Michael Warren; Jeffrey Reese; Lawrence Haber, MD;

Brielle Plost, MD; Korak Sarkar

Ochsner Clinic Foundation, New Orleans, LA

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10:54 AM–10:58 AM  **Cast Saw Alarm System Reduces Blade to Skin Contact**

Susan Scherl, MD; Max Twedt; Jeffrey Garvey;

Joshua Cameron; Matthew Halanski, MD

University of Nebraska Medical Center, Omaha, Nebraska

SCIENTIFIC PROGRAM

SATURDAY, MAY 15 CONTINUED

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10:59 AM–11:03 AM



Comparison of Commercially Available Cast Protectors

Stephanie Goldstein, MD; Scott Hetzel; Pamela Lang, MD;

Matthew Halanski, MD

University of Wisconsin-Madison, Madison, WI

158

11:13 AM–11:17 AM

Post Operative Scoliosis X-Rays - Before Discharge or First Follow Up

*J Wattenbarger, MD; Ashley Carpenter; Franklin Gettys, MD
SHC-Greenville, Greenville, SC*

159

11:18 AM–11:22 AM

Zero Patient-Controlled Analgesia is an achievable target for postoperative rapid recovery management of Adolescent Idiopathic Scoliosis patients

*Vishal Sarwahi, MBBS; Sayyida Hasan; Benita Liao; Aaron Atlas;
Jesse Galina; Yungtai Lo; Terry Amaral, MD; Michelle Kars
Cohen Children's Medical Center, New Hyde Park, NY*

160

11:23 AM–11:27 AM

Establishing a Gold Standard for Estimation of Blood Loss During Spine Surgery

*Nicholas Fletcher, MD; Laura Gilbertson; Robert Bruce, MD;
Humphrey Lam; Kathy Spitzer; Matthew Lewis;
Marney Moore; Thomas Austin
Children's Healthcare of Atlanta, Atlanta, GA*



Looking Under the Hood: Factors that Drive Successful Study Group Participation and Publications in Pediatric Spine Programs

*Michael G. Vitale MD; Sonya B. Levine; Bradley Hammoor; Abby Morris; Sushrut Arora; Afrain Z. Bobby; Hiroko Matsumoto PhD; Michael Fields; Matthew E. Oetgen MD; Tricia St Hilaire; Brandon A. Ramo MD; Richard Anderson; John T. Smith MD; David L. Skaggs MD; Pediatric Spine Study Group
Columbia University Medical Center, New York, NY*

LOE-Not Applicable-

Purpose: Multicenter clinical research is critical in a constantly evolving landscape, particularly in early onset scoliosis (EOS). There is variability from center to center with regard to the “quality of participation” in such research efforts, as well as amount of publications on EOS. The purpose of this study is to examine factors associated with “high-performing” centers.

Methods: This was a multicenter retrospective cohort study of 21 academic medical centers participating in an EOS registry. Factors examined included research personnel, spine research focus, and regular participation of faculty in research, collected through a survey. Outcomes included the quality of participation in the study group, derived from quarterly site reports generated by the EOS registry, and average annual publication volume of each institution obtained from a PubMed search. Univariable analyses were utilized to investigate institutional factors associated with the quality of performance and publication volume.

Results: All 21 sites completed the survey. Centers with full-time spine research staff had higher average quality of participation scores (90 vs 60, $p=0.026$) as did centers with dedicated spine research meetings (90 vs 70, $p = 0.074$) than those that lacked these features. Additionally, centers with higher average publication volumes were more likely to have fulltime research staff (8.0 vs 3.5, $p = 0.115$), a research team focused on spine (8.9 vs 4.8, 0.067), and a dedicated physician assistant (PA) or nurse with >95% focus on spine (9.0 vs 5.4, $p = 0.107$).

Conclusions: The single most important and significant factor in quality of participation in the registry was a center having full-time research staff. Factors associated with publication volume was a research team focused primarily on spine and a spine dedicated PA or nurse. If institutions want to improve spine research, we recommend investing in these factors.

Significance: This study showed that there is precedent to investigate how the organizational and institutional factors of a department can influence research productivity, so future studies could be conducted to interrogate other institutional factors of hospital systems and their effect on research and quality of performance.

Improving Hip Surveillance across a Tertiary Children's Hospital: A Multi-Disciplinary Quality Improvement Initiative

Kathryn Suzanne Milks; Jessica B. Holstine; Lynne Ruess; Alec McGinnis; Courtney Bishop PA-C; Erin L. Mesi; Amanda Tencza Whitaker MD
Nationwide Children's Hospital, Columbus, Ohio

LOE-Not Applicable-

Purpose: A hip surveillance (HS) program prevents hip dislocations in children with cerebral palsy (CP). CP HS requires the efforts of many services, including orthopaedics, radiology, primary care, neurology, physical medicine and rehabilitation, early intervention, physical therapy, and others. Not all involved specialties are well versed in the importance of HS and the radiographic evaluation. We present our quality improvement initiative to increase CP HS across our institution.

Methods: The key drivers were established and departments that see CP patients were assembled. We identified and addressed barriers to HS. All involved physician groups were educated about surveillance, schedules, and interventions. Radiologists led a QI effort to standardize patient position, measurement, and interpretation. Provider and family noncompliance was addressed through a multifaceted approach. We cross referenced our initiatives with the number of referrals to the orthopaedic surgery department, hip surgeries, open hip reductions and hip salvage procedures.

Results: At the initiation, 35% of patients between the ages of 2-16 years with nonambulatory CP received the appropriate HS. HS increased to 53% with the initiation of a department champion in the multidisciplinary cerebral palsy and orthopaedic clinics. Incorporating the early detection program further increased compliance to 68%. Standardizing the radiology reads and positioning increased compliance to 73%. Covering all the multidisciplinary clinics with an orthopaedic surgery practitioner increased surveillance to 80%. For reporting, in the first 5 months 183 (81%) of 225 children with CP referred for radiographic hip screening were found to have at least 1 abnormal hip. Two children were identified with rapid increase in hip migration (from 30 to > 60% hip migration), which prompted surgical intervention. As radiographic HS increased from 35% to 73% from 2012 to 2019, a similar and expected increase in our open hip reduction rate occurred (2.2/year to 9/year). This number has been reduced for 2020 to 2 open hip reduction. Our hip salvage surgeries remain high (4.75/year).

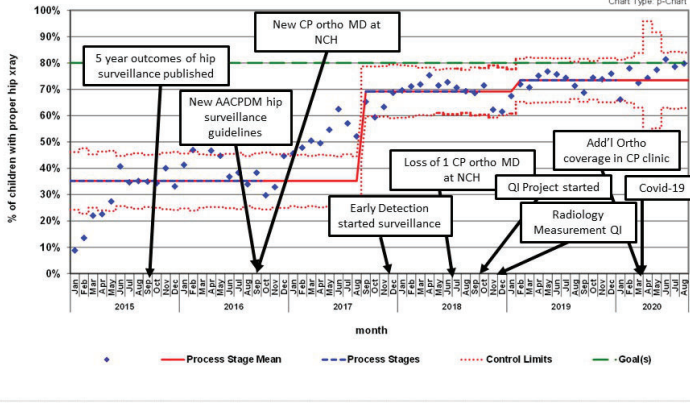
Conclusions: A successful hip surveillance program requires a multidisciplinary approach. A champion, resources, education, reminders, proper positioning, and radiographic measurements are key to success to promote timely detection, referral, and treatment of hip abnormalities in children with cerebral palsy.

Significance: This QI initiative identifies and addresses barriers to institution of a hip surveillance program. While there was an increase in hip procedures for fixed dislocation initially, we predict it will ultimately decrease the number of fixed hip dislocations and painful salvage hip surgeries in the future.

Children Ages 2-16 with Nonambulatory Cerebral Palsy and One Hip Xray within Compliant Time Frame

Desired Direction

Chart Type: p-Chart



Month	1	2	3	4	5	6	7	8	9	10	11	12
2015	15	25	30	35	38	40	42	45	48	50	52	55
2016	35	38	40	42	45	48	50	52	55	58	60	62
2017	60	62	65	68	70	72	75	78	80	82	85	88
2018	70	72	75	78	80	82	85	88	90	92	95	98
2019	75	78	80	82	85	88	90	92	95	98	100	100
2020	78	80	82	85	88	90	92	95	98	100	100	100

Outcome Measure

How Much Will My Child's ACL Reconstruction Cost? Availability and Variability of Price Estimates for Anterior Cruciate Ligament Reconstruction in the United States

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LOE-Economic-

Purpose: Price transparency is an important way, especially for the uninsured, to empower patients to make value-based healthcare decisions. Despite recent policy efforts to increase transparency, obtaining estimated prices for surgery remains difficult for most patients and families. This study aims to determine the availability and variability of price estimates for pediatric anterior cruciate ligament (ACL) reconstruction in the United States.

Methods: From July to August 2020, investigators called 102 hospitals using a standardized telephone script to impersonate the parent of an uninsured child with a torn ACL for whom ACL reconstruction was recommended. The 51 “top-ranked” hospitals according to the 2020-2021 US News and World Report rankings and one “non-top-ranked” hospital randomly selected from each state and the District of Columbia were included as study subjects. Hospital, surgeon, and anesthesia price estimates; availability of a self-pay discount; and the number of calls and days required to obtain price estimates were recorded for each hospital. Hospitals were compared on the basis of ranking, teaching status, and region.

Results: Only 31/102 (30.3%) hospitals provided a complete price estimate. 52.9% of top ranked hospitals were unable to provide any price information versus 31.4% of non-top-ranked hospitals ($p = 0.027$). The mean complete price estimate for top-ranked hospitals (\$34,910; range \$17,848-\$76,394) was higher than for non-top-ranked hospitals (\$25,207; \$12,558-\$46,649) ($p = 0.07$). The mean complete price among hospitals in the Northeast region was greater than that of the Midwest, South, and West regions (\$41,812, \$33,925, \$21,400, and \$20,490, respectively) ($p = 0.023$). 39 hospitals specified a self-pay discount, but not all could disclose exact dollar or percentage discounts. The mean total self-pay dollar discount offered by top-ranked hospitals (\$18,305; \$8,299-\$28,111) was larger than that of non-top ranked hospitals (\$9,902; \$6,907-\$12,524) ($p = 0.011$). An average of 3.1 calls (range 1-12) over 5 days (range 1-23) were needed to obtain price estimates.

Conclusions: Healthcare costs for pediatric sports medicine procedures are difficult to obtain, even for the educated consumer. Top-ranked hospitals and hospitals in the Northeast region charge more than their counterparts. Self-pay discounts can be massive, likely creating an information disadvantage for the unaware patient.

Significance: This study is the first to examine availability and variability of healthcare cost in pediatric sports medicine and the first to assess availability and magnitude of self-pay discounts, setting expectations for the uninsured patient incurring large out-of-pocket expenses.

Pricing Availability Compared Across Hospital Types					p*
	n (%)				
	Complete Price (N = 31)	Hospital Price Only (N = 6)	Surgeon Price Only (N = 8)	No Price Provided (N = 43)	
Ranking					
Top-ranked (51)	14 (27.5)	4 (7.8)	0 (0)	27 (52.9)	0.027
Non-top-ranked (51)	17 (33.3)	2 (3.9)	8 (15.7)	16 (31.4)	
Teaching Status					
Teaching hospital (76)	26 (34.2)	5 (6.6)	1 (1.3)	33 (43.4)	0.658
Nonteaching hospital (26)	5 (19.2)	1 (3.8)	7 (26.9)	10 (38.4)	
Region					
Midwest (29)	11 (37.9)	2 (6.9)	3 (10.3)	10 (34.4)	0.451
Northeast (20)	6 (30.0)	1 (5.0)	2 (10.0)	7 (35.0)	
South (27)	7 (25.9)	2 (7.4)	0 (0)	12 (44.4)	
West (26)	7 (26.9)	1 (3.8)	3 (11.5)	14 (53.8)	

*chi-squared analysis between hospitals who provided no price information and hospitals that provided any price information (any combination of hospital, surgeon, and anesthesia prices) using significance $\alpha \leq 0.05$.

Disposal of Unused Opioids Using an At-home Disposal Method

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LOE-Not Applicable-

Purpose: At-home opioid disposal systems have been shown to increase proper opioid disposal following cessation of acute post-operative pain. As part of our Opioid Stewardship Initiative, we sought to improve proper opioid disposal by providing an at-home medication disposal product to all patients prescribed opioids for at home use.

Methods: From May 2019 to May 2020, patients prescribed opioids for acute at-home post-operative pain were given a packet of an at-home disposal product and an educational flyer describing safe at-home storage and disposal methods. Instructions regarding disposal were further iterated by an anesthesiologist during the preoperative. Families with unused opioids at the conclusion of the first post-operative meeting were encouraged to dispose of these opioids and given a reminder call two weeks after following up on opioid disposal.

Results: 452 packets of the at-home disposal product were distributed. There were 355 encounters with unused opioids who were followed up. Of these 338 (95%) ultimately disposed of their unused opioid. All but 10 families used the at-home disposal product (328, 92%) as provided. A total of 97 were excluded from final analysis due to surgery cancellation (20), failure to follow-up (39), never filled prescription (21) and used all of the prescribed medication (17).

Conclusions: Providing an at-home disposal product is a viable method of ensuring proper disposal of unused opioids. The combined cost of the disposal packet plus the instructional flyer was \$1.90 per patient. Additional efforts are being undertaken to evaluate whether follow-up reminder calls at 2 weeks can be simplified to be included in the post-operative follow-up call to increase parent/guardian adherence

Significance: Providing an at-home disposal product is a viable method of ensuring proper disposal of unused opioids.

Opioid Use in Children and Adolescents Following Common Orthopaedic Surgeries

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LOE-Therapeutic-Level II

Purpose: The use and misuse of opioid medications is an epidemic and public health emergency by the Centers for Disease Control. Pain control is an important component of post-operative care following orthopaedic surgery and opioid medications are commonly prescribed. The purpose of this study is to describe the average opioid use among adolescents following common orthopaedic surgeries.

Methods: Patients between 5 and 20 years of age undergoing one of 7 common orthopaedic surgeries (posterior spinal fusion for adolescent idiopathic scoliosis (PSF AIS), epiphysiodesis, closed reduction and percutaneous pinning (CRPP) of supracondylar humerus fracture, ACL reconstruction, knee arthroscopy, shoulder arthroscopy for labral repair, and hip arthroscopy for femoroacetabular impingement) were prospectively enrolled in this IRB-approved study. All patients received either hydrocodone-acetaminophen 5-325mg tablets or hydrocodone-acetaminophen 7.5-325mg/15mL elixir for post-operative pain control. Patients and their families completed a medication logbook to track all doses of pain medication and associated pain scores.

Results: 340 patients completed the medication logbook, including 172 females and 168 males with a mean age of 14.0 years (range 5 – 20 years). A total of 9796 tablets and liquid doses of the narcotic pain medication were prescribed, with an average of 28 tablets or liquid doses per person. 98% of patients filled the prescription. The mean number and range of hydrocodone tablets and elixir consumed and remaining at the end of treatment and VAS pain scores at the time the patients consumed the pain medication are listed in the figure below. A total of 4297 tablets or liquid doses of the narcotic medication were consumed. Fifty-six percent of the prescribed medication remained unused. Three hundred and two patients (92%) were either very satisfied or satisfied with their pain control. Two-hundred and three patients (60%) reported one or more side effects from the hydrocodone, with the most common being drowsiness and constipation.

Conclusions: Opioid medication use in children and adolescents following orthopaedic surgery is significantly less than the quantity of tablets prescribed, with 56% of the medication prescribed remaining unused in the post-operative period. Based on the results of our study, our institutional recommendations for prescribing are the sum of the mean plus 1 standard deviation. In these patients, that would have resulted in a decrease in 2,402 doses of narcotic medications.

Significance: We recommend orthopaedic surgeons responsibly prescribe pain medications using evidence-based data or the results of their own experience monitoring medication consumption.

Procedure	# Patients	#Prescribed mean, median (range)	#Consumed mean, SD (range)	Mean % Unused	VAS Pain Mean, SD
PSF AIS	48	61, 50 (30 - 150)	33, 21 (4 - 113)	46	5.3, 1.5
Epiphysiodesis	54	20, 20 (6 - 40)	7, 6 (0 - 28)	65	5.3, 2.2
CRPP Supracondylar Fx	42	18, 18 (6 - 40)	8, 5 (0 - 26)	54	5.7, 1.8
ACL Reconstruction	52	29, 30 (20 - 60)	14, 14 (2 - 54)	52	6.0, 1.9
Knee Arthroscopy	57	21, 20 (10 - 30)	8, 6 (0 - 24)	57	5.6, 1.9
Hip Arthroscopy	52	28, 30 (20 - 30)	7, 5 (0 - 20)	75	6.3, 1.5
Shoulder Arthroscopy	35	25, 20 (15 - 50)	13, 13 (0 - 37)	50	5.1, 1.7

Perioperative steroid use in patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis

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LOE-Therapeutic-Level III

Purpose: Surgeons have been hesitant to use steroids in patients undergoing PSF for AIS for fear of wound complications. Recent literature has supported the use of postoperative steroids in other areas of orthopaedics, touting more rapid recovery and improved postoperative pain management. We hypothesized that using a short course of postoperative doses of dexamethasone following PSF for AIS would result in lower opioid usage without increasing wound healing problems.

Methods: Consecutive patients undergoing PSF for AIS from 2015-2018 at a single hospital were reviewed for patient demographics, curve characteristics, surgical data, and post-operative records were reviewed. Opioid usage was determined by converting all postoperative opioids given into morphine equivalents (MsEq).

Results: Sixty-five patients underwent posterior spinal fusion for the treatment of AIS without postoperative steroids (the NS group), and 48 patients were managed with 3 doses of postoperative steroids (the WS group) (median, 8.0 mg/dose). There was no difference between the groups in terms of curve magnitude, number of vertebrae fused, or estimated bloodloss. There was a 39.6% decrease in total MME used and a 29.5% decrease in weight-based MME used in the group receiving postoperative steroids (82.0 mg [1.29 mg/kg] in the NS group versus 49.5 mg [0.91 mg/kg] in the WS group); $p < 0.001$). This difference persisted after accounting for gabapentin, ketorolac, and diazepam usage; surgical time; curve size; levels fused; and number of osteotomies (median decrease, 0.756 mg/kg [95% CI, 0.307 to 1.205 mg/kg]; $p = 0.001$). Three patients in the NS group (4.6%) and 4 patients in the WS group (8.3%) developed wound dehiscence requiring wound care ($p = 0.53$). One patient in the NS group required surgical debridement for the treatment of an infection. Patients in the WS group were more likely to walk at the time of the initial physical therapy evaluation (60.4% versus 35.4%; $p = 0.013$).

Conclusions: A short course of postoperative steroids after posterior spinal fusion was associated with a 40% decrease in the use of opioids, with no increase in wound complications. Surgeons may consider the use of perioperative steroids in an effort to decrease the use of postoperative opioids following posterior spinal fusion for the treatment of AIS.

Significance: Surgeons should give consideration to the use of perioperative steroids in an effort to decrease the use of postoperative opioids following PSF for AIS.

Reducing Intraoperative Radiation Exposure During Periacetabular Osteotomy: The Use of Flat Panel Detector Fluoroscopy

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LOE-Therapeutic-Level III

Purpose: The Periacetabular Osteotomy (PAO) is a technically demanding procedure that requires precise intraoperative evaluation of pelvic anatomy for reorientation of the acetabulum. Fluoroscopic images pose a radiation risk to operating room staff, scrubbed personnel, and the patient. The purpose of this study was to determine the difference in radiation dosage and intraoperative acetabular correction assessment using a Standard Fluoroscope with an Image Intensifier (SFII) and a novel Fluoroscope with Flat Panel Detector (FPD) C-Arm.

Methods: A retrospective review of 57 patients who underwent PAO at a single institution was performed. The total radiation exposure dose (mGy) was recorded for each case from the SFII fluoroscope (n=29; 1/1/2019-12/31/2019) and the FPD C-Arm (n=28; 1/1/2020-8/21/2020). Intraoperatively, the pelvis was centered in terms of rotation and tilt, and an anteroposterior (AP) fluoroscopic view of the operative hip was printed and lateral center edge angle (LCEA) was measured using a goniometer. The six-week postoperative AP pelvis supine radiograph LCEA was also evaluated (Figure 1). Average radiation dose and intraoperative and six-week postoperative LCEA measurements were compared between SFII and FPD groups. 3° was identified as a clinically significant difference between measures.

Results: A total of 57 patients (95% female) with a mean age of 17.55 years (SFII) and 17.71 years (FPD) were included. The SFII fluoroscope averaged total radiation exposure to be 410.1 mGy, while the FPD C-Arm averaged 94.05 mGy. We saw a decrease of 316.05 mGy (77.07%) between groups ($p < 0.000$). The average difference between intraoperative and 6-week postoperative LCEA measurement was 0.24° for the SFII cohort and 0.29° for the FPD cohort. Finally, the average six-week postoperative LCEA measurement was 34.21 (SFII) and 35.18 (FPD).

Conclusions: Use of fluoroscopy with FPD technology decreased the total radiation dose exposure intraoperatively and did not produce differences in intraoperative assessment of LCEA compared to postoperative imaging. An FPD fluoroscope has the potential to decrease direct radiation due to a digital wider field of view necessitating less fluoroscopic imaging per case, which is consistent with our results. Both cohorts were corrected to LCEA within appropriate limits seen on 6-week postoperative imaging and based on intraoperative assessment, the FPD fluoroscope appears to produce similar quality images as a standard fluoroscope.

Significance: Decreasing radiation exposure to young patients is imperative to reduce the risk of future comorbidities. Further study is necessary to develop an ideal protocol to reduce radiation exposure to young patients, while still providing adequate image quality and surgical correction.

Lowering radiation dose to children with hip dysplasia through a change in radiograph technique

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LOE-Diagnostic-Level III

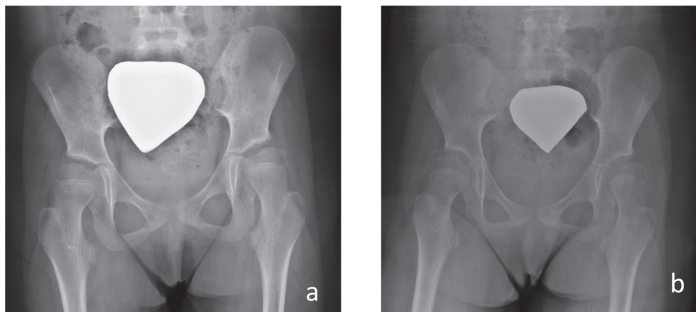
Purpose: To examine whether radiation exposure to children receiving radiographs to monitor hip dysplasia can be decreased without compromising measurement accuracy. Treatment decisions for hip dysplasia require multiple serial radiographs to monitor acetabular anatomy. However, radiation use creates concern for future malignancy. Standard radiograph technique utilizes a grid placed over the plate to absorb scatter and enhance clarity, but requires a larger x-ray dose to compensate for the grid. We hypothesized that removing the grid would not change the inter-rater and intra-rater agreement but decrease radiation exposure to patients.

Methods: Retrospective cohort study of patients with idiopathic and neuromuscular hip dysplasia at a single institution from 2019 through 2020 receiving surveillance radiographs. A cohort receiving modified technique radiographs (grid removed) was compared to an age-matched cohort receiving standard technique radiographs. Four examiners (3 fellowship trained pediatric orthopaedic surgeons and 1 pediatric orthopaedic APRN) measured radiographs on two separate occasions, a minimum of 2 weeks apart. Migration percentage (MP) was measured for neuromuscular patients and acetabular index (AI) for the idiopathic patients. AI was measured using both lateral margin and sourcil landmarks. Intra-class correlation coefficient (ICC) with a 95% confidence interval (CI) was used to evaluate inter-observer and intra-observer agreement for measurements. Patients were excluded if they had prior osteotomies. Average radiation dose for both techniques was calculated by a physicist.

Results: 134 age-matched patients (range 2-18 years) were included for measurement of MP. 30 age-matched patients were included for AI measurements (range 18 months – 5 years). The inter-rater reliability for MP was not different with ICC 0.93-0.98 without grid compared to 0.95-0.98 with grid. Intra-rater reliability for MP was not different (ICC 0.86-0.99 without grid compared to 0.85-0.99 with grid). Inter-rater reliability for AI was not significantly different with ICC 0.92-0.96 without grid compared to 0.70-0.92 with grid. Intra-rater reliability for AI was not significantly different with ICC 0.79-0.98 without grid compared to 0.68-0.96 with the grid. There was a roughly 50-75% decrease in radiation dose per radiograph following grid removal, dependent on patient size.

Conclusions: The adjusted radiograph technique showed no significant difference in MP or AI reliability. A slight decrease in picture contrast did not jeopardize measurement reliability and decreased radiation exposure for the patient by 50-75%.

Significance: A simple change to radiograph technique caused no change to inter-rater and intra-rater reliability while significantly decreasing the radiation exposure to the patient and can be useful for patients requiring multiple radiographs over time.



AP pelvis radiographs of a 10 year old girl with cerebral palsy using standard technique (a) and modified technique with no grid (b). There is a decrease in contrast, but landmarks for measurement are still visible with a significant decrease in radiation exposure for the patient.

Does Surgical Experience Decrease Radiation Exposure in the Operating Room?

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LOE-Therapeutic-Level III

Purpose: Although risk of radiation exposure due to equipment variables has been studied, there is little known about the risk associated with surgeon characteristics. The aim of this study was to determine whether there is a relationship between years of surgical experience and total dose of radiation used for a common pediatric procedure with intraoperative fluoroscopy.

Methods: A retrospective cohort study was performed of patients presenting with a supracondylar humerus (SCH) fractures treated with closed reduction and percutaneous pinning (CRPP) at a Level I pediatric trauma center between the years 2016-2019. For each procedure, information pertaining to radiation dosage was gathered including fluoroscopic time, total images acquired, and dose area product (DAP). Descriptive statistics were calculated, and linear and negative binomial regression were used to evaluate the effect of surgeon experience on the outcome variables.

Results: A total of 759 pediatric patients treated by 17 attending surgeons were included. The median surgeon experience was 8.94 years (interquartile range (IQR): 5.9 – 19.8). Increased number of pins was associated with increased DAP ($p < 0.001$) and decreased years of experience ($p = 0.025$). An operator extremity was visible in at least one saved image in 263 (34.7%) cases. There was a significant increase in fluoroscopy time in seconds (56.9 vs. 42.1 s, $p = 0.001$), DAP (179.9 vs. 110.3 mGy-cm², $p = 0.001$), use of magnification (39.5 vs 31.9 s, $p = 0.043$) and total number of shots (74.5 vs. 57.6, $p = 0.008$) in attending surgeons with less than 1 year of experience compared to those with greater experience.

Conclusions: Increased surgical experience was significantly associated with decreased fluoroscopy usage, including time, number of images, and dose. Surgeons use significantly more radiation and fluoroscopy time during their first year as an attending than in the years afterward.

Significance: Intraoperative fluoroscopy is a requirement in the age of minimally-invasive surgery, and while it is irreplaceable in terms of intraoperative guidance, it can also increase radiation exposure to the surgical staff. This study contributes that there may be elevated use of radiation in a surgeon's first year post-fellowship, revealing an opportunity for improved fellowship training.

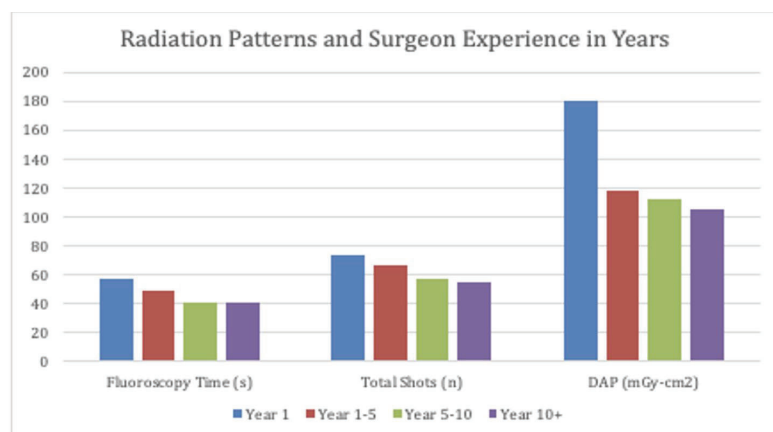


Figure 1: Decreasing fluoroscopy time, total shots taken, and DAP (dose area product) by surgeons with gradually increasing years of experience. Each variable with appropriate units in parentheses.

Methods for Reducing Intra-Operative Breast Radiation Exposure in Orthopaedic Surgeons

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LOE-Not Applicable-

Purpose: We hypothesize that traditional lead vests and vests with cap sleeves do not provide significant protection to the upper outer quadrant (UOQ) of a female surgeon's breasts as compared to no lead. We hypothesize that long sleeves or an axillary supplement added to traditional lead vests will significantly decrease intra-operative breast radiation.

Methods: An anthropomorphic torso phantom with breast attachments (simulating the female surgeon) was placed adjacent to a standard operating table. Dosimeters were placed bilaterally over the upper outer quadrant of the breast. Scatter radiation dose equivalent rates (mrem/hr) were measured during continuous fluoroscopy of a pelvic phantom (simulating the patient). Five protection scenarios (no lead, lead vest, vest with wings, vest with long sleeves, and vest with axillary supplements), two surgeon positions (facing the table and perpendicular to the table), and two C-arm positions (anteroposterior and cross-table lateral projection) were tested. Kruskal-Wallis tests were used to evaluate differences in radiation exposure based on method of lead protection for each scenario.

Results: Pooling data across all scenarios, standard lead vests ($p=0.42$) and lead vests with wings ($p=0.10$) did not statistically decrease intra-operative radiation exposure to the upper outer quadrant of the breast compared to no lead. Long sleeves ($p=0.04$) and an axillary protection supplement ($p=0.04$) statistically reduced intra-operative radiation to the UOQ of the breast as compared to standard lead vest. The mean exposure to the UOQ of the breast was 124 mrem/hr with no lead protection, 97 with a lead vest, 59 with wings, and 1 mrem/hr with long sleeves or an axillary supplement.

Conclusions: The UOQ of the breast, the most common site of breast cancer, is not adequately protected by a traditional lead vest in common intra-operative scenarios. When a cross-table lateral c-arm image is acquired or when the surgeon is facing perpendicular to the table, long sleeves or an axillary supplement significantly reduce radiation exposure to the breast.

Significance: Pediatric orthopaedic surgeons may feel falsely protected from intra-operative breast radiation with traditional lead garments as current lead garments do not protect the female breast well. Breast cancer prevalence has been shown to be elevated (2.9X) in female orthopaedic surgeons and greater intra-operative protection might be helpful in decreasing this risk. (Chou LB et al. Increased breast cancer prevalence among female orthopedic surgeons. J Womens Health 2012)



Healthcare disparities after implementation of standardized care pathway for adolescent idiopathic scoliosis patients undergoing spinal fusion

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LOE-Prognostic-Level III

Purpose: Racial disparities exist in healthcare leading to inferior surgical outcomes based on racial variability. Studies have found black children have higher rates of mortality, postoperative complications, and adverse events than white children after controlling for preoperative risk factors. While the underlying cause of these disparities remains elusive, identifying effective approaches to reduce these disparities is needed. Standardized care pathways have demonstrated improved outcomes in the idiopathic scoliosis (AIS) population but the effect on racial healthcare disparities is unknown. The purpose of this study was to evaluate how the establishment of a standardized care pathway impacts disparities on the basis of race within our patients undergoing posterior spinal fusion (PSF) for AIS.

Methods: A standardized care pathway developed using LEAN process mapping for patient undergoing AIS for PSH was instituted at our institution in 03/2015. We evaluated racial variations in outcomes for these patients before and after implementation of our AIS care pathway, with the primary outcome: length of stay (LOS), and secondary outcomes: perioperative transfusion rate, pain scores, and post-operative complications. Linear and logistic regression models were used to compare outcome means across race/ethnic group, outcome disparities were measured by between-group variance; and disparities were compared between pre-PSH and post-PSH.

Results: 424 patients underwent PSF at our institution between 7/1/13-8/5/19 and were included in the study, 116 in the pre-pathway and 308 in the post-pathway group. In the pre-pathway group, after adjusting for age, deformity magnitude, surgical lag time, ASA class, weight, and insurance status we found significant differences in LOS between white and black patients (5.3 vs. 5.8 days, $p=0.05$), significantly higher pain levels on POD 1 and POD 2 in the "other" group compared to white patients (4.9 vs. 3.8, $p=0.040$; 5.8 vs. 4.2, $p=0.012$, respectively), and significantly higher perioperative transfusion rate in Asian compared to white patients (100% vs 37%, $p=0.04$). No racial variations in outcomes were found in the post-pathway group. Across all racial categories there was a significant decrease of 74% ($p=0.012$) in LOS disparity and 83% ($p=0.002$) in perioperative transfusion disparity between the pre and post-pathway.

Conclusions: Our study demonstrates the implementation of a standardized care pathway reduces racial disparities in LOS and perioperative transfusion in pediatric patients undergoing PSF. Standardized, evidence-based pathways appear to reduce differences in the surgical outcomes of these patients.

Significance: Implementation of a standardized, evidence-based care pathway for pediatric patients undergoing PSF appears to reduce healthcare disparities in the outcomes of these patients.

Perceived physician empathy in pediatric orthopedics: a cross-sectional study

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LOE-Not Applicable-

Purpose: Empathy is the cornerstone of the patient-physician relationship and is consistently ranked by patients as one of the most important factors in the quality of their care. In this project we examine the degree to which perceived physician empathy is determined by the characteristics of the caregiver (parent or legal guardian) and physician. This is the first paper to examine such a relationship in a pediatric orthopedic population.

Methods: This was a cross-sectional survey study of two hundred English-speaking caregivers of pediatric patients at a large children's hospital from March 1, 2017 to November 1, 2018. Caregivers completed a demographic survey, a wait time questionnaire, the Newest Vital Sign, the Literacy in Musculoskeletal Problems survey, the Consultation and Relational Empathy (CARE) Measure, and the Consumer Assessment of Healthcare Providers and Systems Clinician and Group survey. The CARE Measure was used to determine perceived physician empathy.

Results: The factors with significant associations on univariate analysis were the caregiver's estimate of how long they waited (p-value = 0.0230), if the physician was rushed during the visit (p-value < 0.001), the general health literacy of the caregiver (p-value = 0.007), if the caregiver was of Hispanic or Latino descent (p-value = 0.004), if during the visit the physician explained things in a way that was easy to understand (p-value < 0.001), listened carefully (p-value < 0.001), gave easy to understand information (p-value < 0.001), knew the important information about the medical history, showed respect for what the caregiver had to say (p-value < 0.001), and spent enough time with the patient (p-value < 0.001). In the multivariate linear regression, only if the caregiver felt carefully listened to by the physician (p-value < 0.001), and if the physician showed respect for what the caregiver had to say (p-value < 0.001) was statistically significant. This model explains 58.1% of the variation in CARE scores.

Conclusions: The most significant determinant of perceived physician empathy is whether the caregiver felt listened to during the encounter. This accounts for over half of the variation in empathy scores. Caregiver demographics, health literacy, self-rated mental health, wait time, and time spent with the physician do not significantly affect perceived physician empathy.

Significance: This study demonstrates that caregivers still value a physician who listens to their story. Even though the physician may know the diagnosis before entering the room, it is still important to let the caregiver tell their story and to demonstrate active listening.

Table 1. Multivariate linear regression for perceived physician empathy

<u>Risk Factor</u>	<u>Estimate (SE)</u>	<u>P-value</u>
Did the provider give you easy to understand information about health questions or concerns? yes vs not	1.7 (2.1)	0.423
Did the provider listen carefully to you? yes vs not	11.4 (2.1)	<0.001
Hispanic or Latino descent vs not	-2.1 (1.3)	0.124
Did this provider show respect for what you had to say? yes vs not	6.6 (2.4)	0.007
Self-rate mental health as excellent vs not	2.2 (1.2)	0.061

SE = standard error

Efficacy of Virtual Reality in Pain Reduction in Orthopedic Pediatric Patients Measured by Patient Feedback and Heart Rate Monitoring

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LOE-Therapeutic-Level II

Purpose: Pediatric orthopedic patients are frequently exposed to procedures that can result in pain and anxiety. There is a trend to avoid opioid medications when alternative therapies are available. Distraction techniques such as virtual reality (VR) have been studied in the context of hematology-oncology and burn patients for pain reduction, however the technology is novel in the pediatric orthopedic field.

Methods: Pediatric patients between age 5 and 18 years presenting to a tertiary center pediatric orthopedic clinic for post-injury care were included if they had no significant co-morbidities and were not undergoing an emergent procedure. Patients undergoing cast removal, fracture reduction/splinting, or percutaneous pin removal were prospectively enrolled. All pre-procedure parameters for the groups were kept similar. Intervention consisted of an immersive and interactive VR application involving both visual and audio stimuli. Continuous heart rate (HR) monitoring and post-procedural Visual Analog Scale (VAS) scores were used for outcome measurements. Primary outcome variable was HR difference between peak HR and baseline. VAS scores used as secondary outcome variable. Patients were informed and consented about the requirements, risks, and benefits.

Results: 95 patients (66 M, 29 F) met inclusion criteria and were enrolled in the study 48 patients in the VR cohort and 47 in the control group. Average patient age in the VR cohort was 10.2 years with an average heart rate change of $10.6 \text{ bpm} \pm 10.1$. The average patient age in the control group was 10.6 years with an average heart rate change of $18.5 \text{ bpm} \pm 11.0$. 59 patients underwent cast removal, 26 cast applications, 7 hardware removals, and 3 fracture reductions. A greater magnitude in heart rate change was observed in the control group compared to VR group ($p = .0024$). A lower perceived anxiety was also observed in the VR group (1.6) compared to controls (2.9) after the procedure.

Conclusions: The findings from our study suggest an interactive and immersive VR experience can be effective in reducing pain and anxiety for procedures in pediatric orthopaedic clinics. The benefits of avoiding narcotic use, while reducing the morbidity associated with untreated pain, epitomize improvement of patient care through technology.

Significance: Use of virtual reality during pediatric orthopaedic clinic procedures can decrease patient anxiety leading to decreased need for opiates and other sedating medications used to decrease pain and anxiety.

Cast Saw Alarm System Reduces Blade to Skin Contact

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LOE-Not Applicable-

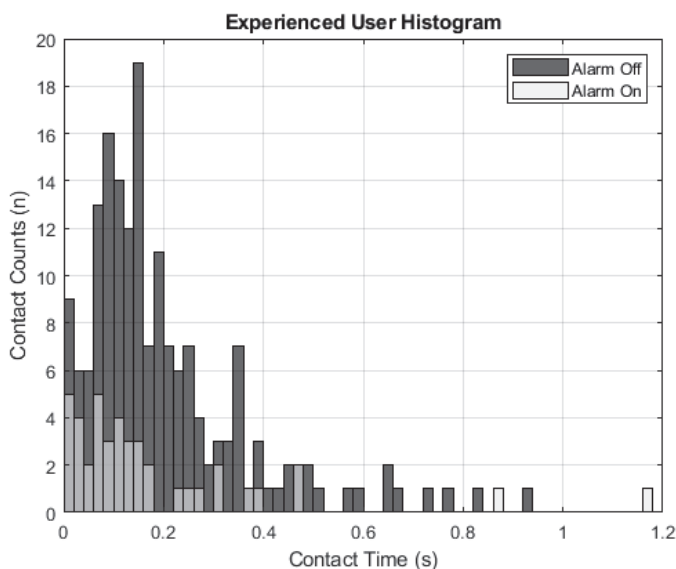
Purpose: To determine the effectiveness of a novel cast saw alarm system to minimize the number and duration of cast saw blade to skin contact.

Methods: 20 orthopaedic residents removed a pair of long-arm casts applied to instrumented pediatric upper extremity models. The model and cast saw were instrumented to detect blade to “skin” contact at a rate of 600Hz. Each resident performed cast removal with and without the use of a cast saw alarm, the order of which was randomized. Five additional “new” cast saw users then removed pairs of casts, without and then with the cast alarm, to evaluate what effect the alarm would have on preventing blade to skin contact in users with no previous cast saw experience. The number and duration of cast saw touches were then evaluated. Statistical significance was determined with a 1 sided students t-test (number of touches) and Wilcoxon Rank Sum (touch time).

Results: For the residents (n=20), the total number of blade-to-skin contacts was 229, 177 blade-to-skin contacts without the alarm and 52 with the alarm (70% reduction) ($t(19)=0.84$, $p=0.001$), averaging 6.25 more blade-to-skin contacts per cast without the alarm. The median blade to skin contact duration was 0.148s without the alarm and 0.108s with the alarm (27% reduction) median contact time ($p=0.028$) (Figure 1). For the inexperienced users (n=5), the total number of blade-to-skin contacts was 193, 176 blade-to-skin contacts without the alarm and 17 with the alarm (90% reduction) ($t(4)=1.10$, $p=0.0466$), averaging 31.8 more blade-to-skin contacts without the alarm. The median blade to skin contact duration for the novice was 0.338s without the alarm and 0.238s with the alarm (30% reduction). Median contact time was not significantly decreased for the inexperienced group ($p=0.088$), however alarm use significantly reduced the number of touches >0.5 seconds (59 vs. 3) in this group, $p=0.0468$.

Conclusions: Blade to skin contact can be reduced with the use of a cast saw alarm. These effects appear most exaggerated in users with little prior cast saw experience.

Significance: This study demonstrates that the cast saw alarm decreases the number and duration of cast saw blade to skin contacts. This in vitro work supports further clinical testing of this novel technology.



Comparison of Commercially Available Cast Protectors

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LOE-Not Applicable-

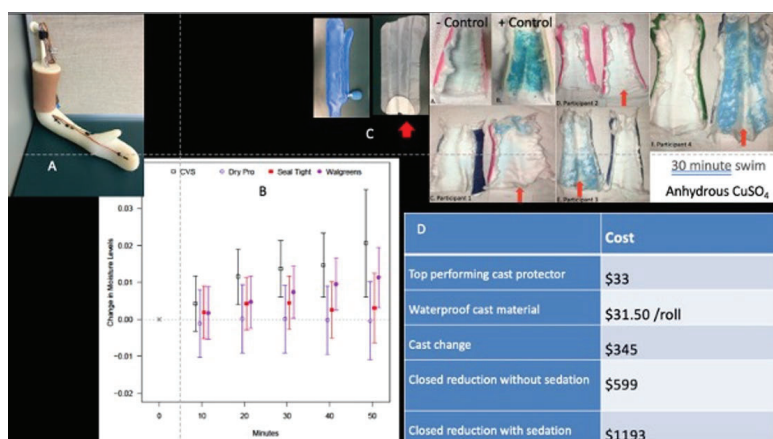
Purpose: The “wet cast” continues to be a clinical nuisance, costly to repair, and a source of patient and physician morbidity. Waterproof cast materials are not feasible in all clinical settings. The efficacy of various commercially available brands of cast protectors for use during water-based activity remains unknown. The purpose of this study was to determine if there are differences in the rate and extent of moisture exposure for four commercially available cast protectors.

Methods: A mechanized arm model was developed with four implanted humidity sensors. Cast protectors were applied over the mechanized arm, and the model was submerged in water with movement back and forth to simulate cast-wearers’ motion. Humidity data were recorded for successive 10-minute trials up to 50 minutes. Trials were analyzed using a mixed effects linear model to determine change in humidity over time. To validate and confirm the model results in “real life” scenarios, the best and worst performing cast protectors were then placed over short arm casts applied to four adult volunteers prior to thirty minutes of swim activities. Questionnaires regarding comfort of the protectors during swimming and a qualitative assessment of cast wetness using a chemical color indicator (anhydrous copper sulfate) were obtained.

Results: 372 instances of sensor data from 96 10-minute trials was collected. The CVS and Walgreens brands showed significant increases in humidity beginning at 20 minutes and 30 minutes, respectively. Both Sealtight and DryPro showed no significant increase in moisture level up to 50 minutes. In successive trials up to 120 minutes, DryPro showed only a 2% increase in moisture. In human subjects testing, 3/4 casts underneath CVS protectors had wetness-related color changes indicative of requiring a cast change, compared to 0/4 casts underneath DryPro protectors. Participants completed questionnaires and reported similar comfort and ease of application for each protector.

Conclusions: Significant differences exist between commercially available cast protectors. Vacuum-sealed protectors performed best in both mechanical and human subject testing.

Significance: Vacuum-sealed protectors appear superior to other designs, allowing minimal change in humidity even after extended periods of sequential water immersion. Their cost is notably less than management of a wet cast. Lower-performing products may place uninformed cast-wearers at an increased risk of wet cast complications.



(A) Model Arm with Humidity Sensors. (B) Change in Humidity with Time of submerged mechanized “swimming”. (C) Best and Worst Performing Protectors and visual results of human testing. (D) Charges associated with a wet cast.

Post Operative Scoliosis X-Rays - Before Discharge or First Follow Up

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LOE-Not Applicable-

Purpose: There is a debate among scoliosis surgeons on the usefulness of postoperative radiographs before discharge after posterior spinal fusion (PSF) for idiopathic scoliosis. The purpose of this study was to evaluate any differences between a group of patients where the first postoperative radiograph taken prior to discharge (Group 1) and a matched group where the first radiograph was taken at the first postoperative visit (Group 2) with regards to coronal and sagittal radiographic parameters at short term follow-up defined as a follow up more than 3 months and less than a year post operatively.

Methods: After IRB approval, we performed a retrospective review of consecutive patients with a diagnosis of idiopathic scoliosis undergoing PSF at a single institution. Demographic and clinical data was collected at the time of surgery. Radiographic parameters, including coronal (6) and sagittal (1) measures, were recorded preoperatively, at first postoperative radiograph (Group 1 average, 2.1 days; Group 2 average, 4.0 weeks), and at short term follow-up (6 month average, both groups). Patients without complete sets of radiographs were excluded. Paired t-tests were used to determine significant differences between measures at each perioperative visit. Unpaired t-tests were used to determine significant differences between groups. Because of the large number of radiographic measurements and the number of statistical tests conducted, significance was set at $P < 0.01$ to lower overall error rates.

Results: From 2015 to 2018, we identified 87 patients with idiopathic scoliosis undergoing PSF. Adequate radiographs were unavailable for 28 patients, with 59 patients meeting inclusion criteria for the study (Group 1, 35 patients; Group 2, 24 patients). Demographics and preoperative radiographic parameters were similar between groups. For the entire cohort there was only a significant change in one coronal measurement from immediate postoperative radiograph to short term x-ray ($p=.006$). For Group 1, there were no statistically significant changes between any measurements from immediately postoperative to short term. For Group 2 there was 1 coronal parameter that was statistically different from immediate postoperative radiograph to short term, but this was not felt to be clinically significant.

Conclusions: Immediate postoperative radiographs taken before discharge give an accurate depiction of scoliosis correction with no significant change in any parameter at short term follow-up.

Significance: Based on the results of this study, all surgeons now get immediate postoperative radiographs prior to discharge. This standardizes care at our institutions and allows for the first postoperative follow up to be done remotely.

Radiographic Parameters for Whole Cohort with Inter-visit Comparison

	Mean (Range)	<i>P</i>		
		Pre/I-Po	Pre/St-Po	I-Po/St-Po
Major Cobb (<i>n</i> =59)		<0.0001	<0.0001	0.02
Preoperative (Pre)	64.9 (45.2 – 116.0)			
Immediate Postoperative (I-Po)	29.3 (16.4 – 74.8)			
Short-term Postoperative (St-Po)	30.7 (17.5 – 71.0)			
C7 to CSVL (<i>n</i> =59)		0.002	<0.0001	0.006
Preoperative	17.1 (0.0 – 42.5)			
Immediate Postoperative	11.5 (0.0 – 54.1)			
Short-term Postoperative	7.2 (0.0 – 22.3)			
Thoracic Apex to C7 Plumb (<i>n</i> =59)		<0.0001	<0.0001	0.9
Preoperative	40.6 (3.6 – 68.1)			
Immediate Postoperative	15.0 (0.0 – 44.7)			
Short-term Postoperative	15.2 (0.0 – 36.3)			
Thoracic Apex to CSVL (<i>n</i> =59)		<0.0001	<0.0001	0.3
Preoperative	42.2 (0.0 – 90.5)			
Immediate Postoperative	12.9 (1.4 – 38.6)			
Short-term Postoperative	11.8 (0.0 – 33.5)			
Thoracolumbar-Lumbar Apical Translation (<i>n</i> =59)		0.002	<0.0001	0.2
Preoperative	22.4 (0.0 – 70.7)			
Immediate Postoperative	15.0 (0.0 – 32.7)			
Short-term Postoperative	13.8 (0.0 – 42.6)			
T1 Tilt Angle (<i>n</i> =59)		0.6	0.7	0.1
Preoperative	6.0 (0.0 – 16.9)			
Immediate Postoperative	6.5 (0.0 – 16.7)			
Short-term Postoperative	5.7 (0.0 – 13.4)			
Lateral C7 to Sacrum (<i>n</i> =59)		0.0006	0.02	0.07
Preoperative	33.9 (1.0 – 79.5)			
Immediate Postoperative	22.5 (1.0 – 61.0)			
Short-term Postoperative	27.5 (0.0 – 84.0)			
Trunk Shift (<i>n</i> =53)		<0.0001	<0.0001	0.05
Preoperative	20.0 (0.0 – 46.6)			
Immediate Postoperative	9.7 (0.0 – 31.4)			
Short-term Postoperative	7.5 (0.0 – 22.2)			

Major Cobb and T1 Tilt Angle are measured in degrees, all other measures are in millimeters
 Bold values indicate statistical significance at *P* < 0.01

Zero Patient-Controlled Analgesia is an achievable target for postoperative rapid recovery management of Adolescent Idiopathic Scoliosis patients

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LOE-Therapeutic-Level III

Purpose: Narcotics have been used in complex spine surgeries for pain control, administered as patient controlled analgesia (PCA) during postoperative recovery and as take home medication. This study reports on the use of single bolus micro-dose intrathecal morphine (ITM) during Posterior Spinal Fusion (PSF) for Adolescent Idiopathic Scoliosis (AIS) and its comparison to patients whose pain was controlled with PCA. We hypothesize that intrathecal single micro-dose Duramorph can replace PCA in a rapid recovery pathway (RRP) protocol after scoliosis surgery.

Methods: In 2018, we instituted RRP for scoliosis patients undergoing PSF utilizing micro dose ITM. Prior to this, PCA was the mainstay for pain management. In the ITM protocol, patients receive 1.5 mcg/kg ITM diluted in 1 cc saline administered preoperatively by anesthesiologists or intraoperatively by surgeons. Postoperatively, patients received IV ketorolac at 0.5mg/kg Q6h, PO Tylenol (15 mg/kg q6h), PO Oxycodone (0.1 mg/kg q4), and breakthrough IV Hydromorphone (15 mcg/kg). At discharge, PCA patients received 14-day prescriptions for 5mg Oxycodone q6 versus 7-day prescriptions in the ITM group. AIS patients undergoing PSF from 2011 – 2019 reviewed. PCA patients in Group 1 and ITM in Group 2. Perioperative data analyzed using Kruskal-Wallis and Chi-squared tests.

Results: 198 PCA and 98 ITM patients. Major Cobb angles ($p = 0.195$), levels fused ($p = 0.481$) and BMI ($p = 0.978$) were similar. 84% of patients in group 1 had a length of stay greater than four days versus 12.6% of patients in group 2 ($p < 0.001$). Group 2 patients had sig lower pain scores at activity ($p < 0.001$) and total morphine consumption ($p < 0.001$) versus group 1 ($p < 0.001$). Time to ambulation, time to first stool, time to first fluid intake and time to foley catheter removal were sig earlier for ITM patients ($p < 0.05$). No patients had pruritus, respiratory depression, or required supplemental oxygenation.

Conclusions: Micro-doses of ITM with oral analgesics have significantly better postoperative pain control and superior perioperative outcomes to PCA in the AIS population following PSF. This supports our hypothesis that single micro-dose ITM may supplant PCA. From perspective of safety and quality of care, this implementation can alleviate risk for opioid addiction and encourage more efficient recoveries from invasive spine deformity procedures.

Significance: This is the first study to show that use of micro-dose ITM with oral analgesics have adequate recovery, significantly better postoperative pain control, and superior perioperative outcomes to PCA in the AIS population following PSF.

Establishing a Gold Standard for Estimation of Blood Loss During Spine Surgery

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LOE-Diagnostic-Level II

Purpose: Blood loss (BL) during spinal fusion for scoliosis may be estimated using a wide variety of unproven techniques. Patient care and research on BL is likely impacted by a lack of standardization. A novel FDA-approved blood volume (BV) analysis system (BVA-100 Blood Volume Analyzer) allows rapid processing and repeat testability with >97% accuracy. The purpose of this study was to investigate common methods to identify a gold standard for estimation of BL.

Methods: BV assessment was performed with the BVA-100. After obtaining a baseline sample of 5 mL of blood, 1 mL of I-131-labeled albumin was injected intravenously over 1 min. Five milliliter blood samples were then collected at 12, 18, 24, 30, and 36 min post-injection, and plasma volume was measured by extrapolating to time zero. Intravenous fluid was minimized over the duration of each blood sampling interval in order to minimize variability and maintain euvolemia. Salvaged blood was not administered during surgery. BL was calculated for each patient based on four methods based on change in Hct: the Waters Formula, Gross equation, the Bourke and Smith equation, and the Camarasa formula. BL was estimated volumetrically by measuring the amount of salvaged blood and multiplying this number by a factor of 3 (CS3EBL). Finally, estimates by the surgeon, anesthesiologist, and nurse were evaluated.

Results: 30 AIS patients were included in this analysis with median [interquartile range (IQR)] age and weight of 14 [13, 15] years and 55.8 [46.1, 65.3] kg, respectively. Major curves of 54° [49°, 62°] and underwent fusions of 10 [6, 12] levels with 3 [2, 3] osteotomies. Blood loss based on the BVA-100 (BVABL) was 519.2 [322.9, 886.2] mL. BVABL was correlated to levels fused ($r=0.53$, $P < 0.001$), number of osteotomies, ($r=0.61$, $P < 0.001$), and length of surgery ($r=0.56$, $P = 0.001$). The Waters, Gross, Bourke/Smith, and Camarasa formulas and team member estimates all failed to approximate BVABL. CS3EBL approximates BVABL well with a Spearman correlation coefficient and ICC of 0.80 and 0.72, respectively.

Conclusions: Formulaic approaches including the Waters, Gross, Bourke/Smith, and Camarasa techniques do not approximate true surgical blood loss. Multiplying the cell saver volume by 3 had the highest correlation coefficient and ICC suggesting that this straight forward technique may be the best method currently available for BL estimation.

Significance: Surgeons should carefully evaluate their techniques for blood loss estimation. Simply multiplying the cell saver by 3 may be a simple and easily standardized method.

Table 1. Similarities between Blood Loss Estimates

	BVA Blood Loss	Cell Saver x 3 Blood Loss	Waters Blood Loss	Gross Blood Loss	Bourke/Smith Blood Loss	Camarasa Blood Loss	Surgeon Subjective Blood Loss	Anesthesiologist Subjective Blood Loss	Circulator Subjective Blood Loss
Volume (ml)	519.2 [322.9, 886.2]	390.0 [165.0, 648.8]	302.0 [120.0, 418.8]	282.7 [103.2, 369.2]	258.7 [96.0, 334.5]	261.5 [117.2, 528.6]	300.0 [200.0, 390.0]	262.5 [150.0, 368.8]	200.0 [150.0, 255.0]
Spearman's Correlation Coefficient With BVA Blood Loss	--	0.80	0.75	0.55	0.58	0.56	0.69	0.53	0.52
Intraclass Correlation Coefficient With BVA Blood Loss	--	0.72	0.34	0.25	0.24	0.46	0.31	0.18	0.11
Limits of Agreement With BVA Blood Loss	--	[-600.2, 287.8]	[-800.4, 184.3]	[-1008.1, 272.9]	[-1016.8, 225.9]	[-907.5, 365.5]	[-874.1, 279.2]	[-972.3, 321.1]	[-840.5, 491.2]

Volume noted in median [interquartile range]. BVA = Blood Volume Analyzer (Daxor, Inc)

ePOSTERS

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Biomarkers for Prediction of Skeletal Disease Progression in Mucopolysaccharidosis Type I

Klane White, MD; Troy Lund; Terence Doherty; Julie Eisengart; Rebecca Freese; Kyle Rudser; Ellen Fung; Bradley Miller; Paul Orchard; Chester Whitley; Lynda Polgreen
Seattle Children's Hospital, Seattle, WA

ePoster 2

Single Cell Expression Analysis of Pediatric Cartilage Demonstrates Unique Signatures for Articular and Physeal Chondrocytes

Donna Pacicca, MD; Tammy Brown; Jeffrey Johnston; Emily Farrow
Children's Mercy Hospital, Kansas City, MO

ePoster 3

Primary cilia disturbances in the physes of immature hypothyroid mini-swine

Ashley Mohrman, PhD; Erica Reber; Fayez Safadi; Mark Adamczyk, MD
Akron Children's Hospital, Akron, OH

ePoster 4

Is the Lateral Cuneiform Large Enough to Support Interference Screw Fixation for Tibialis Anterior Tendon Transfer in Children Aged 3 to 6 Years?

Jordan Polk; Jacob Zide, MD; Yassine Kanaan; Zachary Meyer; Anthony Riccio, MD
Scottish Rite for Children, Dallas, TX

ePoster 5

Prenatal Counselling for a Suspected Clubfoot Diagnosis Reduces Parental Anxiety During the Corrective Phase of Ponseti Treatment

Maryse Bouchard, MD; Leah Hatcher
The Hospital for Sick Children, Toronto, ON, Canada

ePoster 6

Predictive Ability of Clinical and Radiographic Findings For Detecting Tarsal Coalition

Kianna Nunally; Collin May MD; Patricia Miller MS; Jodie Shea;
Benjamin Shore, MD, MPH, FRCSC
Boston Children's Hospital, Boston, MA

ePoster 7

The Scapholunate Interval in the Pediatric Population Decreases in Size as Age Increases

Timothy Shaver; Alexandria Case; Danielle Hogarth; Joshua Abzug, MD
University of Maryland School of Medicine, Baltimore, Maryland

ePoster 8

A Novel 'Starfish' Flap for Syndactyly Release: Technique and Early Results

Rameez Qudsi, MD; Kevin Little, MD
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ePOSTERS

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Hip Arthroscopy Following Slipped Capital Femoral Epiphysis Fixation: Early and Progressive Chondrolabral Damage

*Javier Besomi, MD; Valeria Escobar; Santiago Alvarez; Juan Jose Valderrama; Jaime Lopez; Claudio Mella; Carlos Tobar; Joaquin Lara; Claudio Meneses, MD
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ePoster 10

Subjectively Reported Hip Function and Activity Levels Weakly Correlate with Objective Temporospacial Parameters in Adolescent Patients Before and After Hip Preservation Surgery

*Wilshaw Stevens; Lauren Luginsland; David Podeszwa, MD; Kirsten Tulchin-Francis, PhD
Scottish Rite for Children, Dallas, Texas*

ePoster 11

Validation and initial results of international web-based survey of adults who had childhood Legg-Calvé-Perthes disease (LCPD)

*Harry Kim, MD; Bella Vakulenko-Lagun; Molly McGuire; Earl Cole; Roi Almakias; Michael Millis, MD
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ePoster 12

A Biomechanical Analysis of The Surface Contact Pressure After An Innominate Osteotomy For The Correction Of Acetabular Dysplasia

*Emmanuel Gibon, MD; Mackenzie Roof; Pablo Castaneda, MD
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ePoster 13

The Importance of Globalization in Prospective Study Groups: Increasing the Relevance of Research on Developmental Dysplasia of the Hip to a Global Patient Population

*Emily Schaeffer, PhD; Alaric Aroojis; Hitesh Shah, MD; Venkatadass Krishnamoorthy; Sandeep Patwardhan, MD; CHITTA SAHU; Kishore Mulpuri, MD
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ePoster 14

Patients With Ehlers-Danlos Syndrome Who Undergo Periacetabular Osteotomy for Symptomatic Hip Instability Report Sustained Improvements At Two Years Comparable To Those Observed in Patients Without Ehlers-Danlos Syndrome

*Patrick Whitlock, MD; Nicholas Auteri; Sydney Herold; Rachel Breitenstein; Molly Uchtman; James McCarthy, MD
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ePoster 15

Femoral Head Coverage should be included in treatment protocols for Graf IIa Developmental Dysplasia of the Hip

*Margaret Siobhan Murphy-Zane, MD; Patrick Carry; Kaley Holmes; Brian Kohuth, PA-C; Debbie Burke PA; Tyler Freeman; Matthew Belton; Nancy Miller, MD; Gaia Georgopoulos, MD
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ePOSTERS

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Mountain or Mole Hill: The Clinical Significance of Infolded Labrum on Post-Reduction Arthrogram in Developmental Dysplasia of the Hip

William Morris, MD; Sai Susheel Chilakapati; Sean Hinds; John Herring, MD; Harry Kim, MD

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ePoster 17

Oncological and Functional Outcomes in Joint Sparing Resections of the Proximal Femur for Malignant Primary Bone Tumors

Dipak Ramkumar; Sean Kelly; Santiago Lozano Calderon; Mark Gebhardt, MD; Megan Anderson, MD

Boston Children's Hospital, Boston, MA

ePoster 18

Are "Quick" MRI scans reliable for diagnosis of pediatric peri-pelvic musculoskeletal infections?

Jarrett Warden; Ian Kuckelman; Scott Hetzel; Pamela Lang, MD; Laura Bellaire, MD; Kenneth Noonan, MD

University of Wisconsin, Madison, WI

ePoster 19

Diffuse Tenosynovial Giant Cell Tumors: Case Series From a Large Pediatric Orthopaedic Hospital

Ryan Guzek; Max Cornell; Jie Nguyen; Alexandre Arkader, MD

Children's Hospital of Philadelphia, Philadelphia, PA

ePoster 20

Guided Growth Treatment can improve Depression of the Medial Tibial Plateau in Infantile Blount Disease –An update

Regina Hanstein; Chris Schneble; Jacob Schulz, MD; Adrienne Socci, MD;

Melinda Sharkey, MD

Montefiore Medical Center, Bronx, NY

ePoster 21

Infantile Blount Disease: Radiographic Predictors of Spontaneous Resolution

Regina Hanstein; Chris Schneble; Jacob Schulz, MD; Adrienne Socci, MD;

Melinda Sharkey, MD

Montefiore Medical Center, Bronx, NY

ePoster 22

Creation and Validation of a "Shorthand" Knee MRI Bone Age Assessment Tool as an Alternative for Skeletal Maturity Assessment

Carey Politzer; James Bomar, MPH; Hakan Pehlivan, MD; Preet Gurusamy;

Eric Edmonds, MD; Andrew Pennock, MD

Rady Children's Hospital, San Diego, San Diego, California

ePOSTERS

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◆ Novel application of the internal, magnetically-controlled, telescopic nail to the extramedullary femur in the skeletally immature patient: Early results.

Katherine Rosenwasser; Nickolas Nahm, MD; Philip McClure, MD; John Herzenberg, MD; Shawn Standard, MD
Sinai Hospital of Baltimore/Lifebridge Health, Baltimore, Maryland

ePoster 24

Predictions of the Amount of Growth Remaining in the Lower-Limb

Kyung Rae Ko; Jong Shim, MD; Jaesung Park
Samsung Medical Center, Seoul, Korea, Republic of

ePoster 25

Multicenter Series of Deformity Correction using Guided Growth in the Setting of Osteogenesis Imperfecta

Jeanne Franzone, MD; Maegen Wallace, MD; Kenneth Rogers, PhD; Elizabeth Strudthoff; Richard Kruse, DO; Darko Anticevic
Nemours Alfred I. duPont Hospital for Children, Wilmington, DE

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Contractures in Cerebral Palsy and Brachial Plexus Birth Injury Are Similarly Caused by Short, Weak Muscles

Roger Cornwall, MD; Sia Nikolaou; Jason Long; Kendra Eckstein
Cincinnati Children's Hospital, Cincinnati, OH

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Better Understanding the Orthopaedic Burden of Neurosurgical Hemispherectomy in Pediatric Patients

William Belshe; Nicholas Gajewski; Rachel Thompson, MD
University of California, Los Angeles, Los Angeles, CA

ePoster 28

Nutrition Consult in the Year Leading up to Neuromuscular Scoliosis Surgery: Helpful Tool or Self-Inflicted Wound?

Ariana Meltzer-Bruhn; Matthew Landrum, MD; David Spiegel, MD; Patrick Cahill, MD; Jason Anari, MD; Keith Baldwin, MD
Children's Hospital of Philadelphia, Philadelphia, PA

ePoster 29

Reliability and Utility of a Novel Classification Scheme for Gait Deviations in Children with Persistent Idiopathic Toe Walking

Jon Davids, MD; Sancy Childers, BA; Sean Brown, BS; Anita Bagley, PhD; Vedant Kulkarni, MD
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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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The Stability of Sagittal Plane Gait Patterns from Early Childhood to Maturity in Cerebral Palsy

Bidzina Kanashvili, MD; Freeman Miller, MD; Jason Howard, MD; Julieanne Sees, DO; Kenneth Rogers, PhD; Chris Church; Nancy Lennon, MS; John Henley; Timothy Niiler; M Shrader, MD
Nemours - Alfred I duPont Hospital for Children, Wilmington, DE

ePoster 31

Effect of Positioning Error on the Hilgenreiner Epiphyseal Angle and Head-shaft Angle Compared to the Femoral Neck-shaft Angle in Children with Cerebral Palsy

Emily Sullivan; Carly Jones; Stacey Miller; Kyoung-Min Lee; David Wilson; Kishore Mulpuri, MD; Agnes D'Entremont
BC Children's Hospital, Vancouver, BC, Canada

ePoster 32

Factors Associated with Gross Motor Recovery during Rehabilitation Following Single-Event Multilevel Surgery (SEMLS) for Youth with Cerebral Palsy

M Shrader, MD; Nancy Lennon MS; Isabel Biermann; Grace Gerry; Jason Beaman; Nicole Mamula; Abigail Gilmore; Timothy Niiler; Laura Owens
Nemours duPont Hospital for Children, Wilmington, DE

ePoster 33

Baseline Patient Reported Outcomes Measurement Information System (PROMIS) Scores in Children with Adolescent Idiopathic Scoliosis (AIS) and Their Relation to the SRS-22

Daniel Bouton, MD; Graham Fedorak, MD; Donna Oeffinger; Purnendu Gupta, MD; Scott Luhmann, MD; Peter Stasikelis, MD; Michal Szczodry; Vishwas Talwalkar, MD; Man Hung
Shriners' Hospitals for Children, Tampa, FL

ePoster 34

Proof of Concept for Artificial Intelligence Based Estimation of Skeletal Maturity from Biplanar Slot Scan Scoliosis Imaging

Audrey Ha; Bao Do; Joanna Langner; Andrew Champion; Charles Fang; Michael Fadell; Steve Dou; Safwan Halabi; Emily Wang; YongJin Lee; Japsimran Kaur; John Vorhies, MD
Stanford University, Stanford, CA

ePoster 35

Surgical Site Infection Following Neuromuscular Posterior Spinal Fusion: Comparing Incidence Before and After the 2013 Best Practice Guideline

Stephen Stephan; Kenneth Illingworth, MD; Kavish Gupta; Lindsay Andras, MD; David Skaggs, MD, MMM
Children's Hospital Los Angeles, Los Angeles, CA

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ePoster 36

National Trends in Performing Osteotomies for AIS in North America: Greater Incidence Is Associated with Significant Complications and Greater Cost

*Kiley Poppino; Chan-Hee Jo; Daniel Sucato, MD, MS
Texas Scottish Rite Hospital for Children, Dallas, TX*

ePoster 37

Evaluation of the AOSpine Injury Classification in the Pediatric Population: Results of a Multi-Center POSNA Grant

*Daniel Hedequist, MD; Nora O'Neill; Andrew Mo; Patricia Miller, MS; Craig Birch, MD; Vidyadhar Upasani, MD; G Li, MD; Nicholas Fletcher, MD; Walter Krengel, MD; Sumeet Garg, MD; Anthony Riccio, MD; David Spence, MD; Jennifer Bauer, MD; Michael Glotzbecker, MD
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ePoster 38

Cervical Degenerative Disc Disease is Associated with Increased Cervical Kyphosis in Adolescent Idiopathic Scoliosis

*Kenneth Illingworth, MD; Adrian Lin; David Skaggs, MD, MMM; Lindsay Andras, MD; Vernon Tolo, MD
Children's Hospital Los Angeles, Los Angeles, CA*

ePoster 39

Characterizing Mortality in Patients with Early Onset Scoliosis

*Ryan Guzek; Robert Murphy, MD; Christina Hardesty, MD; John Emans, MD; Sumeet Garg, MD; John Smith, MD; George Thompson, MD; Benjamin Roye, MD; Michael Glotzbecker, MD; Peter Sturm, MD; Brian Snyder, MD; Selina Poon, MD; Connie Poe-Kochert; Pediatric Spine Study Group; Jason Anari, MD
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ePoster 40

A Wireless Intraoperative Neuromonitoring System is as Reliable and Accurate as the Traditional Wired Systems for Spinal Deformity Surgery

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Comparative analysis of Post-op Motion between Spinal Fusion and VBT

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Can Bone Health Improvement from the Initial 2-Year Calcium and Vit-D Supplementation Persist Towards Peak Bone Mass after 4-Year of Supplement Discontinuation in Adolescent Idiopathic Scoliosis – A Randomized Controlled Trial

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University of Maryland School of Medicine, Baltimore, Maryland

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Joaquín Nuñez De Armas, MD; Vidyadhar Upasani, MD; Luis Moraleda Novo, MD;

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Craig Birch, MD; Donald Bae, MD; Patricia Miller, MS;

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Boston Childrens Hospital, Boston, MA

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Nathan Markiewitz; Divya Talwar; Sachin Gupta; Apurva Shah, MD;

John (Jack) Flynn, MD

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Three-dimensional predictors of FAI disease progression in the contralateral hip

Lucas Fowler; John Clohisy, MD; Wahid Abu-Amer; Cecilia Pascual-Garrido;

Jeffrey Nepple, MD

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Biomarkers for Prediction of Skeletal Disease Progression in Mucopolysaccharidosis Type I

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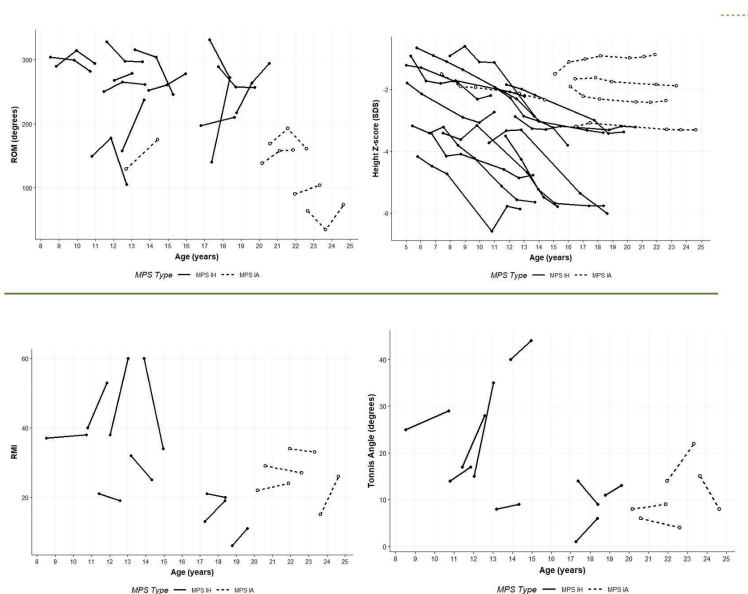
Purpose: Orthopedic disease progresses in individuals with mucopolysaccharidosis type I (MPS I), even with approved therapies. Intractable orthopedic disease remains a major factor in persistent suffering and disability, thus novel therapies and accurate predictors of response are urgently needed. The primary objective of this study was to identify surrogate biomarkers of future change in orthopedic disease for application in testing novel therapies.

Methods: As part of a 9-year observational study of individuals with MPS I, range-of-motion (ROM) and height were measured annually (ROM years 5-9; height years 2-9). Biomarkers in years 1 and 2 were compared to those from a group of healthy controls. Tonnis Angle, Reimers Migration Index (RMI), and Tonnis Grade were measured from anterior-posterior pelvic radiographs. Linear regression tested for associations of change in biomarkers over the first year with change in ROM and height.

Results: Nineteen MPS I participants, 5-16 years, who were on average 6.9±2.9 years post-treatment initiation were compared with 51 healthy controls, age 9-17 years. Plasma IL-1β, TNF-α, osteocalcin, pyridinolines (PYD) and deoxypyridinolines were higher in MPS compared to controls. Within MPS, a 1 pg/ml increase in IL-6 was associated with -22 degrees/year change in ROM (95% CI: [-28, -15]; p<0.001) and a 20 nmol/mmol creatinine/year increase in urine PYD was associated with a -0.024 SDS/year change in height Z-score ([-0.043, -0.005]; p=0.016). Progression of hip dysplasia was present in 46% (N=6) by RMI and 77% (N=10) by Tonnis angle. Change in urine PYD was associated with change in RMI (95% CI -3.8 to -0.1; p=0.037).

Conclusions: Levels of inflammatory cytokines are high in MPS I. IL-6 and PYD were associated with progression in joint contracture, short stature and hip dysplasia over time. Once validated, these biomarkers may prove useful for predicting response to treatment of joint contractures or growth in MPS I.

Significance: Once validated as predictive of long-term response to a therapy aimed at treating the joint and skeletal manifestations of MPS I, these biomarkers could be used for predicting outcomes in both clinical practice and clinical trials.



SINGLE CELL EXPRESSION ANALYSIS OF PEDIATRIC CARTILAGE DEMONSTRATES UNIQUE SIGNATURES FOR ARTICULAR AND PHYSEAL CHONDROCYTES

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Purpose: Investigators are using single cell transcriptome analysis (scRNAseq) to better characterize cells and functions in skeletal tissues, primarily relying on rodent models. We have devised a reliable method for isolation of primary human chondrocytes from discarded surgical samples. We hypothesize scRNAseq will identify novel chondrocytic cell types in articular and physeal cartilage.

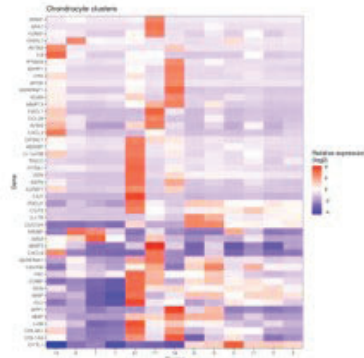
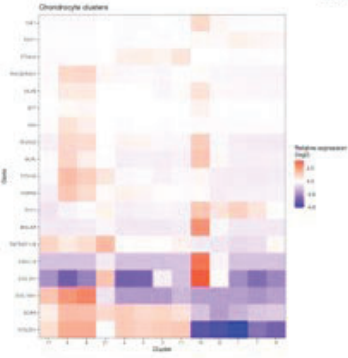
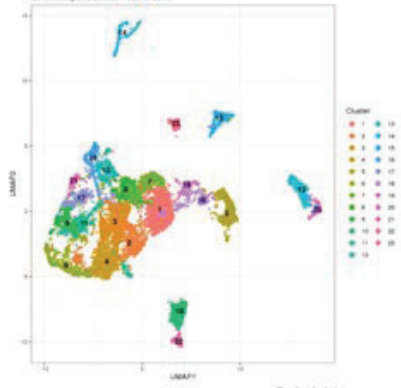
Methods: Deidentified discarded polydactyly samples from healthy pediatric patients were obtained from elective orthopaedic surgeries. Samples were digested to remove mineral and cells. After isolation ~10,000 cells were targeted for single cell mRNA capture and subsequent sequencing using the 10X Chromium system. Individual libraries were processed and aggregated using Cell Ranger v3.0.2 with normalization disabled. Cells with greater than 10% mitochondrial reads were excluded. Remaining cells were processed and clustered by Seurat v3 workflow. Cells did not cluster by library, indicating no sample batch effect in clustering. To refine analyses COL2A1 expression was used to positively select for chondrocytes.

Results: A total of 4 individual samples (all female) were used for analysis. The positive COL2A1 selection resulted in 23 subclusters of chondrocytes (9943 cells). CHI3L1 and CYTL1, associated with articular cartilage, are upregulated in subclusters 3 and 8. COL2A1, ACAN and PTHLH are upregulated in 2 and 4. PTHLH, GREM1 and OPG are upregulated in 11. THY1, EXT1, STMN1, G0S2 and MSMP are upregulated in 1 and 7. COL10A1, FGFR3, IHH are upregulated in 6, 9 and 17. COL1A1, IGF1, CXCL12, BGLAP, RUNX2, DLX5, ASPN and SPP1 are upregulated in 16, which also demonstrated upregulation of PTGS2, SEPP1, TPM1.

Conclusions: Based on our data, subclusters 3 and 8 represent articular chondrocytes. 1 and 7 represent resting zone, while 2, 4 and 11 are early proliferative zone. 6, 9 and 17 are hypertrophic zone. Importantly, we show that 16 represents a cartilage to bone cell, which may be key to temporal regulation of growth. Unique mesenchymal precursor genes such as PTGS2, SEPP1 and TPM1 are also upregulated in this subcluster, adding further support as a transitional cell. IGF1 upregulation suggests that subcluster 16 also stimulates chondrocyte proliferation.

Significance: ScRNA analyses of primary human chondrocytes resulted in identification of both articular and physeal cartilage cell types. We demonstrate evidence of a transitional state for cells at the physis-metaphysis interface. This subcluster likely plays a regulatory role in longitudinal growth of the physis via IGF1-mediated chondrocyte proliferation. This could lead to novel targeted strategies for physeal disorders and dysplasias.

Chondrocyte clusters - 9,243 cells



Primary cilia disturbances in the physes of immature hypothyroid mini-swine

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Purpose: We used a reversible mini-swine model of hypothyroidism to study changes to the primary cilia in the growth plate (GP). This model has been previously shown to generate GP pathology similar to slipped capital femoral epiphysis (SCFE). We hope to relate ciliary alterations to altered endochondral ossification in disease states such as SCFE.

Methods: Sinclair mini-swine were split into healthy control (n=3) or hypothyroid (HypoTH; n=3) groups at 11 weeks of age. The HypoTH swine were orally fed propylthiouracil daily while the control swine received placebos for 15 weeks. The hindlimb GPs were surgically removed from euthanized swine and split for qPCR, μ CT and histological analyses. Real time PCR was used to quantify key chondrocyte genes. Histology samples were stained with Safranin O for glycosaminoglycans then total GP height and zone heights were measured. Acetylated α -tubulin antibody immunostaining was used to measure cilia length and directional characteristics. The contralateral proximal tibia was scanned using μ CT. Bone volumes distal to GP were analyzed in the ImageJ plugin BoneJ for trabecular characteristics. Group means were compared using a Student's T-test, any p-value < 0.05 was considered significant.

Results: Obvious differences were observed in HypoTH GP histology compared to healthy controls. A gross disorganization of chondrons as well as a lack of a clear hypertrophic zone occurred was observed in HypoTH GPs. Chondrocytes were spaced farther apart, however, extracellular matrix markers assessed by qPCR had lower expression levels compared to control group. Indeed morphometric measures revealed increased resting but a greatly decreased hypertrophic zone fraction only in the HypoTH GPs. In the proliferative zone, cilia were longer and directionally more diverse in HypoTH samples than controls. Thicker and highly spaced trabeculae were measured in the μ CT scans of HypoTH tibiae, leading to an increased bone volume fraction.

Conclusions: Hypothyroidism disrupts bone lengthening and indeed our data show evidence of GP disruption in mini-swine that corroborates published literature. We observed evidence of retardation of hypertrophy in GP chondrocytes that coincided with thicker, highly spaced trabeculae. We believe that changes in primary cilia, including longer cilia and disturbed orientation, are related to the slow of the natural progression of chondrocytes through proliferative and hypertrophic stages.

Significance: Using a large animal model with kinematics closer to humans, we believe our findings may be more clinically relevant. Through observation of ciliary alterations, we can better understand disorganization of the growth plate in disorders such as SCFE.

Control

HypoTH

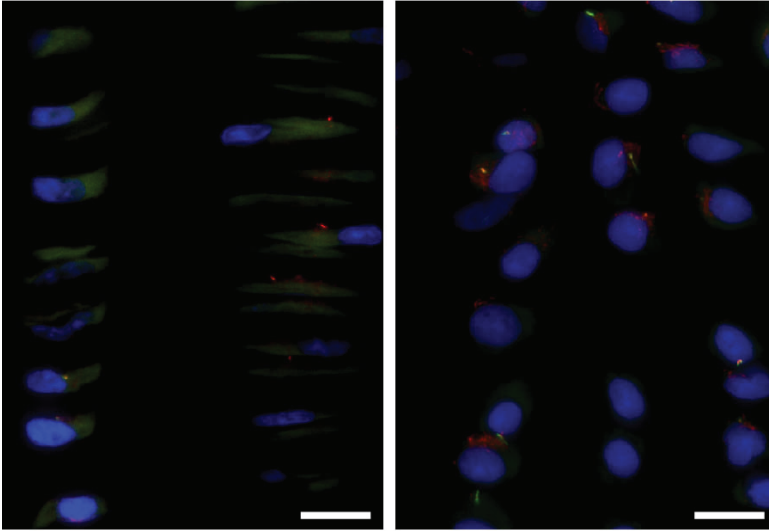


Figure 1: Primary cilia were longer and disorganized in the HypoTH group, shown here dual stained with acetylated tubulin (red) and ARL13b (green). Nuclei in blue; scale = 10 μm .

Is the Lateral Cuneiform Large Enough to Support Interference Screw Fixation for Tibialis Anterior Tendon Transfer in Children Aged 3 to 6 Years?

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Purpose: While transfer of the tibialis anterior tendon (TAT) to the lateral cuneiform (LC) following serial casting has been used for over 60 years to treat relapsed clubfoot deformity, modern methods of tendon fixation remain largely unstudied. Though interference screw fixation has the potential of obviate concerns of pressure necrosis and proper tendon tensioning associated with plantar button suspensory stabilization, a better understanding of lateral cuneiform morphology in young children is a necessary first step in assessing the viability of this fixation technique. The purpose of this investigation is therefore to define lateral cuneiform morphology in children aged 3-6 years.

Methods: A retrospective radiographic review of 40 healthy pediatric feet aged 3-6 years who had either MRI or CT scans was performed at a single pediatric hospital. The length, width and height of only the ossified portion of the LC were measured digitally using sagittal, coronal and axial imaging. In addition, the maximal cross-sectional diameter of the TAT was measured at the level of the tibiotalar joint.

Results: Average ossified LC width ranged from 8.5mm in the 3-year old cohort to 10.3mm in 6-year old children. While the average width increased with each year of age, ANOVA testing revealed no statistically significant difference in width between age groups ($p=0.091$). Average ossified LC length ranged from 13.5mm in the 3-year old cohort to 18.3mm in 6-year old children with statistically significant increases in age all groups separated by two or more years ($p=0.017$). The TAT to ossified LC width ratio ranged from 44% to 53% across age groups. (Table 1)

Conclusions: The ossification center of the lateral cuneiform is of sufficient width, height and length to accommodate a variety of commercially available interference screws in children aged 3-6 years. Assuming central bone tunnel preparation that matches TAT diameter with line to line screw fixation, 47%-56% of the LC width and 70%-74% of the LC height would remain intact to circumferentially support interference screw fixation following TAT transfer.

Significance: The dimensions of the lateral cuneiform ossification center are large enough to allow interference screw fixation in children 3 to 6 years of age.

Table 1. Lateral Cuneiform and Tibialis-Anterior Tendon Measurement Averages by Age

Age (years)	Number of Feet	Length (mm)	Width (mm)	Height (mm)	Tendon Diameter (mm)
3	7	13.5 (11.9-15.6)	8.5 (6.5-9.6)	11.1 (8.1-13.7)	4.0 (3.7-4.1)
4	13	15.1 (7.4-18.6)	8.8 (6.6-10.4)	15.0 (13-16.8)	3.9 (3.2-4.4)
5	12	16.8 (13.8-19.9)	9.1 (6.5-12.9)	14.6 (9.6-17.3)	4.4 (3.9-5.2)
6	8	18.3 (17.1-21.2)	10.3 (8.8-14.4)	15.8 (13.1-18.4)	5.5 (4.8-6.4)

Prenatal Counselling for a Suspected Clubfoot Diagnosis Reduces Parental Anxiety During the Corrective Phase of Ponseti Treatment

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Purpose: Clubfoot is increasingly identified during prenatal obstetric screening. When suspected, parents may be referred for prenatal counselling with a paediatric orthopedic surgeon. We aim to determine if prenatal counselling for parents of infants with confirmed clubfoot deformity at birth reduces parental anxiety regarding their child's diagnosis and comfort during Ponseti treatment.

Methods: This is a retrospective cohort study with prospectively collected survey data of clubfoot patients in an ethics board-approved registry whose parents have completed \geq two Parent Experience Surveys (PES) during their child's clubfoot treatment at a single institution between June 1, 2019 and May 31, 2020. The PES (see Table 1) is administered at routine time points: 1. Initial consultation; 2. Completion of casting prior to tenotomy; 3. Initiation of foot abduction bracing; 4. Transition to nighttime bracing, 5. Annually until age 4 years. PES responses across three groups were compared: parents who knew of their child's potential clubfoot prenatally and received prenatal counselling (Group A), parents who knew of the potential clubfoot diagnosis prenatally but did not receive prenatal counselling (Group B), and parents who did not know of their child's clubfoot until birth (Group C).

Results: Forty patients from the clubfoot registry met inclusion criteria, with 18 assigned to Group A, 11 to Group B, and 11 to Group C. All patients completed a PES at time points 1 and 2, 29 at the third, 13 at the 4th and 2 at the fifth. Parent anxiety scores in all groups decreased significantly between time points 1 and 2 ($p=0.005$), but this decrease in Group 1 was significantly greater than in group 2 ($p=0.046$). There were no significant decreases in anxiety scores at subsequent time points in any group. Neither participant group nor survey time point significantly impacted perceived child comfort scores or total PES survey scores. Treatment satisfaction scores were high across all groups at all time points.

Conclusions: Parental anxiety decreased from initial consultation to conclusion of Ponseti casting prior to tenotomy in all groups regardless of prenatal counselling or prenatal knowledge of the clubfoot. This reduction of parental anxiety was significantly greater in parents who received prenatal counselling compared to those who knew of the clubfoot diagnosis prenatally and did not receive counselling.

Significance: With increasing prenatal detection of clubfoot, encouraging obstetricians to offer prenatal counselling with an orthopaedic surgeon is an important step in preparing and reassuring parents regarding their child's diagnosis and future treatment.

Table 1 - Parent Experience Survey Questions and Scoring

Question	Question	Subsection	Interpretation
1	The shape of my child's foot is now / remains corrected. (Answer only if after tenotomy and casting)	Satisfaction with outcome	High Score = High Satisfaction
2	I am pleased with the shape of my child's foot (Answer only if after tenotomy and casting)		Low Score = Low Satisfaction
3	My child is comfortable undergoing clubfoot treatment	Child comfort during treatment	High Score = High Comfort
4	It is easy to care for my child during clubfoot treatment		Low Score = Low Comfort
5	I am anxious about my child's treatment	Parental anxiety	High Score = Low Anxiety Low Score = High Anxiety
6	I worry about my child's ability to walk, run or play		
7	I miss too much work because of my child's clubfoot treatment		
8	My child's treatment was well explained to me	Satisfaction with care team	High Score = High Satisfaction
9	I feel supported by my SickKids team		Low Score = Low Anxiety

Predictive Ability of Clinical and Radiographic Findings For Detecting Tarsal Coalition

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Purpose: The purpose of this study was to (1) examine the utility of clinical exam findings for detecting tarsal coalition (TC), and (2) analyze the efficacy of plain radiographs for detecting TC, stratified by coalition type.

Methods: We performed a retrospective review of patients (5 – 22years), with bilateral computed tomography (CT) scans of the foot/ankle for suspicion of TC (2011-2019). Presence or absence of coalition on CT was collected, along with clinical exam findings. Multivariable analysis was used to assess associations between patient and clinical exam characteristics and the likelihood of a positive coalition diagnosis. Agreement between x-ray and CT coalition diagnosis was assessed using Fleiss's kappa along with 95% confidence intervals (CIs).

Results: Three hundred thirty-six patients were analyzed with bilateral CTs. The average age at CT was 13 ± 2.85 years (male 50%). Of the 672 feet in the study, 259 (38%) were diagnosed with coalition. Bivariate analysis identified coalitions were more common in younger patients (mean, 12.7 vs. 13.2; $p=0.02$), with lower BMI (mean, 21.9 vs. 22.9; $p=0.03$), males (56% versus 47%; $p=0.02$), feet with pain (86% versus 60%; $p<0.001$), and with limited motion (84% versus 60%; $p<0.001$). Multivariable analysis found that feet with limited motion had 7.3 times the odds of coalition (OR=7.3; 95% CI = 4.3-12.5; $p<0.001$) and feet in male subjects had 1.9 times the odds of coalition compared to feet in females (OR=1.9; 95% CI = 1.2-3.0; $p=0.008$). Based on the multivariable model, predictions for the probability of coalition were calculated (Figure 1). No association was detected between peroneal spasm, recurrent ankle sprains or trauma. X-ray and CT agreed in 87% of cases for an agreement kappa of 0.72 (95% CI = 0.62-0.81) indicating substantial agreement. Of the 69 calcaneonavicular coalitions, 62 (90%) were accurately diagnosed on x-ray as compared to CT ($k = 0.80$; 95% CI = 0.70-0.91). Of the 79 talocalcaneal coalitions, only 52 (66%) were accurately diagnosed on x-ray ($k = 0.63$; 95% CI = 0.52-0.74).

Conclusions: This study demonstrates that TC is associated with limited motion and male sex. The clinical symptoms of recurrent ankle sprain and peroneal spasm are not associated with tarsal coalition as previously thought.

Significance: These findings will help orthopedic providers better understand at risk patients for TC based on clinical examination. Understanding which patients will benefit from a CT scan for diagnosis will decrease practice variation and improve our diagnostic accuracy.

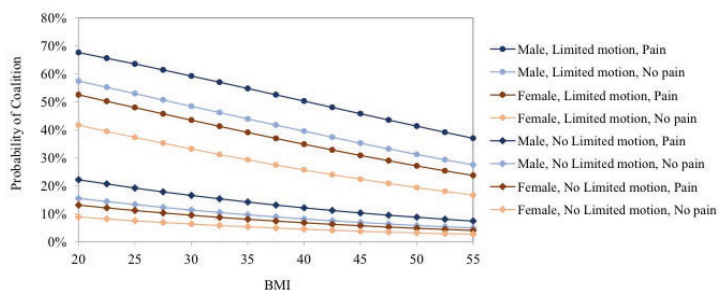


Figure 1. Predicted probabilities of coalition based on the multivariable GEE model for coalition given sex, motion, pain, and BMI.

The Scapholunate Interval in the Pediatric Population Decreases in Size as Age Increases

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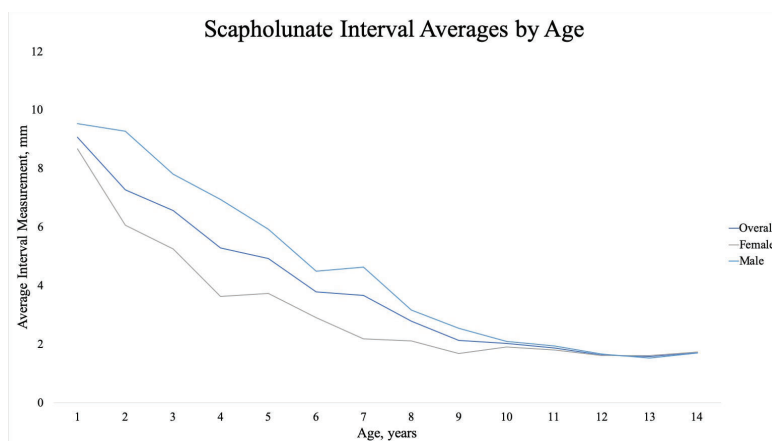
Purpose: Scapholunate instability associated with an injury to the scapholunate ligament can occur as a result of a fall onto an outstretched hand. These injuries are rare in children but nonetheless can occur, especially in the adolescent population. Widening of the scapholunate interval greater than 2 mm is diagnostic of an injury in the adult population. However, the absolute number of 2mm cannot be used in the skeletally immature population due to the ossification of the carpal bones. The purpose of this study was to determine age-appropriate normative values for the scapholunate (SL) interval in the skeletally immature population.

Methods: Imaging databases were queried for pediatric wrist radiographs that were normal. Patient records were cross-referenced to exclude any patients with prior wrist injuries or congenital anomalies. The scapholunate interval was measured as the distance between the scaphoid and lunate at the mid-joint space between the scaphoid and lunate. An initial inter-rater reliability assessment was completed with strong inter-rater reliability. All measurements were reviewed by the senior author to ensure positioning for the radiographs was appropriate regarding assessment of the scapholunate interval. Basic statistical analysis was performed to determine average scapholunate intervals by age.

Results: The scapholunate interval was measured in 529 radiographs of children (276 males, 253 females), aged 4-17. A negative linear correlation between age and distance at the mid-joint space was observed. (Figure 1) Ossifying carpal bones were visible on radiographs in patients as young as four years old. Average values for the scapholunate interval ranged from 9.07 mm to 1.57 mm.

Conclusions: The distance between the scaphoid and lunate decreases with increasing age as the carpal bones ossify. The normative values defined in this study can be utilized to determine if a widening of the scapholunate interval is present in the pediatric population, leading to a diagnosis of a scapholunate ligament injury.

Significance: Having normative values to guide measurement of the scapholunate interval in the pediatric population can help to determine diagnosis of scapholunate ligament injury.



A Novel 'Starfish' Flap for Syndactyly Release: Technique and Early Results

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Purpose: Multiple incisions and flaps have been designed for congenital syndactyly release. Dorsal skin rearrangement is the most common technique to add vascularized flaps to the release. We describe a novel technique, using a 'starfish' dorsal commissure flap, which incorporates a z-plasty advancement of the lateral commissure leaving transverse scars over the metacarpophalangeal (MCP) joints along Langer's lines. This flap is designed to decrease need for skin grafts, and to push graft sites distal in the finger, away from the commissure, when needed.

Methods: The flap presented here is designed with a dorsal star pattern for the commissure instead of a traditional rectangular flap. Its proximal points are placed centrally over each of the 2 involved MCP joints and a standard rectangular commissure is sized to fit $\frac{2}{3}$ - $\frac{3}{4}$ of the length of the proximal phalanx. Lateral wings are drawn with tips in line with the medial and lateral borders of the affected digits. The distal aspect of the commissure flap is broken with a proximal inset to limit transverse scarring. Zig-zag incisions are extended from either distal point of the star dorsally, with mirror-image zig-zag incisions volarly. After separation, the lateral wings are advanced in a z-plasty fashion into the lateral commissure, leaving a transverse scar line dorsally, and the distal flap is inset volarly to create the web. Skin grafts are utilized as needed, typically in the middle-to-distal third of the digits. We present a retrospective review examining early outcomes after utilization of this flap design.

Results: We identified 14 webspaces separated in 9 patients using the Starfish flap design from January 2018-2020. Eight were performed without skin grafts, and 6 required 1-3 skin grafts each, all at the middle or distal phalanx level. Mean follow-up time was 30 weeks (range 3-56 weeks). Early web creep was only seen in 1 patient, after a graftless ring-small partial simple release. Four patients had mild loss of motion, all of whom were atypical or revision cases. One patient, age 10, had mild sensory loss postoperatively which resolved over time.

Conclusions: We report good early outcomes with a low graft rate, no flap necrosis, and only 1 patient with early web creep. Ongoing monitoring is underway for long-term follow-up.

Significance: We present here a novel 'starfish' flap for syndactyly release in children with good early outcomes. This flap is designed to reduce graft and scarring in the lateral commissure, web creep, and overall need for skin graft.



Hip Arthroscopy Following Slipped Capital Femoral Epiphysis Fixation: Early and Progressive Chondrolabral Damage

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Purpose: To describe the association between chondrolabral damage and time to arthroscopy in slipped capital femoral epiphysis (SCFE).

Methods: This was a descriptive prospective study that enrolled patients with SCFE who underwent hip arthroscopy for femoral osteochondroplasty after SCFE fixation. SCFE type, time from SCFE symptom onset or slip fixation surgery to hip arthroscopy, and intraarticular arthroscopic findings were recorded. Acetabular chondrolabral damage was evaluated according to the Konan and Outerbridge classification systems. Nested analysis of variance and the chi-squared test were used for statistical analyses.

Results: We analyzed 22 cases of SCFE in 17 patients (5 bilateral). The average age at the time of hip arthroscopy was 13.6 years, and average time from SCFE fixation to arthroscopy was 25.1 months (range: 3 weeks–8 years). Labral fraying was present in 20 cases, labral tears in 16, and acetabular chondral damage in 17. The most frequent lesion was type 3 (41%) (Konan classification). Two cases had a grade III and 1 had a grade II acetabular chondral lesion (Outerbridge classification). Positive associations were observed between time from SCFE symptom onset to hip arthroscopy, and from time of slip fixation surgery to hip arthroscopy and hip intraarticular lesions evaluated using Konan ($p=0.004$) and Outerbridge ($p=0.000$) classification systems. There was no association between SCFE severity ($X^2=0.315$), stability ($X^2=0.558$), or temporality ($X^2=0.145$) type and hip intraarticular lesions.

Conclusions: A longer time from SCFE symptom onset and fixation to hip arthroscopy is associated with greater acetabular chondrolabral damage.

Significance: This is the first study showing a positive association between intraarticular damage and time to arthroscopy in SCFE. We also found that in young patients, there is a risk of hip osteoarthritis within 3 years of SCFE symptom onset. Because of the early articular chondral damage and deformity of the proximal femur that occurs in young patients with SCFE, arthroscopic femoral osteochondroplasty should be considered at the same time as or as soon as possible after slip fixation.

Subjectively Reported Hip Function and Activity Levels Weakly Correlate with Objective Temporospacial Parameters in Adolescent Patients Before and After Hip Preservation Surgery

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Purpose: To investigate the pre- and post-operative relationship between self-reported hip function and activity levels to commonly measured temporospacial gait parameters in patients undergoing hip preservation surgery.

Methods: Retrospective analysis of data collected as part of a prospective IRB-approved hip preservation surgery registry was conducted in patients with the following diagnoses: acetabular dysplasia (AD), femoroacetabular impingement (FAI), Perthes Disease (PD) and Slipped Capital Femoral Epiphysis (SCFE). Each subject completed patient-reported outcomes (modified Harris Hip Score [mHHS], UCLA and Marx Activity scales) and gait analysis. Temporospacial parameters included cadence, normalized walking speed, stride time, stride length and a symmetry index comparing limbs for step time, step length and percentage of gait cycle in single and double limb support. A higher symmetry index indicates greater asymmetry between limbs. Pre- and post-operative (1- to 3 year follow-up) was analyzed. Spearman's rank correlations (ρ) were run among the mHHS, UCLA, Marx and temporospacial parameters ($\alpha=0.05$).

Results: 196 patients (average age 16 ± 3 ; AD 95, FAI 54, PD 33 and SCFE 14) were included in this analysis. Combining all diagnoses pre-operatively, there was no correlation between mHHS and temporospacial parameters ($p>0.05$). Higher UCLA scores were weakly correlated with faster walking speed ($\rho=0.204$, $p=0.010$) and longer stride length ($\rho=0.208$, $p=0.008$). Higher Marx scores were weakly correlated to reduced single limb support asymmetry (-0.184 , $p=0.019$). Pre-operatively, only the AD patient group had statistically significant correlations which included a weak positive correlation between UCLA and normalized speed ($\rho=0.277$, $p=0.020$) along with stride length ($\rho=0.241$, $p=0.045$). Post-operatively, higher mHHS scores were weakly correlated to shorter step time ($\rho=-0.252$, $p<0.001$) and less single limb support asymmetry ($\rho=-0.258$, $p<0.001$). Higher UCLA and Marx scores were weakly correlated to longer stride length (UCLA $\rho=0.203$, $p=0.005$; Marx $\rho=0.174$, $p=0.017$) and the UCLA was negatively correlated to step time asymmetry ($\rho=-0.165$, $p=0.024$). The AD, Perthes and SCFE patient groups demonstrated weak relationships between mHHS and UCLA to single and double limb support asymmetry while the FAI patient group had a weak correlation to reduced step time asymmetry.

Conclusions: Objective functional measures, including walking speed, longer stride length and limb asymmetry correlated weakly with subjectively reported high hip function and increased activity levels. Subjective, self-reported functional and activity scores may not accurately reflect a patient's function.

Significance: Objective measures of physical function, including basic overall walking parameters, may provide clinicians with a better overall assessment of physical function than patient reported function and activity level in adolescents undergoing hip preservation surgery.

Validation and initial results of international web-based survey of adults who had childhood Legg-Calvé-Perthes disease (LCPD)

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Purpose: LCPD is an uncommon disorder with very limited data on how patients are functioning in adulthood. Most studies report outcomes of <100 adults. The overall purpose of this study was to collect a large cross-sectional sample of adults who had LCPD as children. In this abstract we present the validation and initial results of our web-based survey.

Methods: After IRB approval, English REDCap-based survey was built for web access. The survey included consent, demographics, childhood and adult Perthes history, UCLA activity scale, SF-36, Hip Disability and Osteoarthritis Outcome Score (HOOS), and a body pain diagram. The survey link was available on the International Perthes Study Group website for 15 months and advertised among Perthes support groups. Survey participation was anonymous, but participants had the option of leaving their email address.

Results: Of 1505 participants who attempted to take the survey, 1182 completed all the patient reported surveys. To arrive at 1182, we removed 89 duplicate records based on email address and fixed characteristics (birth year, BMI, gender, country, etc) and 234 incomplete surveys. Review of survey completion showed that 54, 113, and 67 participants dropped out during the UCLA activity, SF-36, and HOOS sections of the survey, respectively. The median time-to-completion of the survey was 11 minutes. The participants were from 45 countries including US (570, 48%), UK (295, 25%), Australia (133, 11%), and Canada (46, 4%). No relationship between the dropouts and their country of residence or language was observed. Of the 1182 respondents, 58% were females and 16% reported bilateral LCPD. The age of participants ranged from 18 to 79 (median 38y). Ages at LCPD onset were <6y (44%), 6-7y (28%), 8-11y (21%), and >11y (6%), similar to the known age distribution of LCPD. During childhood, 39% had surgery and 29% had casting. As adults, 22% had at least 1 total hip replacement (THR). The number of years since THR varied from 0 to 43y (mean 7y, median 4y). The summary of patient-reported outcome scores is shown in Table 1.

Conclusions: A web-based approach was used to obtain health-related quality of life and functional data of adults with LCPD. Our study shows the feasibility of quickly obtaining a large set of patient-reported data from multiple countries for those who experience rare disease.

Significance: While we expect limitations due to self-selected sampling, further analysis of our large data set will be a step forward in understanding the long-term outcomes of LCPD.

Table 1. Survey scores: larger score indicates better function

Survey type	Score Range [Min, Max]	Median	Mean \pm SD
UCLA Activity Score	[1,10]	6	6.4 \pm 2.5
SF-36 General Health	[0,100]	60	58 \pm 23
SF-36 Physical Functioning	[0,100]	70	65 \pm 28
HOOS Overall Score	[0,100]	64	61 \pm 25
HOOS Pain Score	[0,100]	65	63 \pm 26

A Biomechanical Analysis of The Surface Contact Pressure After An Innominate Osteotomy For The Correction Of Acetabular Dysplasia

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Purpose: The Salter and Pemberton osteotomies are two commonly performed surgical procedures to treat developmental dysplasia of the hip. Accurate data regarding hip surface contact pressure after these two procedures are missing. This study aimed to compare the surface contact pressure of the hip before and after a Salter or Pemberton osteotomy with that of normal hips, and a group of dysplastic controls.

Methods: The surface contact pressure of 70 hips was determined using the HipStress program, which is a nomogram using geometric (radiographic) and biometric (Body Mass Index) parameters. When this program yields a result of peak contact pressure less than 2 MPa, it is considered a typical value. Forty-five hips had undergone an osteotomy for acetabular dysplasia, 17 were Salter osteotomies, 28 were Pemberton osteotomies. Fifteen dysplastic controls and ten healthy hips were also analyzed. Statistical analysis was carried out with Spearman and Pearson correlations. The mean age at the time of analysis was 14.3 years (range 12.1 to 17.6).

Results: The mean HipStress result for healthy hips was 1.66 MPa; for dysplastic controls, it was 8.9 MPa. For hips that had undergone a Salter osteotomy, it was 2.9 MPa vs. 7.6 MPa preoperatively ($\Delta = -4.7$ MPa). For the hips that had undergone a Pemberton osteotomy, it was 3.1 MPa vs. 8.6 MPa preoperatively ($\Delta = -5.5$ MPa). The difference between the preoperative and postoperative results was statistically significant for both the Salter osteotomy group ($p=0.03$) and the Pemberton osteotomy group ($p=0.04$).

Conclusions: Both the Salter and Pemberton osteotomies have the potential to reduce the surface contact pressure of the hip in patients with acetabular dysplasia, although they remain higher than normal controls.

Significance: The reduction in the surface contact pressure of the hip after Salter and Pemberton osteotomies should translate into a longer-lasting joint.

The Importance of Globalization in Prospective Study Groups: Increasing the Relevance of Research on Developmental Dysplasia of the Hip to a Global Patient Population

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Purpose: Screening practices for developmental dysplasia of the hip (DDH) vary widely across centres and between countries, and may depend on resource availability. Multi-centre, prospective studies have potential to generate high-quality evidence to guide screening and management practices, but typically fail to include a truly global representation of the patient population. There may be critical differences in presenting patient populations in different regions that will provide better insight into how best to optimize outcomes for this condition. This study aimed to compare presentation and initial management approaches for patients with DDH at Indian and Western centres.

Methods: A multi-centre, international prospective registry of patients with DDH was established in 2016, with 16 centres from five countries across four continents contributing data. Patients were enrolled if they were diagnosed with any form of DDH under 10 years of age. Patient demographics, clinical and radiologic diagnostic information, and initial management approaches were entered into a REDCap electronic database and compared between 5 centres in India and 11 centres from Canada, the United States, Australia, and Great Britain.

Results: In total, 542 patients across 11 Western centres and 64 patients across 5 Indian centres were included. Patient age at presentation was significantly lower at Western centres compared to Indian centres (4.7 months, 95% confidence interval, CI [3.7,5.6] vs. 31.4 months, 95% CI [24.7,38.0]). There was a higher prevalence of patients presenting with DDH risk factors of breech presentation (35.2% vs. 25%) and family history (24.4% vs. 7.8%), and a higher prevalence of swaddling (48.2% vs. 10.9%) in the Western group compared to the Indian group. In the Western group, 80% of diagnoses were confirmed by ultrasound, compared to 84% of by radiograph in the Indian group. Irreducible dislocations were predominant in the Indian group (90% of dislocated hips), while reducible dislocations comprised 71% of dislocations in the Western group. 93% of Western patients were initially managed by bracing and/or monitoring, while all Indian patients were treated with closed/open reduction.

Conclusions: There are important differences in patient age and severity of dislocation for patients presenting with DDH to Western and Indian centres. Initial management approaches were also in marked contrast, with a predominance of conservative treatment at Western centres, and closed/open reduction at Indian centres.

Significance: Patient population differences will be critical to consider when assessing treatment outcomes. Prospectively capturing this data will be valuable to determine where best to focus screening efforts to ultimately improve outcomes worldwide.

Patients With Ehlers-Danlos Syndrome Who Undergo Periacetabular Osteotomy for Symptomatic Hip Instability Report Sustained Improvements At Two Years Comparable To Those Observed in Patients Without Ehlers-Danlos Syndrome

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Purpose: symptomatic hip instability in Ehlers-Danlos Syndrome (EDS) may lead patients to undergo periacetabular osteotomy (PAO) in order to improve pain and function. However, the literature lacks reports of validated patient reported outcomes (PROs) following PAO in patients with a confirmed diagnosis of EDS. We hypothesized that there would not be a significant difference in PROs between patients with EDS and patients without such diagnoses following PAO for hip dysplasia.

Methods: An IRB approved, retrospective review of patients treated with PAO for hip dysplasia was performed from 2016 to 2018. All outcome data were collected prospectively. Patients whose 2-year postoperative follow-up was not available were excluded. 10 patients with EDS (10 females, 0 males) and 15 patients without EDS (13 females, 2 males) who completed the following PROs were available for analysis: modified Harris Hip Score (mHHS), international Hip Outcome Tool (iHOT), UCLA activity score, and Nonarthritic Hip Score (NAHS). PROs were compared using 95% confidence intervals (CIs).

Results: Mean BMI at surgery was 23.2 ± 3.3 for EDS group and 24.4 ± 5.4 for non-EDS group. Mean age at surgery was 16 ± 1.8 years for both groups. PROs after PAO in patients with EDS improved, were sustained at two-year follow-up, and were comparable to those reported in patients without EDS. 95% CIs for the two groups are presented below.

PRO	EDS	Non-EDS
mHHS	48.08-71.94	48.357-96.108
iHOT	27.54-58.30	27.54-58.30
UCLA activity	2.78-6.47	2.78-6.47
NAHS	44.29-66.55	44.29-66.55

Conclusions: There was significant overlap of 95% CIs between the EDS and non-EDS groups. The pre-operative overlap and demographic data indicate the two groups are similar to allow for post-operative comparison. Significant post-operative overlap indicates that patients with EDS have similar outcomes to patients without EDS following PAO for hip dysplasia.

Significance: To the authors' best knowledge, this is the first series analyzing PROs in patients with a genetic or rheumatologic diagnosis of EDS following PAO for hip dysplasia. Results of this series suggest patients with EDS may do as well as patients without EDS after PAO. Further study is warranted to increase sample size to allow for more complete analysis of outcomes, complications and indications for PAO in patients with EDS.

Femoral Head Coverage should be included in treatment protocols for Graf IIa Developmental Dysplasia of the Hip

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Purpose: This study examines how the addition of femoral head coverage and the application of a recent accepted use criteria (AUC) would change the treatment protocol for Graf IIa developmental dysplasia of the hip (DDH) in our pediatric hip clinic.

Methods: From consecutive patients referred for hip evaluation to a single tertiary institution from 2009 to 2018, 401 hips (289 patients) were classified as Graf IIa (ultrasound acetabular alpha angles of 50-59 degrees in infants less than 12 weeks old). Patients with incomplete documentation or underlying conditions were excluded, leaving 373 hips. Percent femoral head coverage (FHC) and alpha angle measurements were obtained from the initial ultrasound. Based on the AAOS AUC for managing DDH, hips were further categorized as normal (alpha angle $\geq 60^\circ$ and percent femoral head coverage $\geq 45\%$), borderline (alpha angle 50-59° or percent femoral head coverage 35-44%), or dysplastic (alpha angle $< 50^\circ$ or FHC $< 35\%$). Acetabular index (AI) values, alpha angles, and FHC were measured from radiographs or ultrasounds obtained at 6 months of age. Characteristics collected included instability tests (Ortolani and Barlow) and age at initial ultrasound.

Results: Of 373 Graf IIa hips, 71% were treated with Pavlik harness: 24% for instability, 22% based on a more severe contralateral hip and 25% primarily because FHC was less than 50%. Average age at initial ultrasound was 29 days in the treated group and 28 days in the untreated group. 86% of Graf IIa hips were borderline and 14% were dysplastic per the AUC (FHC $< 35\%$). Among the IIa unstable hips, 43% (38/88) were dysplastic. There was no statistical difference in the mean AI, alpha angles or FHC in 117 treated and 42 untreated Graf IIa hips that returned for evaluation at 6 months of age.

Conclusions: 24% of Graf IIa hips were clinically unstable and 14% were dysplastic based on femoral head coverage. Using the AUC, however, many Graf IIa hips were borderline and likely would do well with observation and follow-up ultrasound after 12 weeks old.

Significance: Femoral head coverage, along with clinical instability and Graf classification, should be factored into treatment protocols for developmental dysplasia of the hip.

Mountain or Mole Hill: The Clinical Significance of Infolded Labrum on Post-Reduction Arthrogram in Developmental Dysplasia of the Hip

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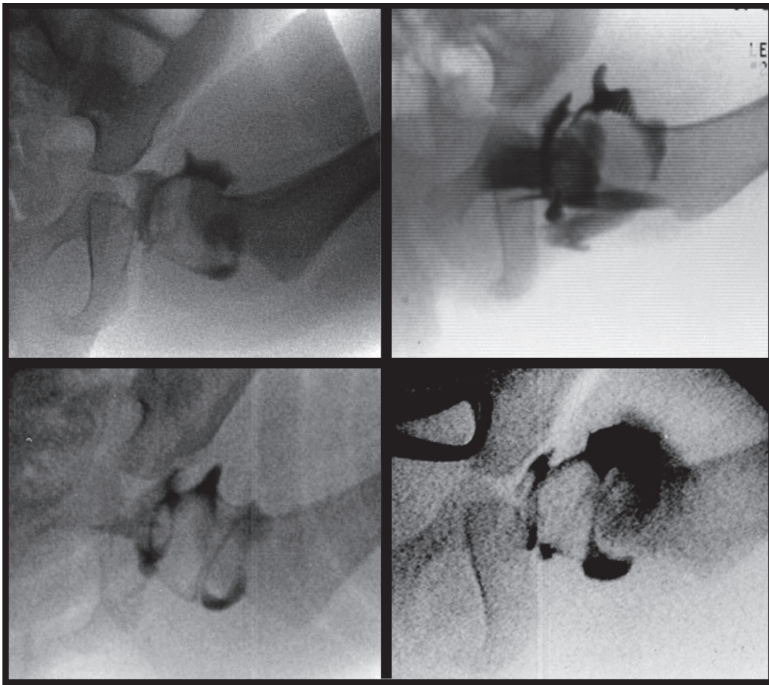
Purpose: Although the width of the medial dye pool has been studied as a marker of the adequacy of closed reduction in developmental dysplasia of the hip (DDH), the clinical significance of a hypertrophic/infolded labrum remains unclear. The purpose of this study was to investigate whether identification of a hypertrophic, infolded labrum at index closed reduction was associated with greater residual dysplasia or increased secondary surgery.

Methods: We retrospectively reviewed all patients who underwent closed reduction for DDH with a minimum 2-year follow-up between 1980-2016. Demographic data was obtained and severity of dislocation was determined based on the International Hip Dysplasia Institute (IHDI) classification. Arthrograms performed at the time of closed reduction were separately reviewed by three fellowship-trained pediatric orthopedic surgeons to evaluate for the presence of a hypertrophic/infolded labrum (Figure). Medial dye pool was measured as a percentage of the femoral head diameter. Residual dysplasia was evaluated radiographically by acetabular index two and four years after reduction. The primary clinical outcome was the rate of secondary reconstructive surgery for residual dysplasia.

Results: We identified 188 hips in 170 patients who underwent closed reduction at a mean age of 10.0 ± 5.8 months and were followed a mean of 9.0 ± 4.9 years. A hypertrophic and infolded labrum was identified in 21% (39/188) of the hips with substantial agreement among the three graders (Fleiss's Kappa = 0.75; 95%CI 0.66-0.83) The frequency of labral infolding increased in more severe dislocations: 8.8% of IHDI II, 26.3% IHDI III, and 24.0% of IHDI IV hips. Hips with infolded labrum were significantly older at reduction (12.4 ± 5.2 vs 9.4 ± 5.8 months, $p=0.003$), though there was no association with gender ($p=0.41$) or laterality ($p=0.73$). Although infolded labrum was associated with an increased medial dye pool at time of reduction ($10.9 \pm 7.3\%$ vs $7.4 \pm 6.2\%$, $p=0.004$), there was no difference in the rate of secondary surgery for residual dysplasia between the hips with labral infolding and those without (38.5% vs 32.2%, respectively; $p=0.46$). Labral infolding was associated with a larger acetabular index at 2 years post-reduction (34.9 ± 4.9 vs 32.6 ± 6.0 , $p=0.03$) but not at 4 years ($p=0.23$).

Conclusions: Labral infolding and hypertrophy were more common in older patients and more severe dislocations. However, this finding was not associated with an increased rate of secondary surgery and predicted only mildly worsened acetabular dysplasia at 2 years post-reduction.

Significance: This data provides guidance for surgeons intraoperatively in deciding the adequacy of a closed reduction for DDH.



Oncological and Functional Outcomes in Joint Sparing Resections of the Proximal Femur for Malignant Primary Bone Tumors

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Purpose: Skeletally immature patients pose unique challenges in limb salvage surgery including the need to address residual limb growth and restoration of limb length after wide resection of a malignant bone tumor. Joint sparing resections (JSpR) of the proximal femur allow for preservation of the proximal femoral growth plate and native hip joint, but the outcomes of this procedure are unknown. In this study we compared the outcomes of patients undergoing JSpR of the proximal femur with intercalary allograft (ICA) reconstruction to those undergoing joint sacrificing resections (JScR) with allograft-prosthetic composite (APC) reconstructions.

Methods: A review of all patients undergoing JSpR with ICA and JScR with APC between 1995 and 2013 was conducted at a tertiary pediatric referral center. Primary outcomes included major and minor complications. Secondary outcomes assessed at the time of final follow-up included secondary procedures, local or distant relapse, survival, pain assessment, overall activity level, presence of a limp, use of assistive device, and walking limitations. Statistical analysis was performed using Fisher's Exact and Wilcoxon rank-sum tests using a two-tailed p-value threshold of $p < 0.05$.

Results: Eight patients underwent a JSpR with ICA and seven patients underwent a JScR with APC. Only patients' age was significantly different between the two groups – JSpR 7.7 years and JScR 11.7 years ($p = 0.043$). In the JSpR group, complications included one allograft fracture, one non-union, and one wound dehiscence, whereas in the JScR group, complications included one angular deformity and 4 non-unions ($p = 0.29$). Four patients underwent secondary procedures. All patients survived in the JScR group and one patient died in the JSpR group ($p > 0.99$). Only one patient experienced severe pain (VAS 7-10) in the JScR group ($p = 0.56$) whereas the majority of patients experienced either mild (VAS 1-6) or no pain (VAS 0). Additionally, there were no significant differences in activity level, presence of limp, use of assistive device, or walking limitations. One patient in the JSpR group used an assistive device and two JScR patients had walking limitations.

Conclusions: Treatment of proximal femoral bone sarcomas in pediatric patients remains a challenging enterprise. JSpR with intercalary allograft reconstruction in the proximal femur, when allowed by tumor anatomy, may provide a similar risk of major and minor complications when compared to JScR and APC reconstructions, with the added theoretical advantage of a maintained native hip joint.

Significance: JSpR with ICA reconstruction should be considered, when tumor characteristics allow, for primary bone sarcomas in the pediatric proximal femur.

Are “Quick” MRI scans reliable for diagnosis of pediatric peri-pelvic musculoskeletal infections?

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Purpose: It is difficult to discern septic hip arthritis, osteomyelitis and pyomyositis about the pediatric pelvis on history and exam alone. Full MRI with contrast has become standard of care to characterize these infections and plan next steps. To expedite care, we protocolized a “Quick” MRI to scan such patients without contrast or sedation. This study aims to compare the accuracy of diagnosis and management based on Quick and full MRI findings.

Methods: We retrospectively identified 29 patients over the last 15 years who were ≤ 17 years old with a culture positive peri-pelvic infection and who had a full MRI with contrast of the region. For each patient we created two blinded files; one with full images and one with only the limited sequences (coronal T1, axial and coronal T2, and axial and coronal STIR images) obtained with our Quick protocol. Three pediatric orthopaedic surgeons independently evaluated the Quick MRI’s. One month later, the team jointly reviewed and reached consensus on those cases with divergent assessments. Six weeks later, the same was done for the full MRI’s. Fleiss’ Kappa statistic was calculated for each outcome.

Results: When the scans were evaluated independently, there was moderate agreement of diagnosis between reviewers with Quick (0.488) and strong agreement with full (0.684) MRI ($p < 0.003$). While full MRI was slightly more consistent, agreement on treatment recommendations was poor between reviewers of both Quick (0.09) and full (0.233) MRI ($p < 0.046$). There was no difference in team consensus diagnosis and actual diagnosis based on medical records between full (0.569) and Quick (0.523) scans ($p = 0.662$). Similarly, consensus for next steps in treatment showed no difference in agreement with actual diagnosis between full (0.071) and Quick (0.182) scans ($p = 0.254$).

Conclusions: Independent evaluation of Quick MRI was less reliable in determining diagnosis and treatment strategy when compared to full MRI for pediatric peri-pelvic infection. When evaluated in collaboration with other providers, the diagnostic abilities of Quick MRI approached those of full MRI. Variances in ultimate treatment approach are likely due to differences in training and experience as opposed to which type of scan was evaluated.

Significance: Quick MRI can facilitate the diagnosis of peri-pelvic MSK infection without requiring sedation or general anesthesia provided a team or perhaps an individual with extensive experience performs the evaluation. Those with less experience should consider a full MRI with contrast in formulating a diagnosis.

Diffuse Tenosynovial Giant Cell Tumors: Case Series From a Large Pediatric Orthopaedic Hospital

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Purpose: Tenosynovial giant cell tumor (TGCT) is a rare benign tumor of synovial tissue. Diffuse type TGCT, previously termed pigmented villonodular synovitis (PVNS), can be locally aggressive and carries a high rate of recurrence. As TGCT usually presents in adults, data on the presentation and treatment of pediatric exclusive disease is limited. This study aims to characterize a series of pediatric patients with diffuse type TGCT.

Methods: Electronic medical records at a single tertiary care pediatric hospital were used to identify all patients with pathology proven diffuse TGCT or PVNS. Patients with insufficient clinical documentation, age > 18, localized form, or recurrent disease on presentation were excluded. Demographics, presentation, timeline of evaluation and treatment, operative and nonoperative treatment, and recurrence information was collected and analyzed using descriptive statistics.

Results: 30 patients (18 female) were identified. The most commonly involved joint was the knee (20), followed by the ankle (5), elbow (2), hip (1), sacroiliac joint (1), and thumb IP joint (1). Mean age of symptom onset was 12.6 years (range 1.8-18.7). Mean time from onset to initial presentation was 9.3 months (range 2 days-4.7 years). The most common symptoms at presentation included pain (97%), swelling (87%), and loss of range of motion (50%). Only 6.5% of patients had a previous joint injury. Mean time from presentation to surgery was 4.4 months (range 1 day-3.3 years). 35 procedures were performed in 30 patients (8 open, 16 arthroscopic, 6 combined open and arthroscopic). Three (10%) patients underwent biopsy prior to definitive surgical treatment and one patient received radiation therapy. Eight (27%) had at least one recurrence (Table 1) and two (7%) had multiple recurrences. Two patients had asynchronous disease at a site other than the original tumor site (contralateral knee). Mean time to recurrence after initial surgery was 1.9 years (range 1.0-4.0).

Conclusions: Diffuse type TGCT is a rare finding in the pediatric population and carries a high risk for recurrence. It should be included in the differential diagnosis for a child presenting with acute or chronic joint pain and swelling without a history of joint injury. Further multicenter studies are needed to identify risk factors for recurrence and characterize outcomes in these patients.

Significance: This study represents the largest single institution and largest United States series of pediatric patients with diffuse type TGCT.

Table 1: Recurrence Characteristics

	n (%)
Total	8 (100%)
Sex	
Male	3 (36%)
Female	5 (64%)
Location	
Knee	7 (87%)
Ankle	1 (13%)
Initial Operation	
Arthroscopic	7 (87%)
Open	0 (0%)
Combined	1 (13%)

Guided Growth Treatment can improve Depression of the Medial Tibial Plateau in Infantile Blount Disease –An update

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Purpose: Last year, we reported that guided growth (GG) plate treatment was associated with improvement in MAD as well as improvement or resolution of even advanced pathologic bony changes at the proximal tibia typical of Infantile Blount disease. To date, we collected data on 60% more patients and present an update of the prior study.

Methods: We performed a retrospective review of infantile Blount patients who underwent GG surgery using a tension band plate-and-screw construct between 2010 and 2019 at one of two institutions. The severity of deformity of the medial tibial plateau was determined radiographically based on the Langenskiold stage (LS); lower extremity alignment was evaluated by assessing mechanical axis deviation (MAD). These measurements were recorded before surgery, at minimum of 1 year after initial surgery or at removal of hardware (1yr FU/ROH), and at most recent follow-up (F/U).

Results: A total of 25 limbs in 16 children who underwent GG surgery were evaluated. Patients were on average 5.8 ± 2.3 years old and average length of implant retention was 1.7 ± 0.7 years. Average F/U was 3.3 ± 1.6 years. LS ranged from 1 to 5 pre-operatively with 14/25 (56%) limbs rated 3 and higher. The pathologic changes at the proximal tibia as classified by Langenskiold improved in 13/25 (52%) limbs at 1yr FU/ROH and in 18/22 limbs (82%) at most recent F/U. Tibial plateau changes completely resolved in 7/22 (32%) limbs. Pre-operatively, the MAD showed pathologic varus in all limbs but corrected to neutral or into valgus in 19/23 limbs (83%) at 1yr FU/ROH and 12/19 limbs (63%) at F/U. Average MADs were: pre-operative 35.1 ±15.6mm, 1yr FU/ROH 2.7 ±25mm and F/U 8.8 ±16.9mm. A total of 6 limbs in 5 patients had no improvement in LS at recent F/U: 3 worsened and 3 showed no change. However, MAD corrected in 5/6 of these limbs after GG surgery. To date, 4 limbs underwent revision GG surgery for varus recurrence, and 1 limb underwent tibial dome osteotomy and hemiplateau elevation after progression to LS 6 (premature fusion of growth plate).

Conclusions: GG surgery for Infantile Blount disease can improve MAD as well as improve or resolve even advanced pathologic bony changes at the proximal tibia in the majority of limbs.

Significance: Guided growth surgery for Infantile Blount disease may be a better first-line treatment option than more invasive surgery such as osteotomy and hemiplateau elevation, even in those with advanced pathologic bone deformity.

Table 1

Patient	Age (Y)	Sex	Late- (88%)	Length of GG (Y)	F/U (Y)	Age @ F/U (Y)	Langenskiold Class Pre-op	Langenskiold Class @ 1yr FU/ROH	Langenskiold Class @ recent FU	Langenskiold Class Improved	MAD pre-op (mm)	MAD @ 1yr FU/ROH (mm)	MAD @ F/U (mm)	Complication
1	7.9	M	R	1.4	1.5	9.4	1	0	0	Yes	43.7	8.9	5.6	Screw breakage
2	6.1	F	L	1.8	4.1	10.2	4	3	0	Yes	14.2	-9.9	16.6	Recurrence, Revision GG
3	9.5	M	L	1.4	5.1	13.4	3	2	1	Yes	15.6	0.0	8.6	None
4	9.3	M	R	2.2	3.0	12.3	1	0	0	Yes	38.4	-6.9	12.7	None
			L	2.9	3.0	12.3	2	1	1	Yes	56.0	30.5	30.5	None
5	2.6	M	R	1.5	1.6	4.2	2	2	1	Yes	54.5	12.3	12.3	None
			L	1.0	1.6	4.2	3	3	3	No	54.1	5.5	7.4	None
6	6.7	F	L	1.2	6.3	13.0	4	1	1	Yes	28.4	-12.5	10.8	None
7	4.5	F	R	2.0	3.7	8.1	2	1	1	Yes	28.3	-3.7	3.0	None
			L	2.0	3.7	8.1	2	1	1	Yes	27.0	4.4	11.0	None
8	5.8	F	R	1.3	5.9	11.7	3	3	0	Yes	20.9	-7.6	37.7	Recurrence, Revision GG
			L	1.3	5.9	11.7	3	3	0	Yes	9.9	-32.0	11.5	None
9	8.5	M	R	1.3	5.0	13.5	2	2	0	Yes	15.0	-4.8	0.0	None
			L	1.3	5.0	13.5	3	2	0	Yes	31.6	6.4	0.0	None
10	7.5	F	R	3.5	3.6	10.7	5	3	4	Yes	55.3	2.8	17.0	Recurrence, Revision GG
			L	3.5	3.6	10.7	5	3	4	Yes	51.5	10.8	34.8	Recurrence, Revision GG
11	2.5	F	R	1.3	4.3	6.9	2	2	1	Yes				None
			L	1.3	4.3	6.9	3	3	1	Yes				None
12	7.0	M	R	1.7	1.7	8.3	5	4		Yes	27.2	3.5		None
			L	1.2	1.7	8.3	5	6		No	54.0	95.0	11.6	No correction, Revision*
13	4.3	M	R	2.5	2.5	5.2	4	1	1	Yes	31.5	-40.7	-40.7	None
14	3.6	M	L	1.8	1.8	4.9	2	3	3	No	59.1	0.0	0.0	None
15	3.6	F	R	1.5	1.6	4.7	3	3	5	No	30.6	13.8	-13.8	None
16	4.0	M	R	1.3	1.3	4.8	2	2		No	30.9	5.9		None
			L	1.3	1.3	4.8	2	2		No	23.6	12.4		None
TOTAL	5.8 ± 2.3	44 % F	52% L	1.7 ± 0.7	3.3 ± 1.6	8.9 ± 3.3	Class 0: 0 Class I: 2 Class II: 9 Class III: 7 Class IV: 3 Class V: 4 Class VI: 0	Class 0: 2 Class I: 5 Class II: 7 Class III: 8 Class IV: 1 Class V: 1 Class VI: 0	Class 0: 7 (16%) Class I: 5 (12%) Class II: 0 (0%) Class III: 2 (5%) Class IV: 2 (5%) Class V: 1 (2%) Class VI: 1 (2%)	19/25 (76%) Improved 3/25 (12%) no change 2/25 (8%) no change	35.1 ± 15.6	2.7 ± 2.5	8.8 ± 16.9	

* 1-year MAD=mechanical axis deviation; GG=guided growth
* tibial dome osteotomy and hemiplateau elevation
Blue highlighted rows indicate limbs/patients without improvement of Langenskiold stage.

Infantile Blount Disease: Radiographic Predictors of Spontaneous Resolution

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Purpose: This study aimed to identify radiographic markers associated with spontaneous resolution of medial tibial plateau changes in non-surgical patients with Infantile Blount disease.

Methods: Retrospective review of patients with Infantile Blount disease who presented between 2010 and 2019 to one of two institutions and did not undergo surgery. The severity of the medial tibial plateau deformity was radiographically determined by Langenskiöld stage (LS). Lower extremity alignment was evaluated using mechanical axis deviation (MAD), mechanical lateral distal femoral angle (mLDFA), medial proximal tibial angle (MPTA) and Drennan angle of the affected limb(s) at diagnosis and most recent follow-up (f/u).

Results: A total of 23 limbs in 13 children were included: average age was 2.0 ± 0.5 years at diagnosis and 46% were female. Average f/u was 3.2 ± 2.5 years and average age at most recent f/u was 4.9 ± 2.1 years. LS ranged from 1-3 at diagnosis, with 8 limbs LS 1 (35%), 14 limbs LS 2 (61%) and 1 limb LS 3 (4%). At f/u, LS had improved in 11 limbs (48%), was unchanged in 3 limbs (13%) and had progressed in 9 limbs (39%). Of the 9 limbs with LS progression: 4 were initially LS 1 and 5 were LS 2 while at f/u, 5/9 (55%) were staged as $LS \geq 3$, whereas none were above LS 2 at f/u in the no progression group ($p < 0.0005$). Tibial plateau changes completely resolved in 5/23 (22%) limbs at f/u. There were no differences in demographics between those with progression of disease and those without (Table 1). In patients with LS progression, lower extremities had significantly greater overall varus malalignment at diagnosis (Table 1): MAD 45.1 ± 13.9 mm vs 26.5 ± 11.9 mm in those without progression ($p = 0.004$). Additionally, mLDFA measurements were significantly greater in those with disease progression compared to those without: $104.3 \pm 7.4^\circ$ vs $97.7 \pm 5.6^\circ$ ($p = 0.031$). At initial presentation, there were no significant differences in Drennan Angle or MPTA between the two groups.

Conclusions: Patients with spontaneous resolution of Infantile Blount disease had significantly less overall varus malalignment and significantly less distal femur varus alignment on initial presentation as compared to patients with disease progression.

Significance: This is the first study to measure significant differences on initial radiographic imaging in patients presenting with Infantile Blount disease who go on to spontaneous resolution of the disease vs. those that progress to worsening deformity.

Table 1 – Comparison of infantile blount patients with progression vs no progression of Langenskiöld (LS) stage

Demographic Parameters	LS - No Progression	LS Progression	P-Value
Age at diagnosis, years, median (IQR)	1.8 (1.6, 2.2)	2.0 (1.5, 2.2)	1.000
Gender, F, N (%)	6 (43%)	3 (33%)	1.000
Ethnicity, N (%)			0.064
Hispanic	7 (50%)	1 (11.1%)	
Black	2 (14%)	4 (44.4%)	
Caucasian	5 (36%)	2 (22.4%)	
Other	0 (0%)	2 (22.4%)	
BMI, median (IQR)	20.3 (16.9, 23.4)	21.0 (16.5, 23)	0.587
BMI percentile, median (IQR)	88.8 (84, 99)	99 (53, 99)	0.878
Radiographic Parameters	LS - No Progression	LS Progression	P-Value
MAD Pre, mm, mean \pm SD	26.5 \pm 11.9	45.1 \pm 13.9	0.004
MAD FU, mm, mean \pm SD	4.5 \pm12.2	35.5 \pm38.3	0.042
mLDFA Diagnosis, $^\circ$, mean \pm SD	97.7 \pm5.6	104.3 \pm7.4	0.031
mLDFA FU, $^\circ$, mean \pm SD	89.3 \pm 6.3	94.6 \pm 12.7	0.194
MPTA Diagnosis, $^\circ$, mean \pm SD	82.4 \pm 4.2	83.2 \pm 6.4	0.714
MPTA FU, $^\circ$, mean \pm SD	88.5 \pm 4.4	84.7 \pm 5.5	0.086
Drennan angle Diagnosis, $^\circ$, mean \pm SD	19.2 \pm 4.4	22.3 \pm 2.9	0.078
Drennan angle FU, $^\circ$, mean \pm SD	13.2 \pm4.1	20.9 \pm6.2	0.007

Statistics used: unpaired t-test, Wilcoxon rank-sum test, Fisher's exact test

Creation and Validation of a “Shorthand” Knee MRI Bone Age Assessment Tool as an Alternative for Skeletal Maturity Assessment

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Purpose: The Greulich and Pyle Atlas (GPA) has been the gold standard bone age assessment tool. In 2013, a shorthand bone age (SBA) assessment tool based on this atlas was established as a simpler and more efficient alternative. Recently, a knee bone age atlas was created to potentially circumvent the need for obtaining a left-hand radiograph. Our aim was to create a “shorthand” version of the magnetic resonance imaging atlas similar to what was previously done for the GPA.

Methods: A shorthand bone age method was created utilizing the previously published MRI Bone age Atlas. The shorthand method utilizes a single criteria for each age that is best observed on a single MR image whereas the MRI bone age atlas utilizes multiple criteria that are visualized across a series of images (Figure 1). In the validation phase of this new “shorthand” method, we performed a retrospective assessment of skeletally immature patients that had a knee MRI as well a left-hand radiograph within 4 weeks of each. Four readers who were familiar with the GPA, the SBA assessment tool, the MRI bone age atlas, and the new “shorthand” version of the MRI atlas read each of the images in a blinded fashion. Inter- and intra-observer reliability, as well as variability among observers was evaluated.

Results: 26 patients with a mean age of 13.6 years (range 9.0-16.9) met the inclusion criteria. The intra- and inter-observer reliability of all 4 assessment tools was excellent with kappa values >0.80. (Table 1) When comparing the MRI shorthand to the MRI atlas there was excellent agreement (0.974) whereas the SBA compared to the GPA had good agreement (0.765). Furthermore, the MRI shorthand had perfect agreement in 58% of reads among all four readers and 96% of reads differed by no more than 1 year where as the SBA had perfect agreement in 32% of reads and 82% differed by no more than 1 year.

Conclusions: The “shorthand” method utilizing the MRI bone age atlas is a simple and efficient means of assessing skeletal maturity of adolescent patients with knee pathology. This bone age assessment technique has inter-observer and intra-observer equivalent or better than the standard means utilizing a left-hand radiograph.

Significance: A new “shorthand” MRI bone age assessment tool may be a simpler alternative to skeletal assessment than using the GPA (in full, or short hand) or the full MRI bone age atlas.

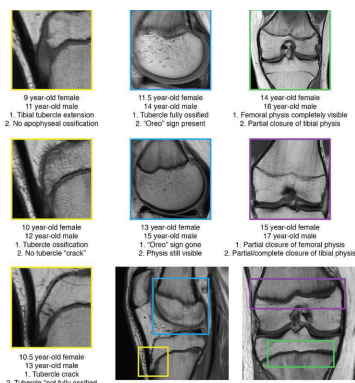


Table 1: Intraclass Correlation Coefficients (ICC)

		ICC	Lower	Upper	Sig.
Inter-observer	MRI – Atlas	0.950	0.912	0.975	p < 0.001
	MRI – Shorthand	0.958	0.926	0.979	p < 0.001
	Hand – Atlas	0.800	0.660	0.900	p < 0.001
	Hand – Shorthand	0.850	0.740	0.926	p < 0.001
Intra-observer	MRI – Atlas	0.951	0.828	0.987	p < 0.001
	MRI – Shorthand	0.905	0.662	0.976	p < 0.001
	Hand – Atlas	0.988	0.953	0.997	p < 0.001
	Hand – Shorthand	0.934	0.772	0.983	p < 0.001
Shorthand v Atlas*	MRI	0.974	0.944	0.988	p < 0.001
	Hand	0.765	0.320	0.912	p < 0.001

Novel application of the internal, magnetically-controlled, telescopic nail to the extramedullary femur in the skeletally immature patient: Early results.

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Purpose: Large predicted congenital limb discrepancies necessitate earlier intervention to mitigate pain and dysfunction. Traditional techniques such as external fixation have fallen out of favor, and both the size and morphology of the young congenital femur preclude more modern internal devices. A novel application of the intramedullary PRECICE (NuVasive, San Diego, CA) lengthening nail has been conceived by applying it in an extramedullary fashion to the lateral femur in conjunction with an internal rod to maintain intramedullary stability. We present our early results utilizing this technique.

Methods: We retrospectively identified patients undergoing internal extramedullary femoral lengthening by a single surgeon. These patients underwent femoral osteotomy with placement of an intramedullary SLIM nail (Pega Medical, Laval, Quebec, Canada) and a PRECICE nail placed in a subvastus lateralis position. Chart and imaging review was undertaken by two fellowship trained pediatric orthopedic surgeons. Demographics included age at treatment, sex and underlying diagnosis. Patient characteristics included anteroposterior and lateral diameter of the femoral canal. Instrumentation characteristics included extramedullary nail type, length, diameter and interlock screw construct. Surgical time and estimated blood loss were recorded. Lengthening data included latency period, lengthening rate, and final length achieved.

Results: Twelve patients with a median age of 9 years (4-14 years) underwent internal extramedullary femoral lengthening from July 2019 to June 2020. All patients had congenital femoral deficiency, and the median lengthening goal was 5cm. Femoral canal diameter measured a median of 9.5mm coronally and 7mm sagittally. PRECICE nails were utilized with either 10.7mm (n=10) or 8.5mm (n=2) diameter. Variable interlocking screw constructs were used. 4.0mm (n=3) or 4.8mm (n=9) diameter SLIM nails were implemented. Median operative time was 151 minutes (110-341 minutes) with median estimated blood loss of 137.5 mL (50-300 mL). Follow up was a median of 3.7 months (0-6.3 months). Among eight patients completing lengthening, the median length achieved was 5.1cm (3.5-8cm). Seven complications were noted in six patients. These included soft tissue infection treated with intravenous antibiotics (n=1) or operative debridement (n=1), PRECICE nail bending (n=2), soft tissue contracture (n=2), and failure of distal interlocking screw requiring revision (n=1).

Conclusions: Goal length was achieved in all patients who completed their program during the study period. While complications were seen in half the patients, this compares favorably to femoral lengthening performed with monolateral fixators.

Significance: Our early term results suggest that this technique is safe and efficacious and that a future prospective comparative study with monolateral fixators is justified.

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

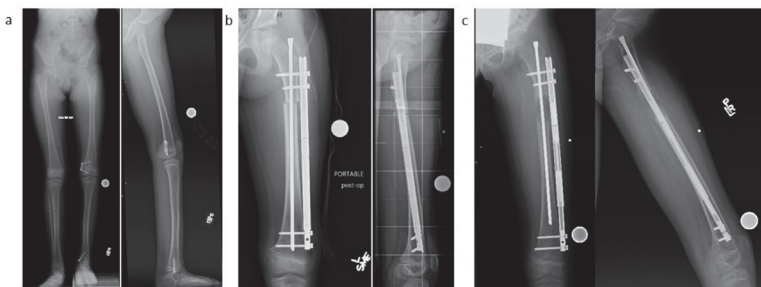


Figure. (a) AP and lateral long leg radiographs of eight year old with congenital femoral deficiency and 4.5 cm leg length discrepancy. Goal lengthening was 4 cm. (b). Immediate postoperative AP and lateral radiographs demonstrate internal extramedullary femoral lengthening with 10.7 x 275 mm retrograde straight PRECICE nail and two 5.0 mm screws proximally and two 4.0 mm screws distally. 4.8 mm SLIM nail was utilized for intramedullary stabilization. (c) AP and lateral follow up radiographs two months after surgery demonstrate 4.2 cm of lengthening.

Predictions of the Amount of Growth Remaining in the Lower-Limb

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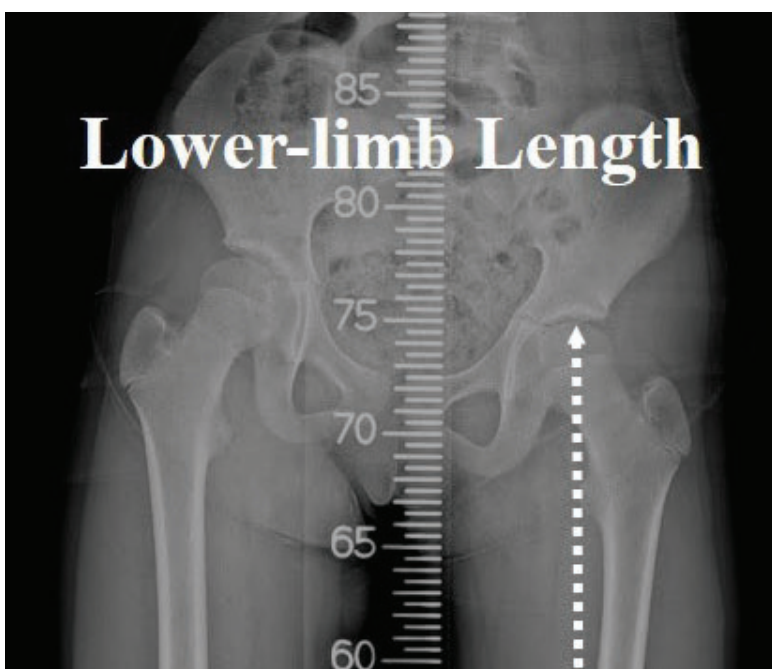
Purpose: Epiphysiodesis is commonly performed to correct leg length discrepancy (LLD). In that situation, it is important to predict the amount of growth remaining in the contralateral leg. The purpose of this study was to compare the real amount of growth in the lower-limb with calculated values by using pre-existing methods.

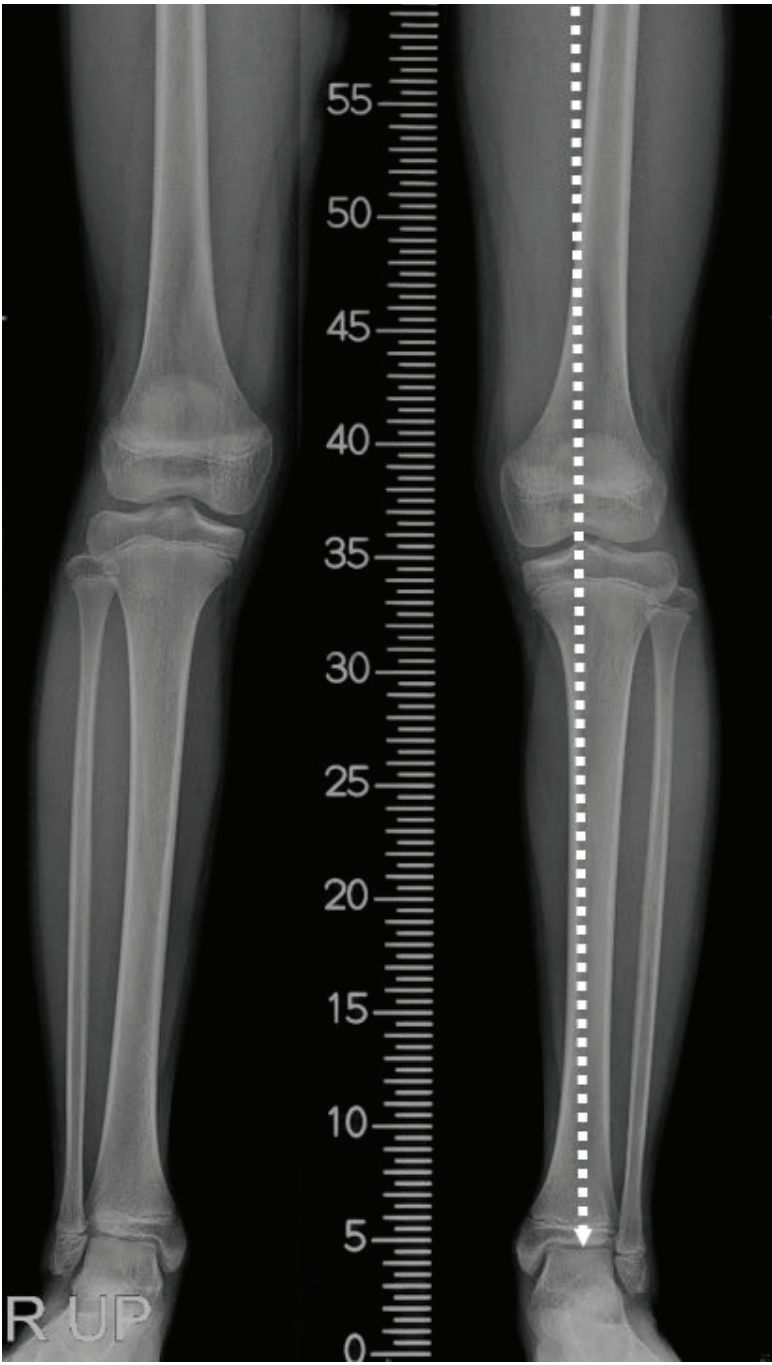
Methods: From a database of patients treated with epiphysiodesis for LLD from 2007 to 2016 at our institution, we identified healthy and unoperated lower-limbs and their serial time points (at the ages of 10–13 years in girls and 12–15 years in boys). The lower-limb length (from the top of the femoral head to the center of the ankle joint) was respectively measured at serial time points and after skeletal maturity from a standing full-length anteroposterior radiograph (made with computed radiography). Regarding the calculation of predicted amount of growth remaining, (1) the White-Menelaus arithmetic method (AM) and (2) the Paley's multiplier method (MM) were used. Both chronological age (CA, i.e., AM-CA & MM-CA) and bone age (BA, i.e., AM-BA & MM-BA) were used.

Results: Based on 319 time points in 62 patients, the real amount of growth was 3.9 ± 3.2 (0–14.6) cm. The calculated value was 5.7 ± 2.1 cm (using AM-CA), 7.7 ± 3.5 cm (MM-CA), 4.2 ± 2.6 cm (AM-BA), and 5.5 ± 3.9 cm (MM-BA), respectively. The real amount of growth was moderately associated with two calculated values by using CA ($r=0.678$ using AM-CA and $r=0.722$ using MM-CA). It was highly associated with two calculated values by using BA ($r=0.845$ using AM-BA and $r=0.870$ using MM-BA). All the four calculated values were statistically greater than the real amount ($p < 0.01$). Based on the difference between the real amount and calculated value of < 1.5 cm, 196 time points (61.4%) met the condition using AM-BA (45.5% using MM-BA, 30.3% using AM-CA, and 15.3% using MM-CA, respectively). On the basis of the difference of > 3.0 cm, 29 time points (9.1%) met the condition using AM-BA (23.4% using MM-BA, 35.3% using AM-CA, and 58.8% using MM-CA, respectively). Regarding the calculation by using AM-BA, non-idiopathic cause of LLD ($p=0.002$) was associated with the difference of < 1.5 cm. In addition, male sex ($p=0.031$) was related to the difference of > 3.0 cm.

Conclusions: The amount of observed growth was significantly lesser than calculated values.

Significance: The difference between observed growth and predicted growth may result in insufficient correction of LLD after epiphysiodesis. A novel approach to predict the amount of growth remaining in a patient-specific fashion should be studied.





Multicenter Series of Deformity Correction using Guided Growth in the Setting of Osteogenesis Imperfecta

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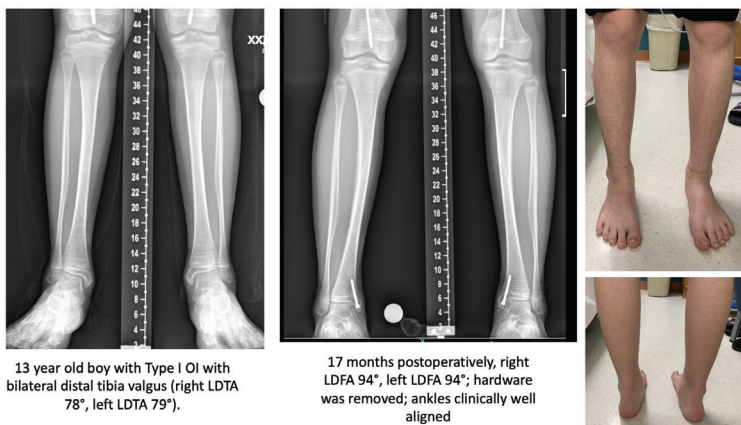
Purpose: The mainstay of deformity correction and fracture prevention for patients with osteogenesis imperfecta (OI) includes osteotomies and intramedullary rodding. Guided growth offers a less invasive means of deformity correction and has been described in the setting of skeletal dysplasias. Our purpose is to report a multicenter series of guided growth procedures in the setting of OI.

Methods: A retrospective review of OI patients at three institutions from April 2012-April 2019 identified patients who underwent guided growth for angular deformity correction with a minimum one-year follow-up or full deformity correction and removal of the guided growth hardware. Clinical characteristics, deformity measurements and complications were collected. Distal femur and proximal tibial hemiepiphyseodeses were performed using figure-of-eight plates and screws; distal tibial medial hemiepiphyseodeses were performed using cannulated screws. Preoperative and postoperative joint angle measurements included the lateral distal femoral angle (LDFA), medial proximal tibia angle (MPTA) and lateral distal tibial angle (LDTA). Frequency and descriptive statistics were completed.

Results: Fifteen OI patients (average age 11.8 years, range 6.5-16.3, 11 males, 4 females) underwent 30 guided growth procedures with a mean follow-up of 3.3 years (SD 1.8). OI Types included: I-5, III-3, IV-4, V-3. All patients received routine bisphosphonate treatment. Preoperative and postoperative mean joint angles include: 8 distal femur medial hemiepiphyseodesis (83.5°,88.3°), 2 distal femur lateral hemiepiphyseodesis (95.2°,89.5°), 7 proximal tibial medial hemiepiphyseodesis (95.3°,91.1°), 3 proximal tibial lateral hemiepiphyseodesis (84.0°,92.3°), 10 distal tibia medial hemiepiphyseodesis (73.3°,83.9°). For the distal femur and proximal tibial guided growth procedures, the mean change in mechanical axis deviation was 25.2mm (SD 30.1). Twelve of the 30 (40.0%) procedures were performed in the setting of an intramedullary rod. One patient demonstrated backout of the epiphyseal and metaphyseal screws of a distal femoral medial figure-of-eight plate. It was revised to a larger plate with longer screws and removed upon completion of deformity correction.

Conclusions: Guided growth may be used as an effective means of angular deformity correction with dysplastic OI bone. In this series, presence of an intramedullary rod did not preclude the use of a guided growth technique. To date, one of the 30 procedures demonstrated screw backout. Given the short stature associated with OI, consideration may be given to perform a guided growth procedure at an early enough age to allow time for correction.

Significance: To our knowledge, this is the first multicenter series reporting the efficacy of guided growth in OI patients.



Contractures in Cerebral Palsy and Brachial Plexus Birth Injury Are Similarly Caused by Short, Weak Muscles

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Purpose: Cerebral palsy (CP) and brachial plexus birth injury (BPBI) both cause disabling contractures, but differences in muscle tone between spastic and flaccid paralysis suggest different potential contracture etiologies. However, the muscle contracture phenotypes in these two conditions have never been directly compared. The current study uses needle microendoscopy of sarcomeres in human subjects with CP- and BPBI-induced elbow flexion contractures, along with isokinetic strength measurement, to test the hypothesis that contractures in both conditions are similarly caused by short, weak muscles.

Methods: Patients were recruited with spastic hemiplegic CP or isolated unilateral BPBI, with elbow flexion contractures $>10^\circ$ previously untreated with surgery or recent (<6 months) botulinum toxin. Bilateral elbow flexor torque was isokinetically measured at multiple speeds and trials, recording average peak torque and torque/angle area under the curve (AUC). Subsequently, under general anesthesia with neuromuscular blockade (indicated for non-study-related procedures), both elbows were symmetrically positioned at the affected limb's maximum passive extension. Needle microendoscopy was used to image sarcomeres from multiple fibers in bilateral biceps muscles for average sarcomere length calculation.

Results: In 5 subjects with CP (2 males, 3 females, age 14-16 years) and 5 with BPBI (3 males, 2 females, age 7-19 years), contractures averaged 25.6° (range 10 - 50°) and 39.8° (range 34 - 50°), respectively. In both conditions, sarcomeres were significantly longer in the affected versus unaffected biceps ($p<0.05$), indicating overstretched (thus functionally shorter) biceps muscles in the affected limb. Similarly, in both conditions, affected limbs had lower elbow flexion peak torque than unaffected limbs ($p<0.01$), and an even greater reduction in torque/angle AUC ($p<0.05$), demonstrating not only lower maximum strength but also narrower dispersion of torque across their arc of motion. The magnitude of sarcomere overstretch and muscle weakness in affected versus unaffected limbs did not differ between CP and BPBI.

Conclusions: The present study demonstrates that contractures in CP and BPBI share a common phenotype of short, weak muscles. Similar sarcomere overstretch, combined with similarly reduced isokinetic torque generation, demonstrates a deficiency in length, not an excess in strength, as the hallmark of contractures in both conditions.

Significance: Identifying a common short, weak muscle contracture phenotype between CP and BPBI (1) argues against muscle activity as a driver of contractures, (2) challenges the presumed dichotomy between upper and lower motor neuron lesions, and (3) indicates that findings in BPBI animal models may impact CP and other neuromuscular contractures for which animal models do not exist.

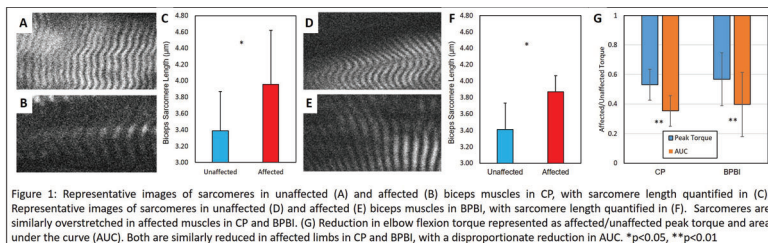


Figure 1: Representative images of sarcomeres in unaffected (A) and affected (B) biceps muscles in CP, with sarcomere length quantified in (C). Representative images of sarcomeres in unaffected (D) and affected (E) biceps muscles in BPBI, with sarcomere length quantified in (F). Sarcomeres are similarly overstretched in affected muscles in CP and BPBI. (G) Reduction in elbow flexion torque represented as affected/unaffected peak torque and area under the curve (AUC). Both are similarly reduced in affected limbs in CP and BPBI, with a disproportionate reduction in AUC. * $p<0.05$, ** $p<0.01$

Better Understanding the Orthopaedic Burden of Neurosurgical Hemispherectomy in Pediatric Patients

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Purpose: Hemispherectomies, hemispherotomies and lobectomies of the brain are neurosurgical techniques used to treat intractable epilepsy. While effective for seizure control, these procedures can produce significant functional deficits including hemiparesis and iatrogenic cerebral palsy. In this study, we aim to catalogue and quantify the orthopaedic outcomes of these procedures in pediatric patients in order to identify pre-operative risk factors and guide post-operative follow-up recommendations.

Methods: A retrospective chart review of 168 pediatric patients who underwent a brain hemispherectomy, hemispherotomy and/or lobectomy between 2001 and 2020 was conducted. Clinical notes were analyzed to determine each patients' underlying pre-operative neurological condition, whether patients developed post-operative orthopaedic conditions and what orthopaedic follow-up patients received. Patient data was summarized using mean and/or frequency. Controlling for pre-existing neurological conditions, a multivariate logistical regression was used to correlate new orthopedic conditions with predictive variables. Stata/IC was used for statistical computations with p-values < 0.05 considered statistically significant.

Results: Of the 168 patients included, 76 (45.2%) developed a new orthopaedic condition post-operatively. Of those with de-novo orthopaedic condition, 23 (30.3%) had received orthopaedic follow-up, and 8 (10.5%) underwent a subsequent orthopaedic surgery. The median time to documented emergence of orthopaedic symptoms was <1-month post-operation, and the average time from the emergence of symptoms to orthopaedic follow-up was 52 months. Twenty-eight patients (16.7%) had documented orthopaedic conditions pre-operatively, which were unchanged post-operatively. Of these 28, 12 (42.9%) had orthopaedic follow-up and 7 (25.0%) underwent orthopaedic surgery. The most common de-novo orthopaedic conditions were hemiparesis (43), extremity contracture (21) and hemiplegic cerebral palsy (8). Younger age (at the time of first neurosurgery) was significantly associated with the development of new orthopaedic conditions (AOR 0.983, 95% CI 0.975–0.991, p < 0.001), as was repeat/revision neurosurgery (AOR 3.728 95% CI 1.530–9.083, p 0.004). A total of 40 separate procedures were conducted for the 15 patients who underwent orthopaedic surgery, the majority of which were foot/ankle reconstruction, including 17 soft tissue and 10 osseous surgeries.

Conclusions: Pediatric patients who undergo brain hemispherectomies, hemispherotomies and/or lobectomies are subject to significant post-operative musculoskeletal disease burden, yet less than 1/3 of newly affected patients receive orthopaedic follow-up – highlighting a gap between the need for and provision of orthopaedic care in these patients.

Significance: The overall prevalence of post-operative musculoskeletal disease in this cohort rises above 60%, suggesting that orthopaedic follow-up need be requisite in the care of this population, especially in those identified as higher risk.

Nutrition Consult in the Year Leading up to Neuromuscular Scoliosis Surgery: Helpful Tool or Self-Inflicted Wound?

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Purpose: Patients with neuromuscular scoliosis undergoing posterior instrumented spinal fusion can be underweight, malnourished, and have higher complication rates. A nutrition consult is common in this population and it is unclear if weight gain occurs from the consult or surgery. The purpose of the study was to determine if nutrition consultation in the year prior to spinal fusion resulted in significant differences in weight gain or percentile on the CP growth chart. The secondary aim was to determine if there would be deformity progression during that time.

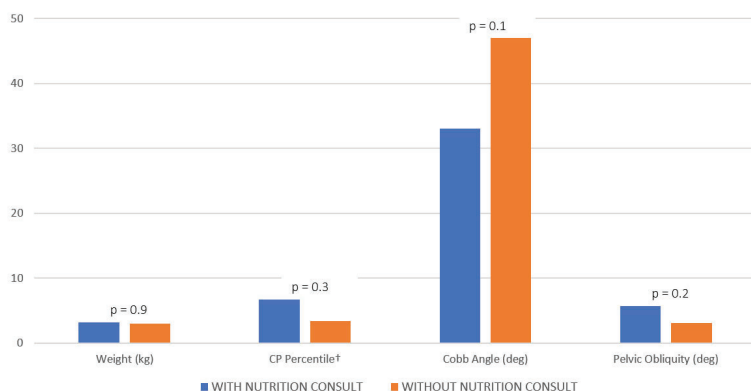
Methods: Retrospective chart and radiograph review was performed for all patients with neuromuscular spinal deformity treated with posterior instrumented spinal fusion at one institution between January 1, 2009 – August 1, 2015. Inclusion criteria included <20 years old, diagnosis of neuromuscular scoliosis, and one year pre-operative percentile on the CP growth chart <50. Patient demographics, GMFCS level, weight, percentile on appropriate CP growth chart, major curve and pelvic obliquity at one year pre-operatively and at surgery were recorded.

Results: Sixty-eight patients met inclusion criteria. Thirty-seven patients had a nutrition appointment within one-year pre-operatively, 31 patients did not. There were no significant differences between the groups when comparing increase in weight ($p=0.9$), percentile on CP growth charts ($p=0.3$), major deformity ($p=0.1$), and pelvic obliquity ($p=0.2$). Overall, there was a mean 3.2kg weight gain, 5.2% increase on CP growth charts, 40° increase in major curve, and 5° worsening of pelvic obliquity in the year before surgery. There was an average overall increase in the pre-operative albumin value, but this was not different between groups ($p=0.6$). Children that were tube fed gained on average 10.8 percentiles on the CP growth chart whereas children without gained only 0.5 percentiles ($p=0.002$).

Conclusions: Nutrition consultations in the year preceding posterior instrumented spinal fusion do not lead to weight optimization prior to surgery in comparison to patients without nutrition consults. Albumin values do not change with nutrition consults. Gastrostomy tubes were found to be helpful for weight optimization

Significance: This study suggests that a nutrition consultation in the year prior to posterior spinal fusion surgery for patients with neuromuscular scoliosis may lead to a larger curve without beneficial weight gain. Nutrition consultations should be initiated with enough time before surgery to enact meaningful weight gain and not cause a prolonged delay resulting in a more substantial and potentially perilous deformity. These consultations should likely be in conjunction with consideration of a feeding tube placement.

Impact of Nutrition Consults in the year prior to Neuromuscular Scoliosis Surgery



†Growth percentile on CP Growth Chart

Reliability and Utility of a Novel Classification Scheme for Gait Deviations in Children with Persistent Idiopathic Toe Walking

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Purpose: Typically developing children in whom toe walking does not resolve spontaneously by school age are considered to have Persistent Idiopathic Toe Walking (ITWp). Little is known about the natural history and surgical management outcomes in children with ITWp. The only existing classification scheme based upon quantitative data for children with ITWp, described by Alvarez, is imprecise, and external validity has not been established. A comprehensive classification scheme based upon gait deviations in children with ITWp has been developed to facilitate clinical decision making and outcomes assessment.(Table 1)

Methods: A retrospective review was performed of subjects with an established diagnosis of ITWp, who were evaluated by a standardized protocol including quantitative gait analysis. Sixty five neurologically normal children (22 girls, 43 boys; mean age was 11.1 years range 6.0-19.4 years; 130 lower limbs) with ITWp were studied. Pre- and post-operative data (mean 13 months following surgery) were available for 26 of the 65 subjects (52 limbs). Cases were classified using the previously described Alvarez classification and a novel Shriners Hospitals classification (SHC-ITWp). Intra- and inter-observer reliability were determined for the SHC-ITWp (30 limbs including pre- and post-op conditions), as was utility (percentage classifiable) for both Alvarez and SHC-ITWp (130 limbs, prior to intervention; 52 limbs following surgery to improve gait).

Results: The SHC-ITWp exhibited excellent reliability, with intra-rater agreement of 96.7% (weighted kappa = 0.98); and inter-rater agreement of 86.7% (weighted kappa = 0.93). The Alvarez classification exhibited poor utility, failing to classify 59 of 130 limbs (45%) prior to intervention, and 23 of 52 limbs (44%) following surgery. The SHC-ITWp exhibited excellent utility, successfully classifying each limb (130 prior to intervention, 52 limbs following surgery) discretely into one unique category.

Conclusions: The Alvarez classification exhibited marked deficiencies when applied to a large cohort of subjects (including pre- and –postoperative data) with ITWp. The SHC-ITWp exhibited excellent reliability and utility in classifying the limbs of children with ITWp prior to interventions and following surgery to improve gait.

Significance: The SHC-ITWp can be used to classify children with ITWp before and after musculoskeletal surgery to improve gait. Standardized classification of ITWp will facilitate sharing and comparison of data among centers. This tool can be utilized to clarify natural history, refine clinical decision making, and improve outcome assessment, following a range of treatment options, for children with ITWp.

Table 1: SHC-ITWp Classification

Ankle Sagittal Kinematics/Kinetics

1	Kinematics: Normal Kinetics: Normal
2a	Kinematics: Present 1 st rocker Kinematics/Kinetics: 1+ abnormality
2b	Kinematics: Absent 1 st rocker Kinematics/Kinetics: otherwise normal
3	Kinematics: Absent 1 st rocker Kinematics/Kinetics: additional 1+ abnormality
4a	Kinematics: Absent 1 st rocker, plantarflexion bias in stance and swing Kinetics: Moment double bump (2 nd peak larger)
4b	Kinematics: Absent 1 st rocker, plantarflexion bias in stance and swing Kinetics: Moment double bump (1 st peak larger)

The Stability of Sagittal Plane Gait Patterns from Early Childhood to Maturity in Cerebral Palsy

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Purpose: To define the trajectory of childhood sagittal plane gait deformities in spastic diplegic cerebral palsy (CP) as defined by the Rodda classification in a cohort from a single specialty institution.

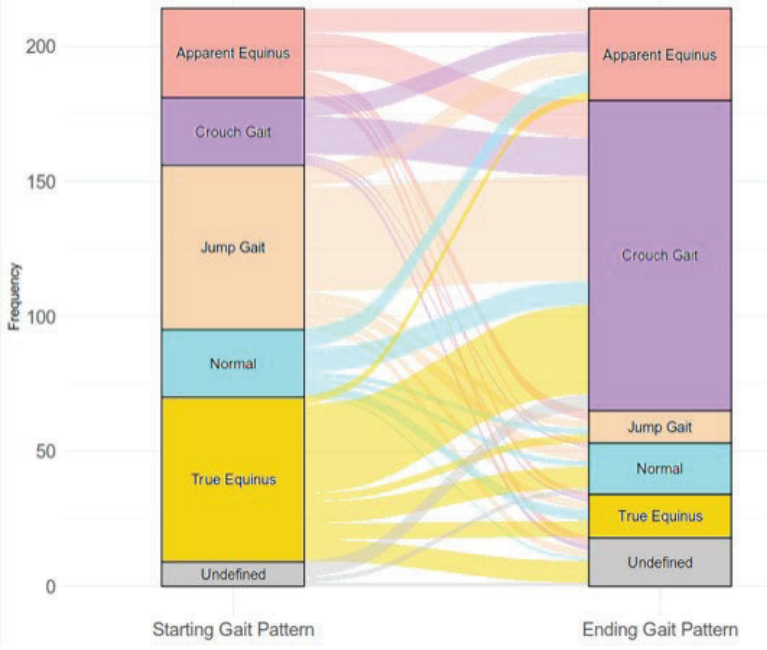
Methods: A retrospective longitudinal observational study of sagittal gait kinematics was utilized to evaluate a cohort with instrumented gait analysis (IGA) before age 8 and after age 15. Children who had gait-related surgeries prior to initial IGA were excluded. Individual limbs were categorized according to Rodda classifications based on mean sagittal plane knee and ankle angle during stance phase. Welch's t-tests were utilized to compare key gait variables from early childhood to maturity and to compare knee angles in patients who had plantarflexor lengthening surgeries to those who did not.

Results: 105 youth with CP were evaluated at mean age 6.0(\pm 1.2) and 19.6(\pm 4.5) years. GMFCS levels were I (10.5%), II (55.2%), III (28.6%), and IV (5.7%). Typical musculoskeletal treatment included PT, orthoses, and orthopedic surgery focused on soft tissue lengthening and lever arm correction, including 259 total operative events (1169 procedures). A high percentage of cases were asymmetric (45%) and so individual limbs rather than participants were classified. At initial visit, a majority of limbs were in either true equinus (28%) or jump-knee gait (29%). Crouch gait was the most common classification (54%) at maturity (Figure) of which 50% were mild (1-3Z)(19-28) $^{\circ}$. For the entire cohort, initial mean knee flexion in stance was 27(+15) $^{\circ}$ and 27(+12) $^{\circ}$ at maturity, normal 17(\pm 6) $^{\circ}$. Dorsiflexion in stance increased from 0(\pm 12) $^{\circ}$ to 9(\pm 6) $^{\circ}$ (p <0.0001); normal 6(\pm 3) $^{\circ}$. Mean knee flexion minimum during stance was 16(\pm 16) $^{\circ}$ and 18(\pm 12) $^{\circ}$ (p >0.1), and passive knee flexion contracture was -4(\pm 1) $^{\circ}$ and -3(\pm 7) $^{\circ}$. There was no difference in stance phase knee flexion between patients who underwent plantarflexor lengthenings versus those who did not, regardless of walking pattern at maturity, (p >0.18).

Conclusions: The trend in this cohort of patients with spastic diplegic CP was towards mild crouch gait classification mainly due to increased stance phase dorsiflexion from early childhood to maturity. Plantarflexor lengthenings were not a significant factor in progression of stance phase knee flexion.

Significance: Rodda classification may assist in understanding gait pathology but it did not reveal a simple prescriptive model for surgical procedures or outcomes. Surgical intervention, informed by IGA was more individualized and complex. Only a small percentage of patients were classified as having normal gait at maturity and a mild crouch gait may represent a positive and sustainable outcome in adulthood.

Changes in Gait Pattern



Effect of Positioning Error on the Hilgenreiner Epiphyseal Angle and Head-shaft Angle Compared to the Femoral Neck-shaft Angle in Children with Cerebral Palsy

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Purpose: Children with cerebral palsy (CP) often have an increased neck-shaft angle (NSA) or femoral coxa valga. True NSA and Hilgenreiner epiphyseal angle (HEA) are used to measure coxa valga, while head-shaft angle (HSA) is used to measure position of the femoral head on the femoral neck. Measurement of NSA on an anteroposterior (AP) pelvis radiograph is influenced by femoral rotation. HEA/HSA may be less affected by femoral rotation than NSA, but the impact of ab/adduction on all three measures is less clear. This study aimed to determine the effect of rotation and ab/adduction on HEA, HSA, and NSA.

Methods: Participant data from a previously published study of 384 patients (695 affected hips), Gross Motor Function Classification System (GMFCS) levels I to V, were utilized to create hip models in children with CP. NSA and HSA were measured on both hips from radiographs and used with femoral anteversion (FA) averages to model 695 hips in children with CP using one computed tomography (CT) scan from a typically developing child. To do this, bones in the CT scan were segmented semi-automatically. Each subject-specific deformity was created from the typical model by rotating the neck about the shaft to match each NSA and FA, and rotating the head about its centre to match each HSA. Models were manipulated in internal (IR) and external rotation (ER) and ab/adduction to simulate malpositioning. HEA, NSA, and HSA were measured in each joint position for each deformity, and the difference in each clinical angle in each joint position was recorded. Summary statistics were performed. Modelling was performed in MATLAB.

Results: NSA showed more error than HEA/HSA in femoral IR/ER, with all measures increasing with GMFCS level. Mean HEA error at 20° of internal and external rotation was -0.60° and 3.17°, respectively, with NSA error of - 6.56° and 9.94° and HSA error of -3.69° and 1.21°. Each degree of ab/adduction added 1° of HEA error, with no NSA/HSA error.

Conclusions: NSA error is higher than HEA/HSA in IR up to 20 degrees. HSA was least affected by changes in position. Abduction is more easily detectable on a radiograph than IR, so although HEA is quite sensitive to abduction, HEA may be less affected by the image positioning errors that are common with children with CP.

Significance: HEA/HSA may be a robust, complementary measure of hip deformities seen in children with CP. Further work is required on the clinical utility of using HEA.

Factors Associated with Gross Motor Recovery during Rehabilitation Following Single-Event Multilevel Surgery (SEMLS) for Youth with Cerebral Palsy

*M Wade Shrader MD; Nancy Lennon MS; Isabel Biermann; Grace Gerry; Jason Paul Beaman; Nicole Mamula; Abigail Gilmore; Timothy Niiler; Laura Owens
Nemours duPont Hospital for Children, Wilmington, DE*

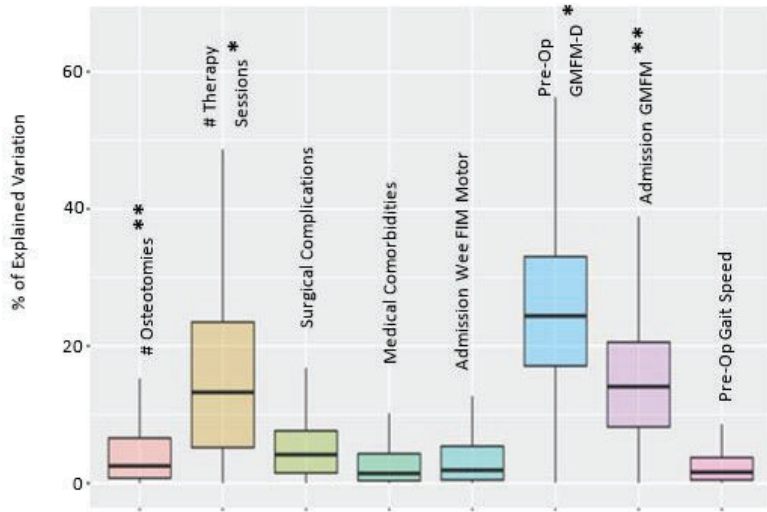
Purpose: Single-event multilevel surgery (SEMLS) is the standard of care for correcting musculoskeletal deformities in youth with cerebral palsy (CP). Rehabilitation following SEMLS is common practice to address postoperative muscle weakness and is considered essential to successful functional outcomes. The purpose of this study was to examine the role of multiple factors, including therapy dose, on the recovery of mobility function during post-SEMLS rehabilitation in youth with CP.

Methods: In this IRB-approved retrospective case-controlled cohort study, inclusion criteria were a diagnosis of CP or a similar condition and a lower extremity SEMLS followed by a rehabilitation episode. The outcome measure was the change in Gross Motor Function Measure (GMFM), measured by the Gross Motor Ability Estimator (GMAE) at admission and discharge from the rehabilitation episode. A bootstrap regression analysis was performed using preoperative gait speed, Gait Deviation Index, and GMFM-D, GMFCS level, age at surgery, number of osteotomies, surgical complications, medical comorbidities, number of therapy sessions during rehabilitation, and rehabilitation admission GMAE, Functional Independence Measure for Children, and Pediatric Evaluation of Disability Inventory-Computer Adaptive Test as predictors. The Akaike Information Criterion was used to minimize the number of variables used to explain the highest percent of variability.

Results: 69 children (GMFCS Levels I (4%), II (35%), III (38%), IV (23%)) met the inclusion criteria. 48% were male and 52% were female, with an average age of 13.8 years (4-21). 67% were Caucasian, 19% were African American, 1% were Asian, and 12% identified as mixed/other. On average, patients had 2.6 osteotomies and 89 (22 to 254) post-op therapy sessions; 27% had surgical complications and 57% had medical comorbidities. Regression analysis revealed eight clinically important factors, explaining 60% of the variability in change in GMFM during a rehab admission. For each osteotomy, the predicted gain in GMFM was reduced by 2.2 points. Therapy sessions, preoperative GMFM-D, and admission GMAE accounted for a combined 45% of the variability in change in GMFM.

Conclusions: The most impactful factors on mobility recovery after SEMLS were number of osteotomies, number of therapy sessions, preoperative GMFM-D, and admission GMAE. We were unable to capture finer details of therapy or account for factors such as motivation and pain, which likely influence recovery.

Significance: This study shows that higher therapy dose has a positive impact on recovery of mobility function during post-SEMLS rehabilitation episodes. Surgical burden and gross motor function pre- and post-surgery are also important to consider.



Baseline Patient Reported Outcomes Measurement Information System (PROMIS) Scores in Children with Adolescent Idiopathic Scoliosis (AIS) and Their Relation to the SRS-22

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Purpose: PROMIS is becoming the most commonly utilized Patient Reported Outcome Measure (PROM) in adult orthopaedics, but its adoption has lagged in pediatrics. Limited baseline data exists in pediatric-specific orthopaedic diagnoses. The objective of this study was to determine baseline PROMIS scores in patients with AIS and to evaluate for correlations with the SRS-22.

Methods: This was a retrospective review of prospectively collected data from six tertiary care pediatric hospitals between July 2016 and July 2018. Patients with a diagnosis of AIS, adequate radiographs for measurement and completion of PROMIS and SRS-22 questionnaires from the same visit were included. Only the first visit during the study period was included for each subject. Post-operative patients were excluded. Spearman correlations were performed between four PROMIS domains (Pain interference [PI], Mobility [M], Peer Relationships [PR] and Upper Extremity [UE]) and SRS-22 domains. PROMIS scores are calibrated such that 50 is the median value in a population and 10 points is equivalent to one standard deviation.

Results: 986 patients with a mean age of 14.6 years were included, 79.8% of which were female. The mean major Cobb angle was 33.0 degrees (range: 10-102). The major curve was thoracic in 56.5%, thoracolumbar in 24.4% and lumbar in 19.1% of subjects. The mean PROMIS domain scores were: Pain Interference 44.5 (IQR 17.7); Mobility 52.7 (IQR 12.5); Peer Relationships 55.7 (IQR 15.0); Upper Extremity 53.4 (IQR 7.7). There was no correlation between scoliosis magnitude and any PROMIS domain. Patients with a Pain Interference score of greater than 60 were found to have a higher BMI (24.4 versus 19.2; $p < 0.001$). Correlations existed between PROMIS Pain Interference and SRS-22 pain ($r = .704$, $p < 0.001$) and PROMIS Mobility and SRS-22 function ($r = .53$, $p < 0.001$). Significant ceiling effects existed in SRS-22 Function (29.9%), Pain (19.2%) and Satisfaction (30.3%) but only for PROMIS Peer Relationships (42.1%).

Conclusions: PROMIS domain scores for patients with AIS are within normal population limits. PROMIS correlates well with SRS-22r in overlapping domains, and fewer domains demonstrate a ceiling effect. Patients with elevated Pain Interference have a higher BMI. There was no relationship between Cobb angle and PROMIS domain scores.

Significance: This is the first large multi-center review of PROMIS in patients with AIS. It establishes baseline characteristics for future studies.

Proof of Concept for Artificial Intelligence Based Estimation of Skeletal Maturity from Biplanar Slot Scan Scoliosis Imaging

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Purpose: Skeletal maturity assessment plays an important role in the management of scoliosis. The most common method to estimate skeletal growth remaining using scoliosis radiographs is the Risser score, which has limited accuracy. Recently, patterns in the closure of the proximal humeral physis have been correlated with bone age, but dedicated hand radiographs remain the gold standard. The modified Oxford bone score (mOBS) has also been described to estimate skeletal maturity through ossification patterns about the hip. Biplanar slot scan scoliosis images commonly include in the field of view multiple development landmarks such as ossifications of the shoulder, pelvis, and proximal femora. Here we describe the development of an artificial intelligence based algorithm to extract multiple skeletal maturity classifications from standard biplanar slot scan scoliosis radiographs.

Methods: After obtaining IRB approval, we retrospectively collected 1197 anteroposterior pediatric scoliosis radiographs performed between 2019 and 2020. All radiographs were manually annotated, and used to train a Faster rCNN (Region-based Convolutional Neural Network) Inception V2 model from the TensorFlow Object Detection Application Programming Interface. The model was trained to detect the humeral head, ilium, and hip joint. Since these anatomic regions of significance were as small as 2% of the image, we applied a multi-class region proposal network to extract the humeral head and five mOBS regions (Figure 1). We then applied multiple compound scaling convolutional neural networks (EfficientNet) in parallel to assign clinical stages to the humeral head and mOBS regions.

Results: Our regional detection achieved an average F1-score of 0.99, indicating excellent accuracy. For the image classification models, average percent accuracy was 89% and the average intraclass correlation coefficient (ICC) was 0.84.

Conclusions: Reliable assessment of skeletal maturity remains a challenge with methods that rely on a single body region. Obtaining multiple radiographs increases radiation exposure and cost. We demonstrate a proof of concept that automated image processing algorithms can reliably classify ossification about the shoulder and hip using established staging systems.

Significance: This study lays the groundwork for the development of future models that may generate a best estimate of skeletal maturity, combining data from multiple staging systems when complete staging is impossible due to partial shielding, collimation, or suboptimal positioning. By simultaneously quantifying ossification of many visible growth centers often captured on scoliosis radiographs, orthopedic surgeons can maximally leverage information gained from standard imaging and avoid the cost and radiation exposure associated with additional radiographs.

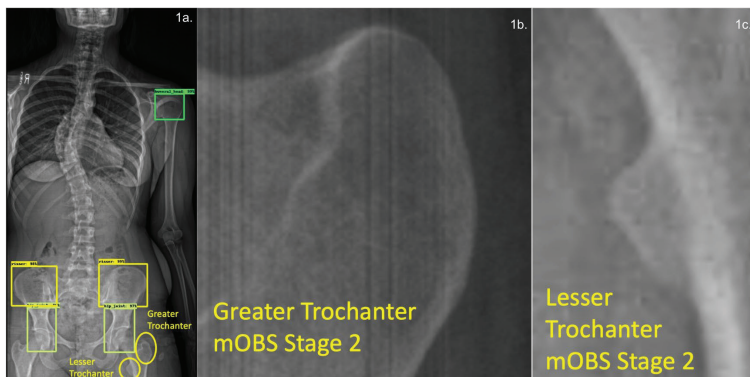


Figure 1: 1a. Annotated Output. 1b: Greater Trochanter. 1c: Lesser Trochanter

Surgical Site Infection Following Neuromuscular Posterior Spinal Fusion: Comparing Incidence Before and After the 2013 Best Practice Guideline

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Purpose: Patients with neuromuscular scoliosis (NMS) are at the highest risk for surgical site infection (SSI) following spine surgery. In 2013, a Best Practice Guideline (BPG) for SSI prevention in high-risk pediatric spine surgery patients reported strategies to decrease incidence. The purpose of this study is to investigate the incidence of SSI in NMS patients at a tertiary children's hospital before and after the implementation of these strategies.

Methods: A retrospective review of SSI in NMS patients was performed. NMS patients undergoing primary posterior spinal fusion from January 2008 - December 2012 (Group 1) and January 2014 - December 2018 (Group 2) were included, with 2013 excluded as a transition year. Patient demographics and characteristics were collected, as well as surgical and procedural details. The primary outcome was incidence of deep SSI within 1 year of surgery.

Results: 198 patients were included, 62 in Group 1 and 136 in Group 2. Age, BMI, sex, fusion to pelvis, preoperative Cobb angle, incontinence, drain use, intra-operative transfusion, and perioperative lab values were similar between groups ($p>0.05$). Deep SSI occurred in 10 (16.1%) patients in Group 1 and 6 (4.4%) patients in Group 2 ($p=0.005$). Thirteen (59.1%) identified organisms were gram-negative and polymicrobial infections accounted for 6 (37.5%) infections overall.

Conclusions: The incidence of SSI in NMS patients decreased significantly (16.1% vs 4.4%) after the implementation of the strategies mentioned in the 2013 BPG. Further studies are needed to assess the impact of BPG adherence on the risk of long-term infections.

Significance: The incidence of surgical site infection in neuromuscular scoliosis patients decreased 72% at our institution after the implementation of the strategies mentioned in the 2013 Best Practice Guideline.

National Trends in Performing Osteotomies for AIS in North America: Greater Incidence Is Associated with Significant Complications and Greater Cost

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Purpose: The use of Ponte osteotomies in kyphotic deformities is well-established, however, their use in AIS is controversial. The purpose of this study was to characterize and compare the demographics and clinical outcomes of idiopathic patients undergoing posterior spinal fusion (PSF) with osteotomies using a national inpatient sample.

Methods: Using the Healthcare Cost and Utilization Project's Kids' Inpatient Database (KID) from 2000 to 2016, patients with ICD-9 and ICD-10 diagnosis codes for idiopathic scoliosis, ages 10-18, who underwent PSF were identified. For national estimates, weights provided by the Agency of Healthcare Research and Quality were used. Patients who had an osteotomy (O+) and those who did not (O-) were compared.

Results: We identified 28,184 patients, (76.5% female, age 14.1 years). O+ occurred in 5.03% of the cases with a significant increase in rate over the years (2000:0.54% to 2016:11.11%, $p<0.001$). No differences were seen between groups in age, gender, hospital type (urban vs. rural), or geographic region in the US. A higher postoperative rate of neurologic complications (1.0% v 0.4%, $p=0.023$), and rate of transfusions (23.6% vs 18.5%, $p=0.009$) was seen in the O+ group. While LOS did not reach statistical significance (5.4 vs 5.1 days, $p=0.094$), the average total hospital charges showed an average 34% increase in O+ patients (\$177,033 vs \$132,232, $p<0.001$).

Conclusions: The use of Ponte osteotomies in AIS has steadily increased over the last decade without regional differences. While LOS remained stable, the use of osteotomies was associated with a doubling of the neurologic deficit rate, an increased blood transfusion rate, and 34% higher hospital charges. This trend in the use of Ponte osteotomies should be evaluated carefully to determine whether a substantially greater outcome can justify the increased healthcare cost and complications.

Significance: Ponte osteotomies are more frequently utilized in AIS surgery with increasing cost to the system with higher complications and incidence of transfusion to the patients.

Evaluation of the AOSpine Injury Classification in the Pediatric Population: Results of a Multi-Center POSNA Grant

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Purpose: The AO Spine Classification System has been developed and validated in adults in multiple studies. The purpose of this study was to assess the reliability and reproducibility of this classification system in the pediatric population.

Methods: Radiographic studies of 78 children (mean age 12.3 years, range: 1-18) with operative and nonoperative spine injuries (AOSpine anatomical regions: 26 upper cervical, 27 subaxial, 25 thoracolumbar) were evaluated. Each anatomical region was studied separately, consecutively. Educational videos, schematics, and clinical papers describing the AOSpine Injury Classification system were sent to a cohort of 9 pediatric spine surgeons in order to familiarize themselves with the classification system. The surgeons were then provided with a secure online viewing program of the axial and sagittal CT and MRI images of each patient. Injuries were classified by type and subtype according to the AO classification. Interrater reliability was assessed for the initial reading across all 9 raters by Fleiss's kappa coefficient (k_F) along with 95% confidence intervals (CI). One month later, all surgeons reviewed and classified the same images with all images being randomized for each read independently. Intrarater reproducibility across both reads was assessed using Fleiss's kappa. Interpretations for reliability estimates were based on Landis and Koch (1977): 0-0.2, slight; 0.2-0.4, fair; 0.4-0.6, moderate; 0.6-0.8, substantial; and >0.8, almost perfect agreement.

Results: For upper cervical injuries, interrater reliability was fair with respect to injury type. Intrarater reliability was substantial. For subaxial injuries, interrater reliability was moderate for fracture type, while intrarater reliability was fair overall. As a comparison, our group's previously published thoracolumbar ratings were near perfect for both interrater and intrarater reliability (Table 1).

Conclusions: The AO Spine Injury Classification when applied to pediatric spine trauma showed inter- and intra-rater agreement ranging from moderate to almost perfect amongst a group of POSNA surgeons. Inter- and intrarater reliability for thoracolumbar spine fractures were higher than the upper cervical and subaxial cervical spine injuries' reliability studied here.

Significance: This study is the first to evaluate the use of the AO Spine Injury Classification System in pediatric patients. While the system is learnable by surgeons, the clinical viability of this classification system may be greater for thoracolumbar fractures than for those in the cervical spine.

Table 1. Inter- and intrarater reliability summary for the AO spine classification system by cervical injury location.

		Statistic	Interrater		Intrarater
			First Read	Second Read	
Upper Cervical	Fracture Location	k_F	0.56	0.24	0.66
	Primary Classification	k_F	0.58	0.30	0.46
	Sub Classification	α_K	0.55	0.70	0.75
Subaxial	Primary Classification	k_F	0.41	0.50	0.63
	Sub Classification	α_K	0.25	0.23	0.48
Thoracolumbar*	Primary Classification	k_F	0.82	0.78	0.81
	Sub Classification	α_K	0.79	0.75	0.81

α_K , Krippendorff's alpha; k_F , Fleiss's kappa.

* Previously published data

Cervical Degenerative Disc Disease is Associated with Increased Cervical Kyphosis in Adolescent Idiopathic Scoliosis

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Purpose: Adolescent idiopathic scoliosis (AIS) is often associated with thoracic hypokyphosis and compensatory cervical kyphosis. In adults, cervical kyphosis is associated with degenerative disc disease (DDD). Although cervical kyphosis has been reported in up to 60% AIS patients, the association with cervical DDD has not been reported.

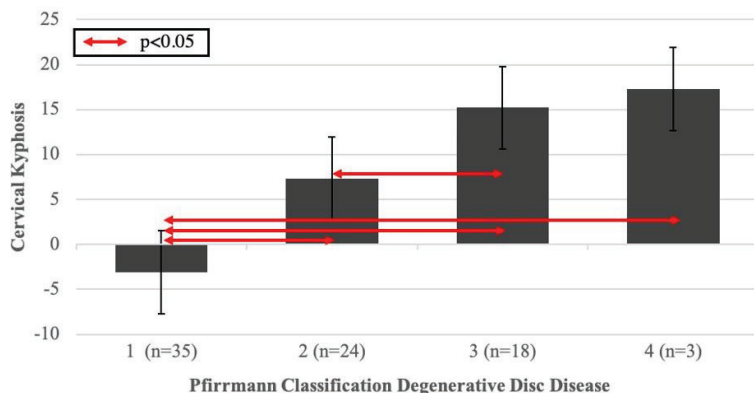
Methods: A retrospective review was conducted at a tertiary children's hospital from January 2014 to December 2019. Inclusion criteria were AIS patients > 10 years that had a cervical MRI and anterior-posterior/lateral spine radiographs within one year of each other. MRIs were reviewed by a pediatric orthopaedic spine surgeon for evidence of cervical DDD. Severity of cervical changes were graded using Pfirrmann classification. Grade 1 was defined as normal disc, grade 2 as mild, grade 3 as moderate, grade 4 as moderate/severe and grade 5 as severe DDD. Cervical kyphosis (C2-C7), thoracic kyphosis (T1-T12), and major coronal curve magnitude were measured. Statistical models included chi-square tests for independence, linear regression, and ANOVA models with post-hoc pair-wise comparison.

Results: Eighty consecutive patients were included (14.1 ± 2.5 years). Increasing cervical kyphosis was significantly correlated to decreasing thoracic kyphosis ($r=0.49$, $p<0.01$) and increasing major curve magnitude ($r=0.22$, $p=0.04$). 35 patients (44%) had no DDD (grade 0) with a mean cervical lordosis of $3.1 \pm 7.9^\circ$ and 45 patients (56%) had the presence of DDD (grades 2-4) with a mean cervical kyphosis of $11.1 \pm 9.5^\circ$ ($p<0.01$). Cervical DDD was as follows: 24 (30%) stage 2, 18 (22%) stage 3, 3 (4%) stage 4 and 0 stage 5. Mean cervical kyphosis by Pfirrmann classification are shown in Figure 1. There was a significant increase in cervical kyphosis with increasing DDD grades 1 through 3. Nine patients had ventral cord effacement secondary to DDD with a mean cervical kyphosis of $22.8 \pm 8.6^\circ$ compared to $2.6 \pm 11.2^\circ$ in those who did not ($p<0.01$).

Conclusions: Cervical kyphosis was significantly associated with increasing severity of cervical DDD in patients with AIS. Patients with evidence of ventral cord effacement had the largest degree of cervical kyphosis with a mean of $22.8 \pm 8.6^\circ$. Future studies are needed to assess the clinical significance and long-term impact of these findings in the AIS population.

Significance: This is the first study to evaluate the association between cervical kyphosis in AIS with cervical DDD. Increasing cervical kyphosis was significantly associated with increasing severity of cervical DDD.

Figure 1. Mean cervical kyphosis for each grade of Pfirrmann classification. There was a significant difference between cervical kyphosis for Pfirrmann grade 1 vs 2, 3, 4 and 2 vs 3 ($p<0.01$) Reproduced with Permission from the Children's Orthopaedic Center, Los Angeles.



Characterizing Mortality in Patients with Early Onset Scoliosis

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Purpose: Early onset scoliosis (EOS) is a spinal deformity that occurs in patients younger than age 10. In severe chest and spine deformity, this may result in thoracic insufficiency, respiratory failure, and premature death. Furthermore, many EOS patients carry life-threatening comorbid conditions. The purpose of this study is to describe the natural history of mortality in patients with EOS.

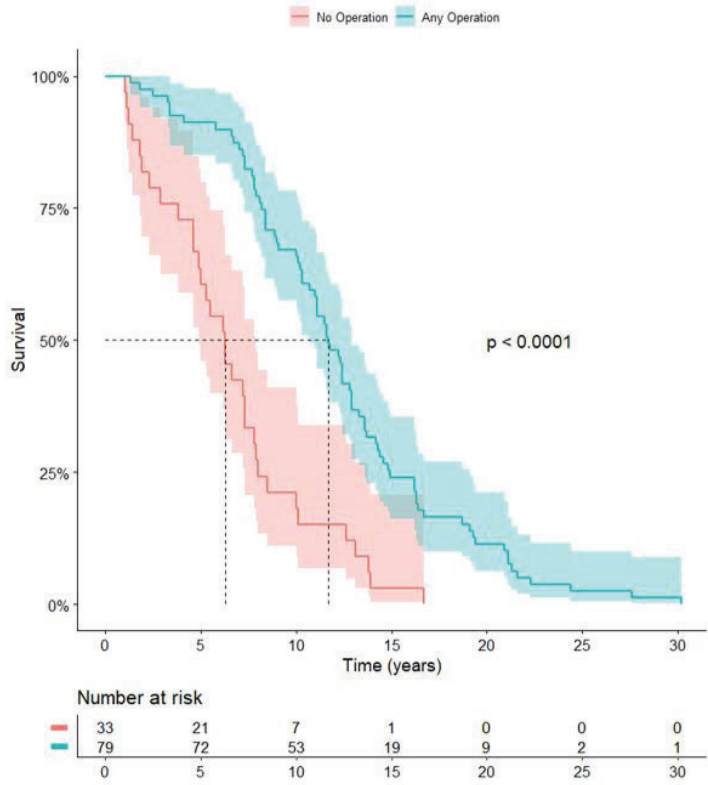
Methods: The Pediatric Spine Study Group database was queried for all patients with EOS who are deceased, without exclusion. Demographic information, diagnosis, EOS etiology, operative and non-operative treatment, complications, and date of death were retrieved. Descriptive statistics and survival analysis with Kaplan-Meier (KM) curves were performed.

Results: 130 deceased patients were identified in the 8,580 patient registry, a mortality rate of 1.6%. Mean age at death was 10.6 years (range 1.0-30.2). The most common EOS etiology in the deceased cohort was neuromuscular (56.2%). Deceased patients were more likely to have surgical treatment than be treated non-operatively with casting or bracing or observed ($p < 0.001$). However, the mean age of death for those patients operatively treated (12.3 years) was older than those non-operatively treated (7.0 years) or untreated (6.3 years) ($p < 0.001$). KM analysis confirmed an increased survival time in those patients with a history of spine operation ($p < 0.0001$) (Figure 1). Deceased patients experienced at least 1 complication from diagnosis to death (range 1-15). Overall, cardiopulmonary related complications were the most common (47.6%), followed by implant-related (21.0%) and wound-related (9.6%) ($p < 0.001$). Primary cause of death could be identified for 78 (60.0%), of which 57 (73.1%) were cardiopulmonary related. Subgroup analysis by EOS etiology revealed no difference in age at death or number of complications.

Conclusions: The mortality rate seen in EOS patients (1.6%) is similar to that of other common childhood diseases such as cystic fibrosis (1.3%-1.7%). This study chronicles the treatment history of deceased patients with EOS and highlights the impact of surgical intervention on the lifespan of these patients. Both fatal and nonfatal complications in children with EOS are most likely to involve the cardiopulmonary system.

Significance: This study represents the largest collection of EOS mortality to date, providing surgeons with a modern-day examination of the natural history and the effects of surgical intervention to better counsel patients and families.

Figure 1: Survival Curve by History of Spine Operation



A Wireless Intraoperative Neuromonitoring System is as Reliable and Accurate as the Traditional Wired Systems for Spinal Deformity Surgery

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Purpose: Intraoperative neurophysiological monitoring (IONM) utilizes subdermal needle electrodes connected to an IONM system through multiple cables that crowd the surgical field, take time for placement and are susceptible to electromagnetic interference affecting signal integrity. We present a new wireless network system to acquire transcranial (TcMEP) signals digitally and wirelessly.

Methods: This was an IRB-approved prospective study of patients undergoing spinal deformity surgery. Four wireless modules were designed with a two-stage amplifier to maximize the TcMEP waveforms. Amplifier gains were tailored to each muscle's specific output. To verify the performance, TcMEPs were recorded by both systems simultaneously. Wireless recordings were digitalized at the recording sites and transmitted across the operating room to computers. The signals were transformed and compared to its equivalent wired IONM waveform. Signals were examined by the goodness of fit, Pearson's correlation, and root mean square errors methods (RMSE).

Results: A total of 20 patients had IONM data simultaneously collected by both a traditional system and a wireless system. Due to differences in hardware and software configurations between the systems, differences in frequency responses and waveform distortion were noted. A system-transfer function was calibrated to establish a relationship between these systems and used to transform the recorded wireless signals to compare with the wired signals. For each patient, calibrated wireless waveforms displayed excellent correlation with the standard wired recording, with similarities ranging from 97.6%- 99.7% in the waveforms from the abductor hallucis. The wireless signals, since they are digitalized in real time at the module near the needle, contain more original contents in the signals and much less noise from the environment.

Conclusions: While wired IONM recording has been considered the gold standard for spinal deformity surgery, a wireless recording application is feasible and advantageous due to its smaller size, lower cost, better signal integrity and shorter setup time. The system allows portability since the wireless devices and its dongle can work with any computer.

Significance: A new wireless sensor network can also be applied to acquire TcMEP signals with high effectiveness and reliability of recordings.

Comparative analysis of Post-op Motion between Spinal Fusion and VBT

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Purpose: Emerging reports of vertebral body tethering (VBT) have shown an acceptable safety and efficacy profile; however no clinical studies have evaluated segmental spinal mobility following VBT to determine whether motion is truly preserved. Our aim was to compare postop motion between a cohort of VBT patients and those that had undergone standard spinal fusion (SF).

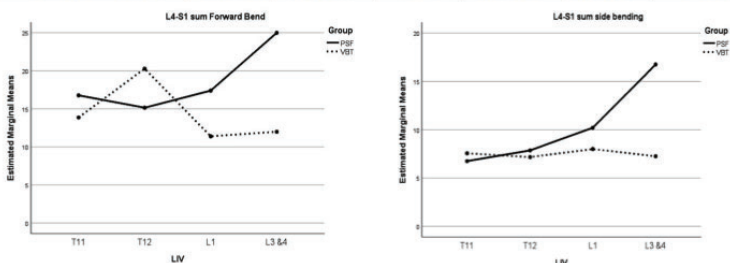
Methods: Intervertebral segmental spinal motion (IVM) was assessed by standardized xrays acquired in maximum right, left and forward bending (FB) for patients treated with either VBT or SF. Patients were matched for LIV and fusion length. An independent observer measured the intervertebral angles via digital xray measuring software. FB IVM was measured by adding the static angle on the upright lateral xray with the static angle on the FB lateral xray. IVM in the coronal plane was measured by adding the static angle on the right bending PA xray and the left bending PA xray and termed side bending (SB). IVM was measured in unfused segments in the SF group and in instrumented and uninstrumented segments in the VBT group.

Results: 25 VBT patients were matched 1:2 to 50 SF patients with minimum 2 yr f/u. Total FB IVM between the groups was not significantly different (43.6° +/- 11.3° SF / 43.4° +/- 13° VBT; p=0.8); however FB motion of the unfused segments was significantly less in the VBT group compared to SF (31° +/- 13.6° vs 39° +/- 11.6°; p=0.003) with no LIV interaction (p=0.4). FB IVM from L4-S1 also showed significantly less motion post VBT compared to SF (14.9° +/- 6.9° vs 17.8° +/- 7.9°; p=0.03). VBT total SB IVM showed greater motion than SF (p=0.013) with no difference in SB IVM in the nonfused, uninstrumented segments between groups (0.9). L4-S1 SB IVM showed significantly greater motion post SF (9.5° +/- 6.6°) compared to VBT (7.5° +/- 3.6°) (p=0.046) and this motion was greater the more distal the LIV.

Conclusions: VBT maintains IVM through the tethered segments allowing for a more even distribution of motion not demonstrated following SF. SF resulted in greater motion through nonfused segments in particular L4 to S1, which may have significant future implications on disc health.

Significance: VBT more uniformly preserves intervertebral motion compared to SF. The increased intervertebral motion below a fusion to maintain flexibility may have implications around degenerative changes over time lending VBT to potentially be an attractive alternative to standard fusion in idiopathic scoliosis.

Patient Demographics	VBT		PSIF			
Age (yrs)	12 +/- 1.2		16.1 +/- 3.5			
Sex	4 M; 21 F		2 M; 48 F			
Pre-op Major Cobb (°)	57 +/- 10.2		49.1 +/- 8.2			
Post-op Major Cobb (°)	22.2 +/- 8.9		20.9 +/- 7.8			
Mean Number Levels Instrumented	9.4 (5-12)		8.4 (5-13)			
% Curve Correction	61%		57%			
LIV (N)	T11:9; T12:7; L1:5 L3:3; L4:1		T11:18; T12:14; L1:10 L3:6; L4:2			
Post-op IVM Motion (°)	FORWARD BEND (FB)		p-value	SIDE BEND (SB)		p-value
	VBT	PSIF		VBT	PSIF	
Total	43.4 +/- 13	43.6 +/- 11.3	0.8	51.2 +/- 13.8	42.8 +/- 12	0.013*
Un-Instrumented Total	31 +/- 13.6	39 +/- 11.6	0.003*	38.3 +/- 14	37 +/- 12.19	0.9
Summed L4 to S1	14.9 +/- 6.9	17.8 +/- 7.9	0.03*	7.5 +/- 3.6	9.5 +/- 6.7	0.046*



Risk of Early Complication Following Anterior Vertebral Body Tethering for Idiopathic Scoliosis

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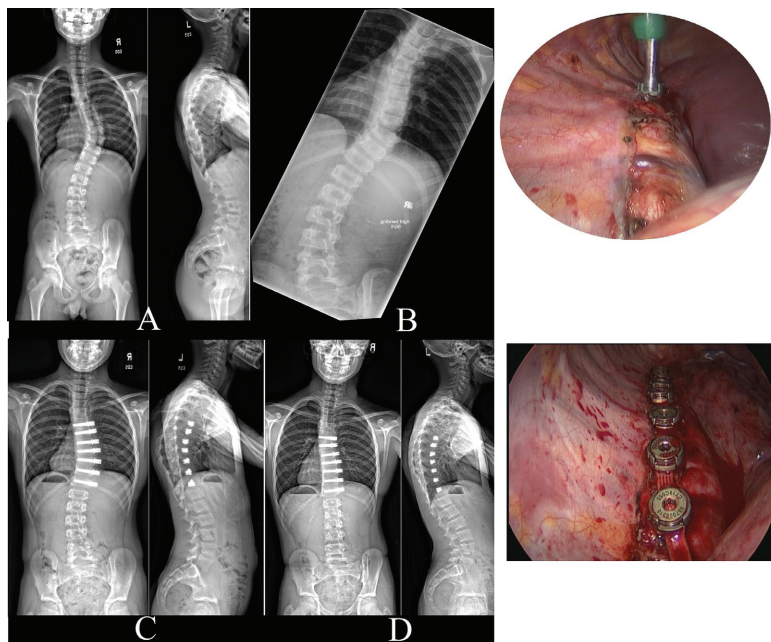
Purpose: This purpose of this study was to determine peri-operative morbidity associated with anterior vertebral body tethering (aVBT) for idiopathic scoliosis. Secondary objective: To measure initial correction of deformity.

Methods: This is a retrospective review of prospectively collected data from an international early onset scoliosis registry. Out of 7,989 patients in the data base, there were 175 patients treated with aVBT. There 120 of those patients who had 1 year follow-up and data available for this study. Inclusion criteria were idiopathic scoliosis, immature skeleton (Risser 0-3), main thoracic deformity with a curve of 40-70 degrees, and at least 1 year of follow up. Clinical and radiographic data were analyzed for this purpose.

Results: Mean age was 12.6yr (8.2-15.7yr), Risser 0-3, thoracic scoliosis 51.2° (40-70°). Immediate postop scoliosis 26.9° (6-53°)* and at 1 yr 22.8° (-11-50°)*. Pre-op T5-T12 kyphosis 16° (-23-52°), 1 yr postop 18° (-14-61°). *p<0.05. All patients underwent thoracoscopic approach with median 4 incisions, EBL 200ml (20-900 ml), surgical time 215min (111-472), anesthesia time 303min (207-480), and hospital stay 4.5 days (2-9) During the in-hospital stay, there was a 0.8% rate of complication and no unplanned return to the operating room (UPROR): 1pneumothorax requiring reinsertion of chest tube By 90 days postop, there was a 5 % rate of complication. 5 complications developed after discharge: 1 CSF leak treated with blood patch injection in the clinic, 2 pleural effusions requiring chest tubes, 1 wound infection and 1 pneumonia treated with antibiotics By 1yr postop, there was a 0.8% rate of UPROR and 8.3% rate of complication. After 90 days, 4 additional complications developed: 2 upper limb paresthesia required outpatient medical management, 1 CSF leak required UPROR and 1 curve reversal

Conclusions: This large, multicenter series of aVBT demonstrated an 8.3% complication rate and a 0.8% UPROR rate at 1yr postop. This early study found higher rates of CSF leaks and overall complications than would be expected for PSFI at 1yr post-op

Significance: aVBT has demonstrated increasing complications with time from peri-operative to 1 year post-operative. However, this study was during the learning curve of the technique and as is common with new procedures, the complication rate may fall with further experience.



Can Bone Health Improvement from the Initial 2-Year Calcium and Vit-D Supplementation Persist Towards Peak Bone Mass after 4-Year of Supplement Discontinuation in Adolescent Idiopathic Scoliosis – A Randomized Controlled Trial

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Purpose: Adolescent idiopathic scoliosis(AIS) is associated with osteopenia which could persist into adulthood affecting attainment of Peak Bone Mass. We previously reported a randomized double-blinded placebo-controlled trial(the Cal study) showing significant bone health improvement with 2-year calcium(Ca)+Vit-D supplementation for AIS girls. This study addressed the issue whether bone health improvement from the initial 2-year Ca+Vit-D supplementation could persist as subjects approached Peak Bone Mass at 6-year ie after 4-year of supplement discontinuation.

Methods: This was an extension of the Cal study on AIS girls(11-14 years old, mean age=12.9 years, Tanner stage<IV) with femoral neck aBMD Z-score<0 and Cobb angle $\geq 15^\circ$. 330 subjects were randomized to Group1(placebo), Group2(600mgCa+400-IU-Vit-D3/day) or Group3(600mgCa+800-IU-Vit-D3/day) for 2-year supplementation after which supplementation was stopped. Investigations at baseline, 2-year and 6-year included High-resolution Peripheral Quantitative Computed Tomography(HR-pQCT) at distal radius and Dual Energy X-ray Absorptiometry(DXA) at both hips.

Results: At 2-year time-point, 270 (81.8%) subjects completed 2-year treatment. The mean drug compliance was 83%. The gain in serum 25(OH)Vit-D in both Treatment Group2/3, and the gain in left femoral neck aBMD in Treatment Group3 were significantly greater than the Placebo Group1(all with $p<0.05$). Increases in Trabecular vBMD, Trabecular Bone Volume to Tissue Volume Ratio and Trabecular Number were greater in Treatment Group2/3 as compared with Placebo Group1(all with $p<0.05$). In contrast, the increase in Trabecular Separation was significantly greater in the Placebo Group1 than Treatment Group2/3. At 6-year time-point, 226 subjects (83.7% of those who completed the 2-year treatment, or 68.5% of the initial cohort) were available for study at a mean age of 19.2 years old. No difference was noted in all DXA and HR-pQCT bone density and bone quality parameters except increase in Cortical Thickness being greater only in Treatment Group3 than in Placebo Group1.

Conclusions: The results provided strong evidences that daily 600mgCa+400/800-IU-Vit-D3 was effective for treating low bone mass in AIS subjects with Z-score<0 resulting in increase in aBMD at left femoral neck and Trabecular vBMD and other bone micro-architecture parameters at non-dominant distal radius. In contrast, at 6-year follow up with 4-year discontinuation of supplementation, the treatment effect seen with 2-year supplementation mostly regressed towards the null hypothesis.

Significance: After 4-year supplement discontinuation, the treatment effect from the initial 2-year supplementation mostly dissipated indicating the need of continued supplementation in AIS girls to sustain therapeutic improvement on bone health as subjects approach towards Peak Bone Mass. (Funding:RGC-HKSAR(Ref:14130216 and 14174517))

Waterproof Mehta Casting for Early Onset Scoliosis

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Purpose: Serial Mehta casts for the treatment of early onset scoliosis (EOS) traditionally utilize cotton padding. Inherent advantages of waterproof casting include clearance for bathing/swimming, avoiding cast holidays, and improved family satisfaction. This is the first series describing the safety and efficacy of waterproof Mehta casts for EOS.

Methods: A consecutive series of EOS patients underwent serial 75% body weight traction-elongation-flexion Mehta cast protocol with waterproof lining. The addition of 3-point apical translation with stockinettes were utilized during casting. Bracing was initiated after correction $<10^\circ$ or 1 year of serial casting.

Results: 17 patients at mean age 22 months, with pre-cast Cobb angle 52.4° (R: 35° - 75°), underwent 10.6 months of casting with 5.7 casts. In-cast correction index was 66%, for post-cast Cobb 18.1° . At mean 5.1 yrs (R: 2.1–9.4 yrs), 14/17 (82%) successfully avoided surgical intervention, and 9/17 (53%) maintained correction $<25^\circ$. 3/17 (18%) required a 2nd round of casting; one underwent surgical conversion at 5.3 yrs, and two had curve control at 30° and 54° at 4.2 and 5.1 yrs post-casting. A total of 3/17 (18%) ultimately required surgery with halo-gravity traction followed by magnetic growing rod therapy at 6.2 yrs post-casting; 2/3 had significant noncompliance with loss to follow-up of ≥ 3 yrs prior to surgery. No major cast related complications, decubiti, or cast holidays were encountered. One patient incurred a superficial 2 cm cast saw burn during creation of abdominal window, and one required early final cast removal due to parental perception of discomfort. Final in-cast correction ratio ($p=0.006$) and post-cast Cobb angle ($p=0.003$) were the only variables predictive of ultimate need for surgical conversion.

Conclusions: Waterproof Mehta casting is safe and efficacious in early onset scoliosis. Of 17 patients with pre-cast Cobb 52.4° , 82% successfully avoided surgery and 53% maintained mild curves $<25^\circ$ magnitude at 5.1 years follow-up. No major complications or skin decubiti occurred, and advantages include clearance for bathing and avoidance of need for cast holidays during treatment.

Significance: Serial waterproof Mehta casting is safe and efficacious when compared to published literature of traditional Mehta casting, with the advantages of clearance for bathing, improved family satisfaction, avoidance of cast holidays between casting intervals, 53% likelihood of maintaining curve correction $<25^\circ$, and 82% likelihood of avoiding surgery at 5.1 years follow-up.

Vertebral Column Resection Improves the Sagittal Plane Greater than Other Techniques but Risks Symptomatic Junctional Kyphosis

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Purpose: The surgical treatment of severe pediatric spinal deformity is challenging with significant risks including neurologic and coronal decompensation which have been well-characterized. However, sagittal plane analysis has been lacking for these patients despite anecdotal reports of significant challenges with proximal (PJK) and distal junctional kyphosis (DJK).

Methods: The prospective, multi-center, international database of pediatric severe spine deformity patients in which the preoperative curves were either greater than 100° or patients who had a VCR was reviewed. All sagittal parameters were analyzed to determine improvement in radiographic parameters and determining the incidence of PJK or DJK occurred. Differences between VCR and no VCR patients were assessed.

Results: There were 228 patients who had 2-year data for review, of which, 110 had a VCR and 118 did not. Preoperatively, the VCR group had a greater Sagittal-Deformity Angular Ratio (S-DAR) (16.9 vs 12.2, $p<0.001$), and measured T10-L2 (25.4 vs 9.2°, $p=0.02$) without differences in other preoperative sagittal plane parameters including T2-T12 kyphosis (65.6° vs 67.5°), lumbar lordosis (63.3° vs 68.2°), and sagittal balance or pelvic parameters. The follow-up lateral radiographs demonstrate improved S-DAR correction in the VCR group resulting in similar 2-year S-DAR (5.7 vs 6.3). Other sagittal parameters were similar including T5-T12 (36.4° vs 40.5°) and there was improvement of the sagittal vertebral alignment (2.2 to 0.1 vs 2.0 vs 0.3). However, the incidence of PJK or DJK requiring further intervention was significantly higher in the VCR group (8 of 102; 7.3%) vs the no VCR group (1 of 117; 0.8%) ($p<0.016$).

Conclusions: Patients who have a larger deformities including S-DAR will often require a VCR procedure to maximize correction, however, more attention should be paid to the sagittal plane to avoid junctional kyphosis requiring repeat surgical intervention.

Significance: Vertebral column resection results in improved correction of the S-DAR but does result in a higher incidence of junctional kyphosis requiring revision (7.3 vs 0.8%, $p<0.01$).

Changes in the Position of the Trochlear Groove in the Setting of Trochlear Dysplasia

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Purpose: Trochlear dysplasia (TD), characterized by flattening of the trochlear groove (TG), is a known risk factor for patellar instability (PI). It has been suggested that medialization of the groove also occurs. The tibial tubercle to trochlear groove (TT-TG) distance is a common metric to evaluate PI, often thought to relate to a lateral tubercle position. There is evidence that TT-TG values are correlated with relative tibial external rotation (rTER). In turn, rTER has been shown to be increased in the setting of TD. We hypothesized: TD causes a pathologic medialization of the TG, the TT-TG distance is correlated with rotational changes in the tibia and TG medialization, and the position of the tibial tubercle (TT) is similar between patients with and without PI.

Methods: Ninety seven patients with PI and MRI imaging were identified along with 94 matched controls.. A protocol for determining % trochlear groove lateralization proximally and distally (%pTGL and %dTGL) as well as %TT lateralization (%TTL) was utilized (Figure 1). Two tailed t-tests were used to analyze continuous variables and Chi-squared tests were used for categorical variables. Pearson correlation matrix was used to determine pairwise differences between variables and multivariate logit regression was used to model associations among the variables with %pTGL, %dTGL, %TTL, and pTT-TG respectively.

Results: Means and standard deviations for all variables are detailed in Table 2. %pTGL, %dTGL and %TTL all had approximately normal distributions. Logit regressions determined that LTI ($p = 0.012$), sulcus angle ($p=0.021$) CD ratio ($p=0.016$) and pTT-TG ($p<0.001$) predicted variation in %pTGL. %dTGL variation was predicted by CD ratio ($p=0.001$), pTT-TG ($p=0.002$), dTT-TG ($p=0.011$) and rTER ($p=0.019$). pTT-TG variation was predicted by rTER ($p<0.001$), %pTGL ($p<0.001$), and %TTL ($p<0.001$). There was no difference in %TTL between groups ($p=0.081$).

Conclusions: The position of the trochlear groove is more medial in patients with PI and is highly correlated with trochlear dysplasia, patellar height, and pTT-TG. There was no significant difference in TT position between patients with and without PI.

Significance: Given the relationship between increased TT-TG measurements, rTER and TD and the documented medialization of the trochlear groove in the setting of trochlear dysplasia, the TT-TG measurement is more an indirect representation of TD than coronal plane malalignment. The role of a medializing TT osteotomy to correct a primary pathology in PI looks to be rare.

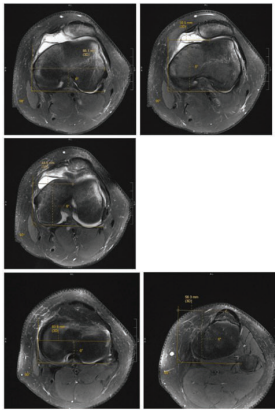


Figure 1. Determination of the position of the trochlear groove and tibial tubercle. A) The distance between the epicondyles is determined on an axial MRI image. B) Determination of the %pTGL, keeping track of the most medial aspect of the medial epicondyle, the most proximal axial image showing fully formed medial and lateral facets with a discernible trochlear groove is identified. The distance from the most medial aspect of the medial epicondyle to the apex of the trochlear groove is determined. The % lateralization of the groove is determined by dividing this distance by the inter-epicondylar distance and multiplying by 100. C) This process is repeated for the %dTGL. D) The axial MRI image that shows the widest portion of the proximal tibia is identified and it is measured relative to a line parallel to the posterior tibial condyles. E) Keeping track of the location of the medial aspect of the tibia, a more distal MRI image showing the most distal aspect of the tibial tubercle in which the patellar tendon is in full contact is identified. The distance between the most anterior aspect of the tibial tubercle and the medial aspect of the tibia is measured. This distance is divided by the width of the proximal tibia and divided by 100.

	Control	Study	P value
Age	14.3 ± 1.7	14.1 ± 1.9	0.53
Gender	F: 44; M: 50	F: 45; M: 52	0.95
BMI	23.7 ± 5.4	25.5 ± 6.4	0.03
LTI	18.8° ± 5.8°	5.8° ± 10.4°	0.0001
Sulcus Angle	140.5° ± 6.3°	158.3° ± 9.4°	0.0001
LPI	8.8° ± 6.4°	20.9° ± 9.2°	0.0001
pTT-TG	9.3 ± 4.3 mm	15.2 ± 4.3 mm	0.0001
dTT-TG	9.0 ± 3.7 mm	15.5 ± 4.4 mm	<0.0001
CD ratio	1.1 ± 0.2	1.3 ± 0.2	0.0001
rTER	-5.6° ± 5.3°	1.6° ± 5.6°	<0.0001
%pTGL	52.0% ± 2.6%	49.4% ± 2.9%	<0.0001
%dTGL	52.9% ± 2.4%	51.7% ± 2.4%	0.001
%TTL	67.2% ± 3.4%	68.1% ± 3.6%	0.081

Table 1. Means, standard deviations and p values for all variables analyzed. Two tailed t-tests were used for continuous variables. Chi-squared tests were used for categorical variables

45° Flexion Anteroposterior Elbow Radiographs Improve Diagnostic Accuracy of Capitellum Osteochondritis Dissecans

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Purpose: To assess the diagnostic performance, inter- and intra-observer reliability, and confidence level for identifying capitellum OCD using plain radiographs (AP, lateral, and 45° flexion AP) in pediatric and adolescent patients.

Methods: This was a retrospective study including pediatric and adolescent patients with capitellum OCD and a healthy control group. Independent clinicians were blinded to the official radiologists' reports and reviewed images on a picture archiving and communication system on two separate occasions 1 week apart. A 5-point Likert scale was used to assess the clinicians' level of confidence (1-not at all confident; 5-very confident). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for individual and combinations of radiographic views. Inter- and intra-observer reliability was determined using kappa statistics.

Results: The study included 28 elbows (24 patients) with a mean age of 12.5 ± 2.0 years. 64.3% were female. There were no differences in age ($p=0.18$), sex ($p=0.62$), or laterality ($p=1.0$) between the two groups. There were marked variations in the sensitivity, specificity, PPV, NPV, and accuracy for each of the following views: AP: Sensitivity 85.1; Specificity 89.3; PPV 88.8; NPV 85.7; accuracy 87.2. Lateral: Sensitivity 73.2; Specificity 91.7; PPV 89.8; NPV 77.4; accuracy 82.4. 45° flexion AP: Sensitivity 91.7; Specificity 91.1; PPV 91.1; NPV 91.6; accuracy 91.4. Standard radiographs (AP and lateral views) failed to diagnose capitellum OCD in 4.8% of cases. The sensitivity of the three combined views was 100%. Confidence levels in the clinicians' diagnostic assessments were similar for each view (AP, 4.0; lateral, 4.0; and 45° flexion AP, 4.1). Inter-observer reliability was substantial for AP and lateral views ($\kappa=0.65$ and $\kappa=0.60$, respectively) but highest for the 45° flexion AP radiographs ($\kappa=0.72$). Intra-observer reliability for all views was moderate to perfect ($\kappa=0.52$ to 0.93).

Conclusions: The 45° flexion AP view can detect capitellum OCD with excellent accuracy, a high level of confidence, and substantial inter-observer agreement. When added to standard AP and lateral radiographs, capitellum OCD can be diagnosed in 100% of cases.

Significance: The 45° flexion AP view increases the diagnostic accuracy of plain radiographs in identifying capitellum OCD, which is crucial for initiating treatment in a timely manner. It should be considered as part of a standard radiographic evaluation in cases of suspected capitellum OCD.

Osteochondral Lesions of the Talus: Factors Predictive of Cartilage Integrity

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Purpose: The integrity of articular cartilage in patients with osteochondral lesions of the talus (OLTs) guides treatment. The ability to predict cartilage integrity in OLTs, as previously published for OCD of the knee, would be beneficial. The purpose of this study is to evaluate the association of radiographic and MRI findings and articular cartilage integrity at the time of ankle arthroscopy for OLTs.

Methods: A single-institution retrospective review identified patients 19 years of age and younger with operative treatment of OLTs from 2010 – 2017. Demographics and intra-operative findings at the time of ankle arthroscopy were identified by chart review. Radiographs were assessed for physeal status, OLT location, and Berndt and Hardy grade. MRIs were reviewed for OLT size and location, modified Kramer grade, and cartilage status.

Results: 53 patients with 54 OLTs and a mean age of 13.6 years (range 7 – 19 years) were included. OLTs were located in the posteromedial talus in 39 patients (72%). Physeal status was closed/closing in 32 patients (59%) and open in 22 patients (41%). On MRI, the cartilage was predicted to be disrupted in 40 patients (74%) and intact in 14 patients (26%). At the time of ankle arthroscopy, the cartilage was found to be disrupted in 38 OLTs (70%) and intact in 16 OLTs (30%). Table 1 lists variables predictive of cartilage integrity. MRI classification of cartilage integrity was 95% sensitive and 75% specific for arthroscopic integrity, with 11% misclassification. In the 16 patients less than 13 years, MRI perfectly predicted arthroscopic cartilage integrity. In patients with open physes, MRI sensitivity was 92% and specificity 100%. In patients with closing/closed physes, MRI sensitivity was 89% and specificity 50%. Receiver operator curve characteristics of a model to predict arthroscopic cartilage integrity combining MRI cartilage integrity, physeal status, and radiographic grade has an AUC of 0.955.

Conclusions: Physeal status, radiographic grade, MRI grade, and cartilage integrity on MRI are independent predictors of cartilage integrity at the time of ankle arthroscopy for patients with OLTs. Overall, MRI has 95% sensitivity and 75% specificity for cartilage integrity at the time of arthroscopy, which improves to near 100% sensitivity and specificity in patients with open physes.

Significance: A model combining MRI cartilage integrity, physeal status, and radiographic grade has the highest predictability of intra-operative cartilage integrity.

Variable	Level	N	Overall N=54	Disrupted N=38	Intact N=16	P-Value
Physeal Status	closed	54	27 (50%)	22 (57.89%)	5 (31.25%)	0.018
	closing		5 (9.26%)	5 (13.16%)	0 (0.00%)	
	open		22 (40.74%)	11 (28.95%)	11 (68.75%)	
Radiographic Grade	1	54	14 (25.93%)	4 (10.53%)	10 (62.5%)	<.001
	2		16 (29.63%)	11 (28.95%)	5 (31.25%)	
	3		20 (37.04%)	19 (50%)	1 (6.25%)	
	4		4 (7.41%)	4 (10.53%)	0 (0.00%)	
	4		4 (7.41%)	4 (10.53%)	0 (0.00%)	
MRI Grade	1	54	14 (25.93%)	2 (5.26%)	12 (75%)	<.001
	2		25 (46.3%)	22 (57.89%)	3 (18.75%)	
	3		14 (25.93%)	13 (34.21%)	1 (6.25%)	
	4		1 (1.85%)	1 (2.63%)	0 (0.00%)	
Cartilage on MRI	Disrupted	54	40 (74.07%)	36 (94.74%)	4 (25%)	<.001
	Intact		14 (25.93%)	2 (5.26%)	12 (75%)	

Nerve Blocks for Pediatric ACL Reconstruction: Comparing Function, Patient- Reported Outcomes, and Efficiency

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Purpose: The purpose of this study was to compare postoperative pain, strength, and functional outcomes between pediatric ACL reconstruction (ACLR) patients undergoing femoral nerve catheter (FNC) placement with single-shot sciatic block and those receiving femoral and sciatic single-shot nerve blocks (SSNB).

Methods: Pediatric patients (≤ 18 years) undergoing primary ACLR between January 2018 and August 2019 at an urban tertiary care children's hospital were identified. Patients were grouped based on regional anesthetic technique (FNC vs. SSNB). Emergency department (ED) visits, clinic visits, and calls for uncontrolled pain and narcotic refills were compared between these two groups. Outcomes including PROMIS scores, strength testing, and active range of motion (AROM) were also compared. Multiple imputation analysis was used to reduce bias as a result of missed follow-up.

Results: 78 patients met inclusion criteria (SSNB-42 patients, FNC-36 patients). There were no differences in age, sex, BMI, or surgical technique between cohorts. Block preparation time ($p < 0.001$) and surgical duration ($p < 0.001$) were significantly longer for the FNC group. Ropivacaine dose (mg) of the sciatic nerve block was significantly higher in the SSNB group (35.0 ± 7.5 vs. 30.1 ± 4.1 , $p = 0.001$). All SSNB cases were performed at a satellite surgical center compared to 1 (2.8%) FNC case ($p < 0.001$). There were no differences in uncontrolled pain or required narcotic refills between groups, and at 1 week follow-up, the proportion of patients with continued opioid consumption was not different (Table I). At 1 week, SSNB patients reported higher PROMIS physical function-mobility scores (25.5 ± 5.6 vs. 22.1 ± 4.9 , $p = 0.009$), with no difference in PROMIS pain interference scores. PROMIS scores were not different between cohorts at 6 weeks, 3 months or 6 months. AROM in extension and flexion also showed no difference between groups. SSNB was associated with a higher hamstrings to quadriceps ratio (i.e. quadriceps deficit) at 3 months (77.4 ± 23.8 vs. 66.2 ± 18.0 , $p = 0.028$), but there were no differences in isokinetic strength at 6 months.

Conclusions: SSNB was associated with shorter operative times and better PROMIS physical function-mobility scores at 1 week compared to FNC. No other differences were observed in post-operative pain management, and cohorts were without differences in AROM and isokinetic strength by 6 months.

Significance: This study revealed equivalent post-operative pain management, motion, and outcome scores at 6 months for both groups. Early post-operative PROMIS physical function-mobility scores, however, suggest there may be advantages to using the single shot nerve block technique.

Table I. Comparison of Outcomes for Single-Shot Nerve Blocks and Femoral Nerve Catheters

	Single Shot	Catheter	P-Value
Uncontrolled Pain	4 (9.5)	4 (11.1)	1.000
ED/Clinic Visit	0 (0)	1 (2.8)	0.462
Call	4 (9.5)	3 (8.3)	1.000
Required Narcotic Refill	2 (4.8)	1 (2.8)	1.000
Infection/Wound Issue	3 (7.1)	3 (8.3)	1.000
1-week follow-up			
Taking Pain Meds	38 (90.5)	32 (88.9)	1.000
NSAIDs/Tylenol	28 (66.7)	20 (55.6)	0.315
Narcotics	10 (21.4)	12 (33.3)	
Returned to school by 1 week			0.085
Yes	13 (31.0)	4 (11.1)	
No	16 (38.1)	21 (58.3)	
Summer Month	13 (31.0)	11 (30.6)	
Isokinetic Strength Data (180°/s)			
3 months			
Hamstrings: Quadriceps Ratio (Involved Limb)	77.4 ± 23.8	66.2 ± 18.0	0.028
Hamstrings: Quadriceps Ratio (Uninvolved Limb)	57.3 ± 10.8	53.6 ± 9.9	0.127
Limb Symmetry Index (Flexion)	89.1 ± 19.0	87.2 ± 18.6	0.679
Limb Symmetry Index (Extension)	69.9 ± 21.7	72.5 ± 14.4	0.597
6 months			
Hamstrings: Quadriceps Ratio (Involved Limb)	66.7 ± 17.3	68.0 ± 31.0	0.830
Hamstrings: Quadriceps Ratio (Uninvolved Limb)	57.8 ± 12.6	52.7 ± 9.8	0.069
Limb Symmetry Index (Flexion)	97.0 ± 13.9	99.8 ± 21.3	0.543
Limb Symmetry Index (Extension)	84.6 ± 19.9	82.4 ± 18.3	0.641
PROMIS Scores			
1 week			
Physical Function Mobility	25.5 ± 5.6	22.1 ± 4.9	0.009
Pain Interference	54.5 ± 15.2	60.0 ± 10.0	0.178
6 weeks			
Physical Function Mobility	31.9 ± 4.5	29.6 ± 5.0	0.137
Pain Interference	50.9 ± 11.8	54.4 ± 11.7	0.385
3 months			
Physical Function Mobility	36.0 ± 7.0	36.0 ± 7.2	0.996
Pain Interference	39.9 ± 9.9	42.4 ± 11.3	0.449
6 months			
Physical Function Mobility	42.7 ± 8.7	41.4 ± 8.6	0.591
Pain Interference	41.2 ± 9.6	41.6 ± 11.9	0.905
Active Range of Motion			
6 weeks			
Extension	0.8 ± 1.7	1.7 ± 2.9	0.111
Flexion	107.5 ± 19.1	105.5 ± 16.8	0.626
3 months			
Extension	0.5 ± 1.4	0.5 ± 1.3	0.781
Flexion	130.6 ± 9.6	128.2 ± 12.3	0.339
6 months			
Extension	0.3 ± 1.2	0.3 ± 0.8	0.768
Flexion	134.5 ± 5.8	132.8 ± 7.8	0.349

Values reported as number (%) or mean ± SD

Outcomes of Pediatric Meniscal Surgeries

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Purpose: Injuries to the meniscus are increasingly common in adolescent patients. Re-injury rates and functional outcomes, however, in pediatric patients who underwent primary meniscal repair or partial meniscectomy are not well defined. The primary aim of our study is to examine the re-injury rate and functional outcomes of meniscal repair or meniscectomy in adolescent patients.

Methods: The medical records of 116 adolescent subjects with documented primary meniscal injury who underwent arthroscopic meniscectomy or meniscal repair \pm ACL reconstruction at a single institution from January 2008 to present were reviewed. Demographic (age and gender), pre-operative (date of injury and concomitant injury), operative (type of procedure and operative findings), post-operative (re-injury, need for revision surgery, type of revision surgery), and outcome score (IKDC, Lysholm, return to previous activity level) information was documented.

Results: At two years follow up, 54 patients with meniscal injuries underwent either meniscal repair (n=24) or partial meniscectomy (n=30). Nine (17%) patients went on to sustain a second meniscal injury (44% female; median age= 15.0 years) and 45 (83%) who did not (49% female; median age= 15.7 years). There was no significant difference in the proportion of patients who sustained a second meniscus tear and those who did not based on whether they had a primary meniscus repair vs. partial meniscectomy. Furthermore, there was no statistically significant association between a second meniscus injury with concomitant ACL tear, skeletal maturity, BMI, or gender (Table 1). At two year follow up, there was no difference between Lysholm or IKDC scores in patients with failed vs successful meniscal surgery and there was also no difference in return to prior activity level between the groups.

Conclusions: Our data demonstrate that the failure rate of meniscal surgery is 17% in pediatric patients. There was no difference in revision rate when repair vs partial meniscectomy was performed as the index procedure.

Significance: In this study, patients had excellent clinical outcomes regardless if they sustained a second meniscus injury.

Table 1. Demographic and injury characteristics for both patient groups.

Variable	Second meniscus tear (n=9)	No subsequent meniscus injury (n=45)	P value
Female sex	4 (44%)	23 (49%)	>0.99
Age (years)	15.0 [14.7 – 16.0]	15.7 [14.2 – 16.5]	0.32
BMI	23.7 [22.0 – 27.0]	22.7 [21.1 – 28.5]	0.62
Skeletally mature (open physis)	5 (56%)	12 (27%)	0.12
Medial primary meniscus tear only	1 (11%)	1 (2%)	0.40
Lateral primary meniscus tear only	7 (82%)	37 (82%)	
Medial and lateral meniscus tear	1 (11%)	7 (16%)	
Concomitant ACL tear	8 (89%)	35 (78%)	0.67

Post-operative Complications and Early Clinical Outcomes Following ACL Reconstruction with Soft Tissue Quadriceps Tendon Autograft in Adolescent Athletes

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Purpose: To investigate rates of post-operative complications and early functional outcomes in adolescents who underwent ACL reconstruction with quadriceps tendon autograft (ACLR-QT).

Methods: Prospective assessment of 12-19 year-olds who underwent primary ACLR-QT by a single surgeon at a tertiary care pediatric hospital was performed. Routine collection of 6-month and 1-year PROs was supplemented by telephone and survey outreach to confirm absence of reoperation in all cases. A minimum of 6 months follow-up was required for study inclusion, with 12 months minimum follow-up for the ACL re-tear analysis. Peri-operative and post-operative complications and subsequent surgeries were analyzed. A sub-analysis excluding the first 25 knees was performed to eliminate any potential effects of a surgical 'learning curve'.

Results: Ninety patients (93 knees, 70% female) were included, with a mean age of 16.0 years (± 1.85) and mean follow-up of 12.6 months (IQR 9.1-21.4). Concomitant meniscal pathology was detected in 57% (30% meniscal repair; 27% partial meniscectomy). There were 51 complications of any kind in 36 knees (39%, Table 1). Reoperation occurred in 22 knees (24%), most commonly for arthrofibrosis/cyclops debridement (15%), with 6 additional knees (6%) diagnosed by MRI, but successfully treated non-operatively. Arthrofibrosis/cyclops lesions were not significantly different based on learning curve (20% vs. 22%, $p=1.00$). ACL graft tear (5%), which was treated with revision ACLR with bone-patellar-tendon-bone (BTB) autograft in all cases, was more common in the 'learning curve' period (16% vs. 1%, $p=0.02$). Pedi-IKDC (Table 1) showed significant improvement from baseline to 6-month ($p<0.001$) and 1-year time ($p<0.001$) periods, with significantly higher 1-year scores amongst those without complications (mean, 93.9) than those with complications (mean, 85.5; $p=0.04$). Overall activity levels were high (mean HSS Pedi-FABS: 19.5), and were lower among patients with complications than those without, but not to a significant degree (17.3 vs. 20.7, $p=0.58$).

Conclusions: When utilized in adolescents, QT-ACLR has a high rate of arthrofibrosis/cyclops lesions, the majority of which may undergo surgical debridement. While early re-tear rates may be similar to those historically reported for HS-ACLR in adolescents, there may be an important surgical learning curve for this newer technique that warrants attention. Patient-reported knee function and activity level at 1-year were comparable to normative values in adolescents.

Significance: QT-ACLR remains relatively understudied as a technique, particularly in adolescents. Continued research into measures designed to minimize rates of early post-operative complications following QT-ACLR is warranted.

Table 1. Early Complications, Treatment, Reoperation, and Trends in Knee Function and Activity Level Patient Reported Outcomes Following ACL Reconstruction (ACLR) with Quadriceps Tendon Autograft

	Full Cohort (n=93 knees)	Learning curve ¹ (n=25 knees)	Post-learning curve (n=68 knees)	p-value
Follow-up (months; median (IQR))	12.6 (9.1-21.4)	24.0 (18.4-25.1)	11.5 (8.3-16.2)	<0.001
# Knees with Complications	36 (39%)	11 (44%)	25 (37%)	0.53
Complication				
ACL re-tear	5 (5%)	4 (16%)	1 (1%)	0.02
Meniscus tear	9 (10%)	5 (20%)	4 (6%)	0.06
Second meniscus tear	2 (2%)	2 (8%)	0 (0%)	0.07
Arthrofibrosis/Cyclops lesion	20 (22%)	5 (20%)	15 (22%)	1.00
Recurrent Arthrofibrosis/Cyclops lesion	2 (2%)	1 (4%)	1 (1%)	0.47
Superficial infection	5 (5%)	1 (4%)	4 (6%)	1.00
Septic arthritis	1 (1%)	0 (0%)	1 (1%)	1.00
Hardware pain/symptoms	5 (5%)	2 (8%)	3 (4%)	0.61
Quadriceps neuropraxia	1 (1%)	0 (0%)	1 (1%)	1.00
Quadriceps tendonitis	1 (1%)	0 (0%)	1 (1%)	1.00
Treatment Type				
Additional/Secondary Surgery	22 (24%)	10 (40%)	12 (18%)	0.02
Revision ACLR	5 (5%)	4 (16%)	1 (1%)	0.02
Isolated Revision ACLR	1 (1%)	1 (4%)	0 (0%)	0.27
Revision ACLR + meniscectomy	3 (3%)	2 (8%)	1 (1%)	0.17
Revision ACLR + meniscus repair	1 (1%)	1 (4%)	0 (0%)	0.27
Meniscectomy	1 (1%)	1 (4%)	0 (0%)	0.27
LOA ² /cyclops debridement	14 (15%)	5 (20%)	9 (13%)	0.51
Isolated LOA ² /cyclops debridement	9 (10%)	2 (8%)	7 (12%)	1.00
LOA ² /cyclops debridement + meniscectomy	2 (2%)	1 (4%)	1 (1%)	0.47
LOA ² /cyclops debridement + ROHP	3 (3%)	2 (8%)	1 (1%)	0.17
ROHP	1 (1%)	0 (0%)	1 (1%)	1.00
Arthroscopic I&D ⁴	1 (1%)	0 (0%)	1 (1%)	1.00
Additional/Tertiary surgery	4 (4%)	3 (12%)	1 (1%)	0.06
Revision ACLR + meniscectomy	1 (1%)	1 (4%)	0 (0%)	0.27
Meniscectomy	1 (1%)	1 (4%)	0 (0%)	0.27
LOA ² /cyclops debridement	2 (2%)	1 (4%)	1 (1%)	0.47
Non-operative				
Antibiotics	6 (6%)	1 (4%)	5 (7%)	1.00
Cortisone injection	1 (1%)	0 (0%)	1 (1%)	1.00
Physical therapy	9 (10%)	0 (0%)	9 (13%)	0.11
Dynamic Extension Brace	2 (2%)	0 (0%)	2 (3%)	1.00
Contralateral ACL tear	4 (4%)	2 (8%)	2 (3%)	0.29
	Full Cohort (n=93 knees)	No Complication (n=55 knees)	Complication (n=38 knees)	p-value
Pedi-IKDC (mean, range)				
Pre-op	58.6 (26.4-87.0)	58.6 (26.4-87.0)	58.5 (42.4-79.3)	1.00
6 months post-op	84.7 (52.2-100)	86.2 (65.2-100)	81.6 (52.2-98.9)	0.27
1 year post-op	90.6 (62.2-100)	93.9 (80.4-100)	85.5 (62.0-100)	0.04
HSS Pedi-FABS (mean, range)				
Pre-op	14.1 (0-30)	12.4 (0-29)	17.6 (0-30)	0.15
6 months post-op	14.7 (0-30)	13.6 (0-29)	16.8 (0-30)	0.20
1 year post-op	19.5 (0-30)	20.7 (4-30)	17.3 (4-30)	0.58

IQR=Inter Quartile Range; ¹Learning Curve = first 25 knees that underwent ACLR with the Quad Tendon Autograft; ²Lysis of Adhesions; ³Removal of Hardware; ⁴Incision and drainage

MAGNETIC RESONANCE IMAGING OF LATERAL MENISCAL ROOT TEARS IN THE ADOLESCENT KNEE: IS THE DIAGNOSIS MISSED, MENTIONED, OR MADE?

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Purpose: The meniscal roots play a vital role in maintaining proper knee kinematics. Neglected meniscal root tears place excess stress on the articular cartilage and increase the risk of premature osteoarthritis. As opposed to medial meniscal root tears, lateral meniscal posterior root tears (LMPRT) are more likely to be associated with anterior cruciate ligament (ACL) pathology. Failure to identify and address meniscal root tears may place excessive loads on ACL grafts and lead to inferior outcomes following reconstruction. The purpose of this study was to review radiologists' interpretations of preoperative knee magnetic resonance imaging (MRI) for the identification of lateral meniscal root pathology in children and adolescents.

Methods: A retrospective review was performed of children and adolescents who underwent knee arthroscopy between 3/1/2010 and 4/1/2020 and had an arthroscopically confirmed LMPRT. Arthroscopic findings were compared to the radiologist's MRI interpretations. LMPRTs were graded using the LaPrade classification. We evaluated if body mass index (BMI), open physes, time from injury to MRI, time from MRI to surgery, MRI strength, musculoskeletal radiologist designation, insurance type, and tear grade were associated with the MRI identification of a LMPRT.

Results: During the study period, 1,285 knee arthroscopies were performed, with 607 ACL reconstructions. Fifty-four children were found to have a LMPRT during arthroscopy, and all were associated with an ACL tear 54/607 (9%). One patient had 2 MRIs for a total of 55 MRIs in 54 patients. The average age was 16 years old (range 14-21). MRI diagnosis of a LMPRT was made in only 14/55 (25%) and missed in 22/55 (40%). In 19/55 (35%), pathology of the lateral meniscus nonspecific to the root was mentioned by the interpreting radiologist. Lateral joint line tenderness was present on preoperative physical examinations in 23/54 (46%). There was no statistical significance found regarding BMI, skeletal maturity, time from injury to MRI, time from MRI to surgery, MRI magnetic field strength, insurance, or if the radiologist was musculoskeletal fellowship-trained.

Conclusions: The final interpretation of preoperative MRIs did not provide a clear, definitive diagnosis of a LMPRT in 75% of this pediatric cohort. All LMPRTs in this study were associated with a concomitant ACL tear. As the intraoperative management of LMPRTs can be involved and diverge from standard meniscal work, a preoperative diagnosis would be advantageous.

Significance: Orthopedic surgeons caring for ACL tears in children and adolescents should be well-prepared to treat LMPRTs regardless of an inconclusive MRI interpretation for meniscal root pathology.

MAGNETIC RESONANCE IMAGING OF LATERAL MENISCAL ROOT TEARS IN THE ADOLESCENT KNEE:
IS THE DIAGNOSIS MISSED, MENTIONED, OR MADE?

	Group 1 Diagnosis Made (N = 14)	Group 2 Diagnosis Missed (N = 22)	Group 3 Diagnosis Mentioned (N = 19)	P-value
Sex (Female, n = 28)	6	14	8	0.304
Skeletal Maturity (Closed physis, n = 49)	14	20	15	0.15
Insurance type Commercial (n = 32) Medicaid (n = 23)	9 5	14 8	9 10	0.497
Lateral joint line tenderness (Yes, n = 24)	7	8	9	0.567
Strength of MRI Magnet 1.5T (n = 45) 3.0T (n = 10)	12 2	17 5	16 3	0.77
Musculoskeletal-trained Radiologist Yes (n = 15) No (n = 40)	5 9	4 18	6 13	0.45
Grade of Tear (LaPrade Classification)				
1 (n = 11)	5	4	2	0.093
2a (n = 3)	0	2	1	
2b (n = 3)	0	1	2	
2c (n = 4)	2	2	0	
3 (n = 4)	0	1	3	
4 (n = 14)	0	6	8	
6 (n = 16)	7	6	3	
BMI (25.86 ± 4.97)	26.98 ± 5.58	24.63 ± 4.39	26.47 ± 5.10	0.168
Age when injured (16.28 ± 1.73)	16.83 ± 1.26	16.31 ± 1.94	15.85 ± 1.74	0.274
Days from injury to MRI (73.69 ± 167.01)	111.50 ± 296.1	52.55 ± 59.39	70.32 ± 120.96	0.592
Days from injury to surgery (135.82 ± 177.74)	176.14 ± 298.17	112.50 ± 80.28	133.11 ± 145.29	0.585
Days from MRI to surgery (62.13 ± 45.21)	64.64 ± 52.11	59.95 ± 47.41	62.79 ± 39.20	0.954

Predicting Arthrofibrosis Following Anterior Cruciate Ligament Reconstruction in the Pediatric Population: A Matched Case-control Study

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Purpose: The purpose of this study was to assess the post-ACL reconstruction changes of range of motion (ROM) in patients who developed arthrofibrosis and age-matched controls, and to determine the optimal time for surgical intervention.

Methods: In a retrospective age and gender-matched 1:2 case-control study, patients ≤ 18 years old who underwent surgery for arthrofibrosis ACLR were selected. The range of knee motion at each post-operative visit was recorded. Based on the typical post-operative visit protocols, visits were categorized into three groups: 1st(in the first 4 weeks), 2nd(5-8 weeks), and 3rd(after 9th week) visits. The total ROM deficit at each visit (flexion+ extension deficit) compared to the contralateral knee was plotted for cases and controls. The mean ROM deficits were compared between cases and controls, and also between visits for each group. Receiver operating characteristic (ROC) analysis was performed to determine the time point at which a diagnosis of arthrofibrosis could be made with the highest accuracy.

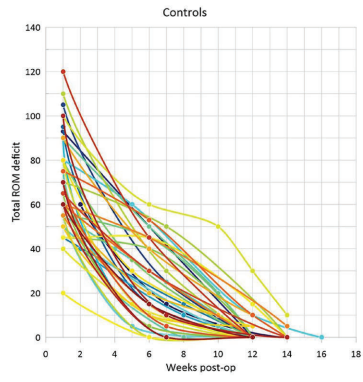
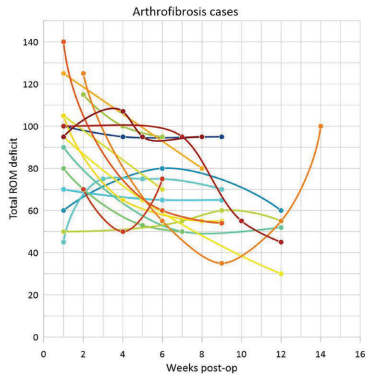
Results: 18 patients with arthrofibrosis (9 male) with a mean age of 14.1 years, and 36 age and gender matched controls with a mean age of 14.3 years were included. Figure 1A summarizes the total ROM deficit at each post-op visit for cases and controls, along with the changes between each visit. Figure 1B depicts the changes in total ROM deficit. Cases had significantly higher total ROM deficit at each visit compared to controls. Pairwise comparisons showed that in arthrofibrosis cases, the total ROM does not change significantly between the second and third visit ($P=0.77$). ROC analysis revealed that the total ROM deficit of 50.75 degrees at the second post-op visit is 89% sensitive and 92.5% specific for the diagnosis of arthrofibrosis, with an area under the curve of 0.962.

Conclusions: The results of this study suggest that the development of arthrofibrosis following ACLR in the pediatric population can be predicted with high accuracy during the second post-operative month. A total ROM deficit of $>50^\circ$ at the second post-operative visit, typically performed during the second post-operative month, has a high sensitivity and specificity for development of arthrofibrosis and the need for surgical correction. Additionally, patients with arthrofibrosis did not have a significant improvement between the 2nd and 3rd post-op months, despite rigorous rehabilitation.

Significance: Our findings suggest that patients with a total ROM deficit of $>50^\circ$ could be offered surgery during the second post-operative month, instead of the currently common practice of non-operative treatment until the third post-operative month.

Post-op visit	Arthrofibrosis	Matched controls	P value
1st visit (1-4 weeks) ROM deficit	91.8 (78.3-105.8)	69.3 (62.6-76.5)	<0.001
Δ 1 st -2 nd	26.7 (8.75-44)	45.1 (37.9-51.8)	0.035
2nd visit (5-8 weeks) ROM deficit	65.1 (55.2-75.8)	24.2 (18.3-29.9)	<0.001
Δ 2 nd -3 rd	9.1 (0.8-19)	22.2 (17.3-28.3)	0.026
3rd visit (9-16 weeks) ROM deficit	55.9 (45.3-67)	1.9 (0.8-3.1)	<0.001

ROM deficit at each post-op visit. Values are presented as degrees (95% Confidence interval).



What are the Causes and Consequences of Delayed Surgery for Pediatric Tibial Spine Fractures?

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Purpose: The uncommon nature of tibial spine fractures may result in delayed presentation, diagnosis, and treatment. Elucidation of the contributing factors to such delays may provide an opportunity to improve patient care. The purpose of this study is to evaluate risk factors for, and peri-operative consequences of, delayed surgical treatment of pediatric tibial spine fractures.

Methods: We performed a retrospective cohort study of tibial spine fractures treated surgically at 10 institutions between 2000 and 2019. Demographic and pre-operative data were collected, as was information regarding intra-operative management and findings. Attention was focused on delays in evaluation and treatment, which were treated as both continuous and categorical variables. Surgery ≥ 21 days after injury was considered "delayed". Univariate analysis was followed by purposeful entry multivariate regression to adjust for confounding factors.

Results: A total of 368 subjects (mean age 11.7 ± 2.9 years) were included. The median time between injury and surgery was 11 days (interquartile range 13 days). In multivariate analysis, patients that underwent delayed surgery had 2.3 times higher odds of having seen another provider before the treating surgeon (95% CI 1.1-4.8, $p=0.02$) and 3.8 times higher odds of having undergone magnetic resonance imaging (MRI; 95% CI 2.1-6.9, $p<0.001$). These subjects were also 2.4 times more likely to have public insurance (95% CI 1.3-4.2, $p=0.003$). Children that had a surgical delay were 3.8 times more likely to have been diagnosed with a tibial spine fracture later than one week after injury (95% CI 1.1-14.3, $p=0.04$) and were 5.8 times more likely to have obtained MRI more than one week after injury (95% CI 1.6-20.8, $p=0.007$). Finally, patients that underwent delayed surgery had 3.3 times higher odds of their procedure lasting greater than 2.5 hours (95% CI 1.4-7.9, $p=0.006$). Surgical delay did not result in increased concomitant meniscal or chondral injuries.

Conclusions: Public insurance and visiting multiple providers prior to surgery led to treatment delays. Delays in initial diagnosis and MRI were also contributing factors. While a surgical delay of ≥ 21 days did not result in more concomitant injuries, it was predictive of longer surgical time, possibly reflecting the greater complexity of these cases. These results provide an opportunity to optimize care for children that are at highest risk for delayed treatment.

Significance: This is the first study to identify risk factors for, and immediate consequences of, delayed surgery for pediatric tibial spine fractures. These results can be used to optimize care for at-risk children.

Pediatric Compliance of Lower Extremity Weight Bearing Restrictions Following Injury

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Purpose: Immobilization of certain lower extremity fractures requires weight bearing restriction not to minimize the potential for displacement. In the adult population, 29% of patients have been found to be non-compliant following weight bearing restrictions, however, no such study has evaluated the compliance of non-weightbearing restrictions in the pediatric population. The goal of this study was to determine the compliance rate of weight bearing restrictions of the immobilized lower extremity in the pediatric population.

Methods: A prospective study following twenty-seven patients ages 12 months to 17 years of age was performed to evaluate for weight bearing restriction compliance. A pressure sensitive film (Fuji Prescale Film, Sensor Products Inc., NJ, USA) was incorporated into the cast beneath the heel pad within the webril soft padding. At the time of removal of the cast the pressure sensor film was analyzed using standard analysis and compliance was recorded as a binary measure (compliant or non-compliant). Patients prescribed with non-weight bearing short leg casts and long leg non-weight bearing casts were included and analyzed.

Results: The majority of participants (23/27) were not compliant with their weight bearing restrictions independent of a short leg cast (n=10) or long leg cast (n=13). Of the four individuals who were compliant, all of them were prescribed long-leg casts. Fortunately, no patients lost alignment despite being non-compliant.

Conclusions: The compliance rate of weight bearing restrictions in pediatric patients following application of a lower extremity cast was only 15%. Further investigation into the need for weight bearing restrictions and better methods for compliance training in the pediatric population are needed.

Significance: The need for weight bearing restrictions can be better tailored to the pediatric population knowing the relative rate of adherence to the restrictions.

Secondary Displacement of Both Bone Diaphyseal Forearm Fractures: Risk Factors and Predictors of Closed Reduction and Cast Immobilization

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Purpose: Closed reduction and cast immobilization is the standard of care for a both bone diaphyseal forearm fracture in children. However, due to the complication of secondary displacement, these often require revision management that can be more difficult to perform in the delayed rather than acute setting. The purpose of the study was to identify risk factors for secondary displacement and to establish predictors that could minimize the risk of index treatment failure.

Methods: Retrospective review of all children managed at two level 1 trauma centers was performed including those that underwent initial closed reduction and cast immobilization. Demographic data and data regarding treatment (setting of treatment, use of manipulation, type of anesthesia, type of cast material, and duration of casting) were noted. Radiographs taken at the time of injury, after reduction and at the time of fracture consolidations were utilized. Measures of reduction and casting quality were recorded. Secondary displacement was defined and recorded.

Results: 370 children with a both bone diaphyseal forearm fracture over a 7 year period met criteria, and 162 children (44%) presented with a secondary displacement. Rate of secondary displacement was related to location of the fracture (higher rate with more proximal location, $p=0.001$); amount of initial displacement both in the coronal and sagittal planes; location where reduction was performed (better in the OR, $p=0.026$); material used for immobilization (better with plaster than fiberglass, $p=0.008$); quality of molding according to cast index ($p=0.06$), gap index ($p=0.033$), and three-point index both AP ($p=0.003$) and sagittal ($p<0.001$); and quality of reduction according to several radiographic measurements ($p<0.001$). Three independent predictors were identified with fractures having 0 predictors losing reduction at a rate of 17.9%, 1 predictor at a rate of 69.3%, and 2 predictors at a rate of 85.5%.

Conclusions: Secondary displacement of a both bone diaphyseal forearm fracture depends on residual sagittal displacement of the radius and ulna, the proximal nature of the fracture, the quality of reduction, and quality of cast molding.

Significance: Consideration of early conversion in treatment strategy, or vigilant follow-up to identify secondary displacement early should be performed in those meeting predictive criteria for initial closed reduction failure in both-bone forearm fractures.

Table 1. Factors related to treatment	No Secondary Displacement (n=208)	Secondary Displacement (n=162)	p value
Cast Material			
Fiberglass	51%	49%	0.008*
Plaster	65%	35%	
Bivalved Cast			
Yes	55%	41%	0.481
No	59%	45%	
Quality of molding			
Cast index	0.78	0.80	0.06
Padding index	0.51	0.48	0.136
Canterbury index	1.29	1.28	0.629
Gap index	0.51	0.49	0.033*
3-point index AP	1.43	1.60	0.003*
3-point index L	1.44	1.81	<0.001*
Time to transition to short cast (days)	35	38	0.019*
Time of immobilization with a cast (days)	56	61	0.004*

Outcomes of Operative Treatment of Pediatric Monteggia Fracture-Dislocations: Open Injuries as a Predictor of Poor Outcomes

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Purpose: Open pediatric Monteggia fracture-dislocations are a relatively uncommon injury pattern, with limited numbers reported in previous series. Open fracture-dislocations frequently represent higher energy injury patterns and potential for fracture site contamination- both of which may place the patient at increased risk for poorer outcomes. No previous study has directly compared the long-term clinical and functional outcomes in the operative management of closed versus open pediatric Monteggia fracture-dislocations.

Methods: A retrospective review was performed within our high-volume Level 1 Pediatric Trauma hospital, identifying all pediatric Monteggia fracture-dislocation patients over the past eight years. Patients undergoing operative treatment were included in analysis and closed versus open injuries were compared. QuickDASH scores were obtained for involved patients. Pearson Correlation, one-way ANOVA, and Linear Regression analysis was performed in analysis of the data.

Results: Of 30 operatively-treated injuries, 12/30 (40%) were open fracture-dislocations. Of the open injuries, 9/12 (75%) were Gustilo & Anderson (GA) Type I, 2/12 (17%) were GA Type II, and 1/12 (8%) was GA Type III. Decreased time to union was observed in the closed injury group at an average of 5.8 weeks versus 8.0 weeks for the open injury group, however this was not statistically significant ($p = 0.07$). 2/18 (11%) patients in the closed fracture group experienced post-operative complications; both were minor in nature. 5/12 (42%) patients in the open fracture-dislocation group experienced a total of six post-operative complications; 5 of the 6 complications were major. Major complications included two instances of deep infection, one case of persistent radiocapitellar instability, re-fracture at the proximal aspect of surgical fixation, and a case of chronic osteomyelitis at the site of the original open fracture. QuickDASH scores were obtained at an average of five years post-operatively; mean QuickDASH scores were significantly higher in the open fracture group, 13.1, compared to the closed fracture group, 5.9 ($p = 0.038$). Increased QuickDASH scores were independently associated with presence of post-operative complications. Of those patients who experienced a major complication, QuickDASH score could be expected to increase by 12.5 points ($p = 0.044$).

Conclusions: These injuries are predictive of poorer outcomes, including increased risk for prolonged time to union, increased risk of major complication, and independently predict worse long-term patient reported functional outcomes.

Significance: We present the largest series of pediatric open Monteggia fracture-dislocation injuries to date.

Operatively-treated Monteggia fracture-dislocations			
	Closed injury	Open injury	P-value
	16	10	
QuickDASH score	5.9	13.1	0.038

Disparities in Care Received for Treatment of Pediatric Fractures

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Purpose: Studies have shown that disparities exist in treatment of orthopaedic conditions in adults. In order to better understand factors affecting care of pediatric fractures in the U.S., we used several state and nationwide databases to assess the effect of patient-specific factors on the treatment provided for the two most common pediatric fractures, forearm and tibia.

Methods: The Healthcare Cost and Utilization Project, State Inpatient, State Emergency Department, and State Ambulatory Surgery and Services Databases (SID/SEDD/SASD) from Maryland, New York, Vermont, and Wisconsin were used to retrospectively review patients with diagnoses of forearm or tibia fracture. Multivariable generalized estimating equations models were used to determine risk factors associated with surgery. The Nationwide Emergency Department Sample (NEDS) was also queried using ICD-9-CM codes to identify these fractures from 2006-2015. The NEDS database is a 20% stratified sample of hospital-based Emergency Departments and can be used to produce weighted national estimates.

Results: Statewide databases identified 128,431 forearm fractures, 50,640 tibia fractures, 1,575 open forearm fractures and 1,339 open tibia fractures. Of those, 2.6% of forearm fractures, 7.9% of tibia fractures, 37.5% of open forearm fractures, and 60.5% of open tibia fractures were treated surgically. A total of 3,320,641 closed and 38,735 open forearm fractures were identified from the NEDS, and 57,998 of all forearm fractures were treated surgically. Nationwide, 1,021,657 closed and 29,880 open tibia fractures were identified, among which 21,033 were treated surgically. Multivariable regression revealed that in 3/4 groups, race or insurance status was an independent risk factor for a lower risk of surgical treatment after controlling for age, fracture type, and mechanism of injury. After controlling for confounding variables, African American patients with forearm fractures were treated surgically less often than Caucasians (RR=0.57, CI: 0.48, 0.66), including those with open fractures (RR=0.65, CI: 0.53, 0.79). For open tibia fractures, those with Medicaid were less often treated operatively statewide (RR=0.83, CI: 0.74, 0.93) and nationwide, (OR=0.80, CI: 0.70, 0.90).

Conclusions: We report the largest series of pediatric forearm and tibia fractures and have identified several disparities in treatment received, dependent on patient race or insurance status. African American patients were 43% less likely to receive surgery after forearm fracture and 35% less likely after open forearm fracture. Medicaid patients were 20% less likely to receive surgery after tibia fractures.

Significance: The findings of this study bring into question the effect of race and insurance on access to proper orthopaedic fracture care in children.

Does an Associated Elbow Dislocation Lead to Worse Outcomes in Medial Epicondyle Fractures?

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Purpose: Fifty percent of all medial epicondyle fractures are associated with an elbow dislocation. The purpose of this study was to assess differences in outcomes and complications between patients with isolated medial epicondyle fractures and those with a concurrent elbow dislocation.

Methods: A retrospective review was performed over a seven-year period. Patients were identified utilizing CPT and ICD-9/10 codes for medial epicondyle fracture and elbow dislocation. Data obtained included demographics, mechanism of injury, concurrent injuries, treatment modality (immobilization alone vs. operative intervention), post-operative range of motion, and complications. Statistical analysis was performed utilizing Student's t-tests to assess differences between the samples. A power analysis concluded that the use of at least 9 patients with complete data yielded a 90.55% power to detect a 5 degree difference.

Results: Forty-eight patients (22 females, 26 males) with an average age of 10.49 years (range: 4-17) were identified with medial epicondyle fractures over the study period, of which 17 had a concurrent elbow dislocation. The most common mechanisms of injury were falls onto outstretched hands (n=22) and falls from heights (n=16). The medial epicondyle fractures with concurrent elbow dislocations more frequently had additional concurrent injuries (8/17 vs 3/31; $p < 0.01$), which included ulnar nerve injuries (2/17 vs 1/31), anterior interosseous nerve injuries (2/17 vs. 0/31), UCL tears (2/17 vs. 0/31), and other fractures (2/17 vs 2/31). Furthermore, the group with concurrent elbow dislocations was more frequently treated operatively (12/17 vs 8/31; $p < 0.01$). However, final range of motion, as compared to the contralateral side, was not statistically different between the groups ($p = 0.25$). There was no difference in the rate of complications between the groups (3/17 vs 8/31; $p = 0.57$), percentage of therapy referrals (6/17 vs 7/31; $p = 0.35$), or length of follow up ($p = 0.77$).

Conclusions: The outcomes and complications of pediatric and adolescent medial epicondyle fractures with a concurrent elbow dislocation are not different than those of isolated medial epicondyle fractures.

Significance: Further investigation into other influencing factors of medial epicondyle fractures that lead to various outcomes and complications is warranted to better guide treatment planning and counseling to these patients and their families.

Comparison of Short and Long Leg Casts for the Treatment of Distal Third Tibial Shaft Fractures in Children

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Purpose: Long leg casts (LLC) are an established treatment for pediatric tibial shaft fractures including fractures involving the distal third. There is a paucity of literature assessing the use of SLC for tibial shaft fractures. The purpose of this study was to determine if SLC was as effective as LLC for the treatment of pediatric distal third tibial shaft fractures.

Methods: A retrospective review was conducted on consecutive distal third tibial shaft fractures treated at a tertiary pediatric hospital from 2013 to 2018. Exclusion criteria included midshaft and proximal fractures of the tibia, distal fractures that violated the tibial physis or plafond, and pathologic fractures. We compared primary outcomes of time to weight-bearing, time to union, and final angulation between LLC and SLC groups.

Results: Eighty-five patients aged 5 to 17 years (mean age 9.2 ± 3.2 years) met inclusion criteria, including 50 LLC and 35 SLC patients. Time to weight-bearing for SLC (3.3 ± 0.6 weeks) was shorter compared to LLC (6.4 ± 0.7 weeks, $p<0.0001$). Overall, fractures treated with SLC had a shorter time to union (7.4 ± 0.9 weeks) compared to LLC (9.0 ± 0.9 weeks, $p=0.026$) without statistical differences in final angulation at the time of union. There was a higher percentage of cast complications in the LLC treatment group (12%) compared to SLC (6%).

Conclusions: Pediatric distal third tibial shaft fractures treated with SLC demonstrated earlier time to weight-bearing and shorter time to fracture union when compared to LLC.

Significance: This is the first study to compare SLC and LLC in distal third pediatric tibial shaft fractures. Surgeons should consider SLC and early weight-bearing for the treatment of distal third tibial shaft fractures in children.

Predicting Failure of Closed Reduction in Paediatric Diaphyseal Forearm Fracture Elastic Stable Intramedullary Nailing (ESIN)

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Purpose: Closed reduction with the elastic stable intramedullary nail (ESIN) is always attempted before open reduction. Multiple attempts at closed reduction not only increase the incidence of tissue trauma, but also lead to severe post-operative complications such as compartment syndrome. Yet, little information exists to help surgeons anticipate when a child is more likely to require an open reduction. This study aims to determine risk factors that point toward a greater likelihood of open reduction.

Methods: 144 cases of forearm fractures fixed using ESINs between 2014 and 2019 were retrospectively identified. Patient factors, fracture characteristics, and surgical details of closed versus open reductions were gathered. Paired two-tailed t-tests, Chi-square tests and Pearson's Correlation Coefficient tests were performed. Statistically significant risk factors were then further analysed by performing a logistic regression. All data analysis was conducted using IBM's SPSS Software, version 19.0.

Results: The statistically significant risk factor for predicting unsuccessful closed reduction in forearm fractures was the amount of bone overlap at presentation ($p < 0.001$). Using the Receiver Operating Curve and Youden index, the cut-off with the highest sensitivity and specificity was 6.64mm. There was no statistical significance with regards to patient-specific factors, such as biological age ($p = 0.317$), skeletal age ($p = 0.623$), BMI ($p = 0.144$), gender ($p = 0.638$), ethnicity ($p = 0.189$), history of forearm fractures ($p = 0.373$), and mechanism of injury ($p = 0.870$). Fracture characteristics were also determined to be non-predictive, including soft-tissue to bone-width ratio ($p = 0.071$), bone angulation in the anteroposterior and lateral view ($p = 0.168$ and $p = 0.399$ respectively), type of fracture ($p = 0.188$), fracture site ($p = 0.508$), fracture pattern ($p = 0.095$), and comminution ($p = 0.255$). Duration from presentation to surgery ($p = 0.399$), time of surgery ($p = 0.140$) and surgeon seniority ($p = 0.768$) were also found to be statistically insignificant.

Conclusions: The amount of bone overlap at presentation significantly predicts the likelihood of failing closed reduction in ESIN treatment of paediatric diaphyseal forearm fractures.

Significance: Children with a higher degree of bone overlap at presentation should be adequately forewarned regarding the increased chances of conversion to an open reduction. Surgeons should avoid excessive attempts at closed reduction of forearm fractures with the ESIN in circumstances when bone overlap is more than 6.64mm, and be well-prepared to switch to an open method instead.

Unicolumnar Pin Fixation of Type III Supracondylar Humeral Fractures is Associated with a Greater than Three Times Higher Odds of Lost Reduction

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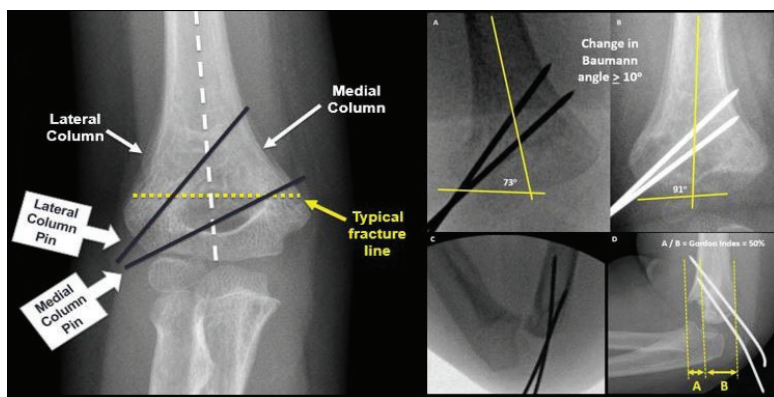
Purpose: Our aim was to compare the rate of loss of reduction between two groups of type III supracondylar humeral fracture patients: a unicolumnar fixation group versus a bicolumnar fixation group.

Methods: Patients with type III supracondylar humeral fractures were identified from surgical billing records. Pin placement was categorized as unicolumnar fixation (lateral column only) or bicolumnar fixation (lateral and medial column). The status of reduction and fixation at time of fluoroscopy was identified by assessing the Baumann angle, the Gordon index, and anterior humeral line (AHL). Loss of reduction was assessed at time of healing and defined as a Baumann angle change ≥ 10 and Gordon index of ≥ 0.5 , and failure of AHL to intersect capitellum. Statistical analysis was performed using the Fischer exact test and logistic regression.

Results: There were 257 patients included in the study (avg age 5.8 yrs, range 2–14 yrs). Of these patients, 183 had bicolumnar fixation with 6% (11/183) demonstrating loss of reduction. Seventy-four patients had unicolumnar fixation with 18% (13/74) showing loss of reduction. These two rates were significantly different ($p=0.008$) with a 3.3 times higher odds [95% CI = 1.3, 8.6] of loss of reduction with unicolumnar fixation. Multivariate analysis showed statistical significance of unicolumnar versus bicolumnar fixation ($p=0.007$) and showed a trend towards higher loss of reduction with increased fluoroscopy time ($p=0.07$).

Conclusions: There is a statistically significant increase in the rate of supracondylar fracture loss of reduction for patients with unicolumnar fixation when compared to bicolumnar fixation.

Significance: As crossed pin constructs (which were virtually always bicolumnar) transitioned to lateral entry pins only, the empiric rate of achieving bicolumnar fixation diminished. Our study adds to existing literature that emphasizes importance of AP radiograph pin spread.



Pediatric and Adolescent Fractures of the Acetabulum treated with ORIF: What are their Functional Outcomes?

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Purpose: Fractures of the acetabulum have been extensively studied in the adult population, and it is well established that an anatomic reduction following ORIF produces the best functional outcome. A paucity of literature regarding appropriate management and outcomes of pediatric and adolescent acetabulum fractures. The purpose of this study was to evaluate the functional outcomes of pediatric and adolescent patients who sustained acetabulum fractures that were treated with ORIF.

Methods: This is an IRB-approved evaluation of a prospectively collected database from a single orthopaedic trauma surgeon at an academic level I trauma center. Patients younger than 18 years with operatively treated acetabulum fractures, complete functional outcome data, and evidence of fracture healing with a minimum 6-month clinical follow-up were included. Indications for operative treatment were consistent with those for adult patients, including fracture of the weight-bearing dome with ≥ 2 mm displacement, instability of the hip and/or failure to maintain a concentric reduction by closed means. Patient demographics, injury characteristics, treatment outcomes and post-operative complications were evaluated (Table 1).

Results: Twenty-one patients were included (12 male and 9 female patients, mean age of 15.4 years old (range 11-17)). Functional outcome data was obtained at a mean of 5 years 2 months (range 6 months to 15 years). The average modified Merle d'Aubigné score was 16.2, with fourteen achieving an excellent outcome, four achieving a good outcome, one fair outcome and two poor with significant post-traumatic osteoarthritis (PTOA). Radiographic follow-up at a mean of 4 years (range 6-132 months) showed fourteen patients with Matta radiographic grade of excellent, two good, and three poor. Mean SF-36 scores were 44.8 (range 16.0-60.0) and 50.1 (range 22.5-63.0) for the physical (PCS) and mental component scores (MCS), which was similar to US population norms (PCS mean: 50, p= 0.061; MCS mean: 50, p=0.973). Mean SMFA Bother Index score was 18.6 (range 0-64.6) which is similar to the population norm mean of 13.8 (p=0.268). However, the Function Index mean was 31.9 (range 0.0-84.6) which was significantly worse than population norm mean of 12.7 (p=0.001).

Conclusions: This is the first study to investigate functional outcomes in pediatric and adolescent patients with acetabular fractures treated with ORIF. We found that 86% (18/21) of these patients had favorable functional outcome with the exception of the SMFA Functional Index.

Significance: Continued long-term follow-up is needed, but we strongly advocate for operative management of pediatric and adolescent acetabulum fractures when adult displacement and instability criteria are present.

Patient	Age	Sex	BMI	MOI	Fracture Type	Dislocation	Phyres	Surgical Approach	Merle d'Aubigne Pain	Merle d'Aubigne Walking	Merle d'Aubigne RCM	Total Merle d'Aubigne	Length of follow-up (months)	Complications
1	11	F	18.2	MVA	PCPW	Y	Open	KL A	6	6	6	18	118	None
2	12	M	26.2	Low Fall	PCPW	N	Open	KL A	5	5	6	16	11	None
3	12	F	28.7	Other	Transverse	N	Closed	KL A	4	6	6	16	24	Cam lesion, labral tear - underwent hip arthroscopy
4	13	M	23.9	Low Fall	PW	N	Open	KL A	6	6	6	18	24	None
5	14	M	27.7	Low Fall	PCPW	Y	Closed	KL A	3	5	4	12	46	AVN, PTOA - converted to THA
6	15	M	24.5	Other	PC	N	Open	KL A	6	6	6	18	57	None
7	15	F	25	MVA	T Type	Y	Closed	KL A	6	6	6	18	130	None
8	15	M	27.1	Other	PW	N	Closed	KL A	6	6	6	18	24	None
9	16	F	28.7	MVA	BC	N	Closed	AIP A	6	6	6	18	110	abductor weakness
10	16	F	34.9	MVA	TPW	Y	Closed	KL A	6	6	6	18	12	None
11	16	F	21.1	MVA	PC	Y	Closed	KL A	6	6	6	18	13	trichanthemic bunions
12	16	M	20.2	Low Fall	T Type	Y	Closed	AIP A	6	6	6	18	27	None
13	16	M	35.2	Low Fall	PW	Y	Closed	KL A	3	5	5	13	26	AVN, PTOA - converted to THA
14	17	M	34.3	MVA	T Type	N	Closed	II & KL I	6	6	6	18	77	None
15	17	M	23.2	MVA	Transverse	N	Closed	KL A	4	6	5	15	118	post-op infection
16	17	M	38.3	MVA	TPW	N	Closed	KL A	5	5	5	15	70	sciatic nerve pain
17	17	F	29.8	MVA	PW	Y	Closed	KL A	6	6	6	18	15	None
18	17	M	21.8	MVA	TPW	Y	Closed	KL A	6	6	6	18	180	None
19	17	M	30.5	MCA	T Type	Y	Closed	KL A	5	5	5	15	83	sciatic nerve pain, partial sciatic nerve palsy, HO
20	17	F	31.9	MVA	PC	N	Closed	KL A	6	6	6	18	26	None
21	17	F	36.1	MVA	PW	Y	Closed	KL A	0	3	2	5	103	PTOA - scheduled to undergo THA
Mean	15.4	-	28	-	-	-	-	-	5.1	5.6	5.9	16.2	61.6	-

Abbreviations: MVA, motor vehicle accident; MCA, motorcycle accident; PCPW, posterior column posterior wall; PC, posterior column; BC, both column; TPW, transverse posterior wall; PW, posterior wall; KL, Kocher-Langenbeck; AIP, anterior intrapelvic; II, ilioinguinal; A, anatomic; I, imperfect; AVN, avascular necrosis; PTOA, post-traumatic osteoarthritis; HO, heterotopic ossification

Ulnar Epiphysiodesis: Success of the Index Procedure

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Purpose: Pre-mature distal radial physal closure is a relatively rare occurrence in children; and is the result of fractures or overuse injury that involve the distal radius physis. When isolated growth arrest of the radius with continued ulnar growth occurs, the resulting ulnar positive deformity leads to altered wrist mechanics and may lead to pain. Timely epiphysiodesis of the distal ulna with and without ulnar-shortening osteotomy can address these issues, but continued ulnar overgrowth is a possible complication if the ulnar physis does not cease growth. We seek to evaluate the success rate of the primary epiphysiodesis of the ulna and the associated clinical outcomes: time to physal closure, improvement in pre-operative symptoms and ulnar variance correction (osteotomy dependent).

Methods: A multi-center, retrospective chart review was conducted at two children's hospitals from 2008 to 2019. Patients between the ages of 6 and 18 years old, with pre-mature distal radius physal closure, with or without positive ulnar variance, and greater than two months follow up were included. We evaluated type of initial injury, amount of ulnar variance, pain, range of motion, instability, and additional procedures performed at the time of epiphysiodesis. Summary statistics were conducted and expressed as proportions, medians and means. A paired t-test evaluated change in ulnar variance for those who had an ulnar shortening osteotomy performed.

Results: Thirty-one patients were identified, and the median age was 12.2 years (IQR: 3.4). Salter Harris Type II fractures of the distal radius composed 56.3% of our cohort, followed by gymnast wrist injuries (12.5%) and other fractures (12.5%). Pre-operative symptoms identified included pain with activities (56.8%), loss of range of motion (20.5%), pain at rest (18.2%), and distal radioulnar joint instability (4.5%). Secondary procedures performed included: ulnar shortening osteotomy (53.1%), bone grafting (28.1%), distal radius osteotomy (15.6%). There were two failures of primary epiphysiodesis indicating an index success rate of 93.7%. The average ulnar variance correction was 4.30 mm (95%CI: 3.17, 5.43). The mean physal time to closure was 134 days. Pre-operative symptoms were resolved for 90.6% cases at final follow up.

Conclusions: Index epiphysiodesis corrects ulnar overgrowth in up to 93.7% of cases. Pre-operative symptoms were completely resolved with a median physal closure of just over 4 months. Ulnar variance was corrected on average by 4.30 millimeters when a radial or ulnar shortening osteotomy was performed at the time of epiphysiodesis.

Significance: Index ulnar epiphysiodesis is successful at closing the physis in most cases.

Table 1 Clinical and Radiographic Parameters of Interest

Variable Mean (SD)	Non-Operative N=92	Operative N=29	p-value	Operative & Non-operative N=121
Age (y)	13.5 (1.7)	15.3 (1.3)	0.0001	13.9 (1.8)
Sex (M/F)	62/30	24/5	0.112	86/35
Shortening (mm)	7.5 (7.4)	15.2 (9.2)	0.0002	9.3 (8.5)
Angulation	22.3 (13.2)	14.9 (10.1)	0.0026	20.5 (12.9)
Displacement (mm)	7.1 (6.3)	16.7 (8.5)	0.0001	9.4 (8.0)
Zed Deformity Present (Y/N)	5/87	10/19	0.001	15/106
Tenting (Y/N)	4/88	7/22	0.001	11/110
Time to Union**(d)	77 (32)	79 (42)	0.4120	77 (33)
Return to Activity**(d)	56 (29)	44 (10)	0.5296	50 (24.5)
Return to Sport**(d)	84 (29)	83 (18)	0.8128	83 (26)
Complications (Y/N)	6/86	2/27	0.614	8/113
Follow-up Length**(d)	83 (48.5)	92 (38)	0.0166	86 (46)

**Median (IQR); Wilcoxon-Mann-Whitney test

Outcomes of Displaced Forearm Fractures in Children Treated With Closed Reduction and Casting and a Loop and Sling Attached to the Cast Proximal to the Fracture Site

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Purpose: Forearm fractures in children account for 45% of pediatric fractures. After reduction and casting, these fractures have a risk of re-displacement. While some re-displacement may be acceptable due to the remodeling capacity of young children, significant re-displacement requires repeat manipulation or internal fixation to prevent deformity and subsequent loss of range of motion. The purpose of this study is to compare the re-displacement rate of displaced mid-shaft both-bone forearm fractures in children treated with closed reduction and casting with or without a loop and sling applied to the cast proximal to the fracture site

Methods: The study was approved by the medical school IRB.] A retrospective review was performed of 42 patients under the age of 14 with displaced mid-shaft both-bone forearm fractures. Twenty-five patients were male and 17 patients were female. The average age was 7 years (range 1 to 13). Data analyzed included: demographics, mechanism of injury (MOI), presence of a pulse, presence of a nerve injury, incidence of compartment syndrome, use of a loop and sling, loss of reduction, need for re-manipulation, need for ORIF. Patients with pathologic fractures or additional fractures were excluded. [SP1]

Results: The most common MOI was a simple fall. Treatment in each case was closed reduction and casting. One patient presented with trace distal pulses and three patients presented with neurological symptoms. The casts were applied with the elbow flexed to 90 degrees and the forearm in neutral. In 15 patients (36%) a loop and sling were attached to the cast proximal to the fracture site ('Rang' method). 27 patients (64%) were given a standard sling. Only one patient (7%) managed with the Rang method lost reduction while 17 patients (63%) given a regular sling lost reduction and required a second fracture manipulation ($P = 0.0004$). No patient was indicated for ORIF. No patients developed a compartment syndrome. The weak pulse returned after fracture reduction; the nerve palsies recovered within 1 month with observation.

Conclusions: Treatment of a displaced both bone forearm fracture in a child age < 14 years typically involves a closed reduction and casting. The 'Rang' method of placing a loop and attached sling proximal to the fracture site creates support for the well molded cast and minimizes deforming force at the fracture site. [D]

Significance: The casting 'pearl' using a loop/sling attached to the cast resulted in significantly less fracture re-displacement

Analysis of Adolescent Idiopathic Scoliosis Care Path and its Effectiveness

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Purpose: This study evaluated the effectiveness of an Adolescent Idiopathic Scoliosis (AIS) Care Path designed to assist pediatricians, family practitioners, orthopaedic surgeons, and other caregivers involved in the diagnosis and treatment of AIS from initial presentation to final disposition by minimizing cost, reducing variations in care, decreasing length of stay, and optimizing patient outcomes. This Care Path was initiated in 2016 and consists of an algorithm of the most current evidenced-based practices for the management of AIS. Metrics included both process measures and outcomes measures.

Methods: Patients 10 to 18 years of age who underwent surgical correction of AIS at our institution from 2014 to 2019 were reviewed. This consisted of 117 patients from 2014 to 2015 before the Care Path was initiated and 219 patients from 2016 to 2019 after the Care Path was initiated. Process measures included >90% of patients with an xray at the first orthopaedic visit, >90% of patients achieving edge-of-bed activity on POD #0, and >90% of patients discharged on POD #3 or earlier. Outcome measures included patient complications and rate of surgical site infection between 1-3 %.

Results: Analysis of process measures revealed that the frequency of having an xray at the first orthopaedic visit also improved slightly from 72% to 86% ($p=0.034$), while the frequency of edge-of-bed activity increased from 17% to 48% ($p<0.00001$). The percentage of patients discharged by post-operative day #3 increased from 45% pre-care path to 75% post-care path ($p<0.00001$). Analysis of outcomes measures revealed that patient complication rates decreased from 17% pre-care path to 9% post-care path ($p=0.047$). Importantly, surgical site infection also decreased from 5% pre-care path to 1% post care-path ($p=0.010$). The incidence of ileus during admission decreased from 9% pre-care path to 2% post care-path ($p=0.010$). Additionally, emergency room visits within 60 days decreased from 13% pre-care path to 6% post-care path ($p=0.038$). Overall readmissions within 60 days decreased from 6% pre-care path to 1% post-care path ($p=0.004$).

Conclusions: Development of a standardized care path for the treatment of AIS resulted in improvements in both process and outcomes measures, thus improving the quality of patient care. It will be important to keep monitoring these measures going forward to ensure that these improvements are not transient.

Significance: Development of a standardized care path for the treatment of AIS resulted in improvements in both process and outcomes measures, thus improving the quality of patient care.

Outcome measure	pre Care Path		post Care Path			
	2014	2015	2016	2017	2018	2019
Xray available at first orthopaedic visit	70.9%	72.6%	72.4%	78.0%	98.5%	100.0%
Mobilized to edge-of-bed POD 0	19.0%	15.0%	44.0%	38.0%	72.0%	69.0%
Discharged POD 3 or earlier	29.0%	60.0%	86.0%	73.0%	66.0%	76.0%
Complications	20.0%	15.0%	14.0%	10.0%	5.0%	5.0%
Ileus	11.0%	6.0%	3.0%	2.0%	2.0%	3.0%
ED visits within 60 days	11.0%	15.0%	9.0%	3.0%	6.0%	11.0%
Infections within 60 days	4.0%	6.0%	0.0%	0.0%	1.5%	0.0%
Readmissions	4.0%	8.0%	2.0%	0.0%	0.0%	3.0%

Caregiver literacy in a pediatric orthopedic population: a cross-sectional study

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Purpose: Approximately 33% of Americans have inadequate health literacy, which is associated with increased hospitalization and use of emergency care, poorer control of chronic diseases, infrequent use of preventative measures, and suboptimal treatment outcomes. In this study, the general and musculoskeletal health literacy of the parents or guardians (caregivers) of pediatric patients presenting to a general pediatric orthopedic clinic were evaluated and risk factors for limited health literacy identified.

Methods: This was a cross-sectional study of 200 caregivers at a large children's hospital. Caregivers completed a demographic survey, the Literacy in Musculoskeletal Problems (LiMP) questionnaire, and the Newest Vital Sign (NVS) to measure musculoskeletal and general health literacy, respectively. Multivariate logistic regression was used to evaluate the relationships between general health literacy, musculoskeletal health literacy, and demographic characteristics.

Results: Limited musculoskeletal health literacy defined as LiMP questionnaire scores of <6 was seen in 46.7% of participants. Inadequate general health literacy, defined as an NVS score <4, was observed in 18.0% of participants. On multivariate logistic regression, the odds of adequate musculoskeletal health literacy were lower for Hispanics (OR 0.38 (95% CI 0.16-0.86), $p = 0.021$), and higher those who have worked in a health care field (OR 2.96 (95% CI 1.37-6.36), $p = 0.006$), and those with a level of education of some college or greater (OR 3.43 (95% CI 1.62-7.25), $p = 0.001$). Upon multivariate logistic regression only caregivers possessing at least some college experience correlated with adequate general health literacy (OR 5.77 (95% CI 1.8-18.1), $p = 0.003$).

Conclusions: Those who had at least some college experience, were non-Hispanic, or held current or prior positions in health care were more likely to possess adequate musculoskeletal health literacy. Those who had at least some college experience were more likely to possess adequate general health literacy. Furthermore, the prevalence of limited musculoskeletal health literacy is far greater than that of limited general health literacy.

Significance: Almost half of all caregivers of pediatric orthopedic patients lack the necessary knowledge and comprehension for making informed decisions regarding the musculoskeletal care of their children, which may leave their children at a higher risk for sub-optimal outcomes. Our study is one of the first to identify risk factors for caregivers of pediatric orthopedic patients with either limited general or musculoskeletal health literacy. Interventions to improve health literacy in caregivers of pediatric orthopedic patients would benefit from a focus on musculoskeletal education.

Table 1. Multivariate logistic regression for adequate musculoskeletal and general health literacy

<u>Risk Factor for MSK Literacy</u>	<u>OR (95% CI)</u>	<u>P-value</u>
Care giver age >=35 vs not	0.88 (0.42,1.840)	0.7371
Female vs Male	2.21 (0.96,5.09)	0.0622
Hispanic vs not	0.38 (0.16,0.86)	0.0210
Health care employee vs not	2.96 (1.37,6.36)	0.0055
At least some college vs not	3.43 (1.62,7.25)	0.0012
<u>Risk Factor for General Literacy</u>	<u>OR (95% CI)</u>	<u>P-value</u>
Hispanic vs not	0.43 (0.18, 1.07)	0.0684
Health care employee vs not	2.05 (0.73, 5.72)	0.1720
At least some college vs not	5.77 (1.8, 18.1)	0.0027

Liposomal Bupivacaine Decreases Opioid Consumption, Length of Stay and Hospital Costs After Pediatric Spine Surgery: A Retrospective Cohort Study

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Purpose: Postoperative pain after spinal surgery may affect exposure to opioids, patients' hospital length of stay (LOS), and medical costs. Liposomal bupivacaine (LB) consists of multivesicular liposomes that release bupivacaine over several days. Use of LB can reduce postsurgical pain and opioid consumption when given via local infiltration. The objectives of this study were to assess opioid consumption, length of hospital stay and total hospital costs associated with the use of LB or non-LB analgesia in a large national database of pediatric patients undergoing spine surgery.

Methods: This retrospective cohort study analyzed records from the Premier Healthcare Database, which contains administrative data from >1041 US hospitals and health care systems, representing 25% of annual US inpatient admissions. The cohort included patients aged 1 to 17 years undergoing inpatient primary spine surgery between January 1, 2015, and September 30, 2019. Patients either received LB or non-LB analgesia for pain management after spine surgery. Outcomes included opioid consumption during hospital stay in morphine milligram equivalents (MMEs), LOS, and total hospital costs. Patients with hospital costs ± 3 standard deviations beyond the mean cost were excluded from the analysis. Statistical comparisons were made using a generalized linear model with gamma distribution and log link function, with adjustment for age, sex, race, Quan-Charlson Comorbidity Index, location, teaching hospital, hospital size (bed number), geographic region, use of patient-controlled analgesia, and surgery type.

Results: A total of 10,189 pediatric patients were identified for this analysis (LB cohort: n=373; non-LB cohort: n=9816). Most baseline characteristics were comparable between groups, except for the LB cohort being older than the non-LB cohort (14 vs 12 years). The LB cohort consumed 47% fewer in-hospital postsurgical opioids than the non-LB cohort (1298 vs 2440 adjusted MMEs; MME ratio, 0.53 [95% confidence interval (CI), 0.46–0.62]; $P < 0.001$). In addition, the LB cohort had a significant 0.6-day reduction in LOS versus the non-LB cohort (adjusted LOS: 3.4 vs 4.0 days; LOS ratio, 0.87 [95% CI, 0.81–0.93]; $P < 0.001$). Total hospital costs were significantly lower in the LB cohort versus the non-LB cohort (adjusted cost: \$29,357 vs \$31,622; cost ratio, 0.93 [95% CI, 0.87–1.00]; $P = 0.04$). This difference in hospital cost was primarily due to a shorter length of stay and associated central supply costs.

Conclusions: Pediatric spinal patients who received postsurgical LB analgesia had significant reductions of in-hospital opioid consumption, LOS, and hospital costs compared with non-LB analgesia patients.

Significance: LB had significant reductions of in-hospital opioid consumption, LOS, and hospital costs.

Evaluation of Calibration Methods for Development of Skeletal Maturity Systems

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Purpose: Estimation of skeletal maturity can be critical for surgical decision-making, and development of a skeletal maturity estimation system requires a “gold standard” measurement. Nearly all existing systems have used chronological age or peak height velocity (PHV) as their gold standard. Recently, 90% of final height was identified as a novel gold standard that can be more easily and accurately implemented than PHV on a longitudinal data set. We recently reported a knee skeletal maturity system which outperforms Greulich and Pyle bone age. We sought to determine if this system calibrated using a 90% final height gold standard performs better than one calibrated with PHV or chronological age.

Methods: A well-documented longitudinal growth collection was queried. 133 serially obtained, peripubertal AP knee radiographs and their associated gender, chronologic age, height, femoral length, and tibial length from 38 subjects were collected. The age at which each subject reached 90% of final height and PHV was recorded. Fourteen radiographic parameters were measured on each knee radiograph. Stepwise linear regression and generalized estimating equation (GEE) analyses were used to produce three skeletal maturity prediction models, respectively calibrated with 90% of final height, PHV, and chronological age gold standards. Those models were used to estimate the skeletal age associated with each knee radiograph. Next, those skeletal age estimates were used to predict ultimate femoral and tibial length via the Multiplier, White-Menelaus, and Growth Remaining methods.

Results: The model calibrated with 90% of final height produced more accurate estimates of skeletal maturity than the PHV or chronological age models (mean prediction discrepancy 0.31 vs. 0.42 vs. 0.61 years; $p < .05$ comparing 90% final height to both). In prediction of femoral and tibial length, the 90% of final height and PHV models performed similarly ($p > .05$); both performed better than the chronological age model ($p < .05$; figure 1).

Conclusions: This analysis demonstrates that skeletal maturity models calibrated with a gold standard of 90% of final height perform as well as those calibrated with PHV in lower limb length prediction, with potential to outperform PHV when applied to other orthopaedic conditions.

Significance: Use of the 90% of final height gold standard allows for simpler development of skeletal maturity systems than PHV with equal versus better performance, while both produce more accurate systems than chronological age. Use of this new gold standard can potentially facilitate the development of new skeletal maturity systems and the optimization of existing skeletal maturity systems.

	Multiplier Method			White-Menelaus			Growth Remaining		
	90% of Standing Height	Peak Height Velocity	Chronological Age	90% of Standing Height	Peak Height Velocity	Chronological Age	90% of Standing Height	Peak Height Velocity	Chronological Age
Mean Prediction Discrepancy: Femoral Length, mm	11.1	11.4	20.6	19.6	19.6	18.1	19.6	19.6	18.1
ANOVA p-value*	-	0.977	<.001	-	1.00	0.67	-	1.00	0.67
Outlier Predictions: Femoral Length†	6.0%	7.5%	33.1%	29.3%	30.1%	27.1%	29.3%	30.1%	27.1%
p-value*	-	0.74	<.001	-	0.89	0.11	-	0.89	0.11
Mean Prediction Discrepancy: Tibial Length, mm	9.7	9.8	10.2	7.7	7.7	10.1	7.7	7.7	10.1
ANOVA p-value*	-	1.00	0.92	-	0.91	0.01	-	0.91	0.01
Outlier Predictions: Tibial Length†	13.3%	12.2%	17.3%	6.1%	7.1%	17.3%	6.1%	7.1%	17.3%
p-value*	-	0.83	0.43	-	1.00	0.02	-	1.00	0.02

*All p-values are compared to the 90% of final height model

† Outlier femoral length predictions were defined as those that were >26.8 mm off from actual ultimate femoral length. 26.8 mm = overall mean femoral length prediction discrepancy + 1 standard deviation

* Outlier tibial length predictions were defined as those that were >19.0 mm off from actual ultimate tibial length. 19.0 mm = overall mean tibial length prediction discrepancy + 1 standard deviation

Descriptive Epidemiology of Venous Thromboembolism after Pediatric Orthopaedic Surgery – A Multicenter Review

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Purpose: A lack of consensus exists regarding the subgroups of children undergoing pediatric orthopedic surgery who may be predisposed to venous thromboembolism (VTE) and would benefit from prophylaxis. Thus, the purpose of this study was to determine the incidence of VTE and define the United States epidemiology of VTE within pediatric orthopaedics.

Methods: A multicenter retrospective database was created involving 17 pediatric centers across the United States. The overall VTE incidence rate and incidence rate after orthopaedic surgery (2014-2017) were calculated with 95% confidence intervals (CIs). A weighted average was calculated for age at diagnosis for both orthopaedic and non-orthopaedic VTEs. Demographics, risk factors, presence of prophylaxis, treatment, and outcome data for orthopaedic-related VTEs were analyzed using descriptive statistics.

Results: The overall VTE incidence (2014 to 2017) was 1.6 per 10,000 patients (CI 1.58-1.72) and the VTE incidence after orthopaedic surgery was 7.0 per 10,000 patients (CI 5.70-8.57). The weighted mean age for orthopaedic VTEs was significantly higher compared to non-orthopaedic VTEs (11.4 years vs. 8.0 years, $p < 0.001$), and 75% of the orthopaedic cohort had a VTE diagnosis over the age of 7.6 years. One-hundred sixteen orthopaedic VTE patients from 17 participating hospitals were in the cohort (median age 13.1 years, 55% male). Of the 116 patients, 90 (87%) had a deep vein thrombosis (DVT), with a majority occurring in the lower extremity (68%). Orthopaedic surgery (52%), blood stream infection (47%), and central venous catheter (35%) were the three most common risk factors associated with VTE. Seventy-seven percent of the orthopaedic VTE cohort had less than 3 risk factors (89/116, 77%). The majority of orthopedic VTEs developed during initial hospitalization (66%) and according to the Best Evidence VTE Statement, only half of the patients were considered to be high risk for developing a VTE (58/116). Of the 35 patients who received prophylaxis, 28 (80%) had prophylaxis administered chemically. Ninety-seven percent of orthopedic VTE patients were treated with anticoagulation, with low-molecular-weight heparin being the most frequently used (80%). Seventy-eight percent of patients did not experience a complication; however, 2 patients died as a result of an orthopaedic-related VTE (2%).

Conclusions: Pediatric orthopaedic related VTE is more common than previously appreciated. Identification of at risk patients is critical to preventing morbidity and mortality associated with pediatric orthopaedic VTE.

Significance: These results may assist with generating clinical practice guidelines to aid clinicians in the screening, prophylaxis, and management of pediatric orthopaedic related VTE.

Spine at Risk Program: 9-year Review of Novel Safety Screening Tool

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Purpose: Spinal cord injury (SCI) under anesthesia during non-spine procedures in pediatric patients is rare but serious. A “Spine at Risk” (SAR) alert program was implemented at our institution in 2011 to identify patients prior to an operation who are at risk for intra-operative SCI, trigger an evaluation by a spine provider, and document recommended precautions for perioperative positioning and care meant to avoid SCI. An SAR alert was activated either automatically by charting an at-risk diagnosis from a pre-determined list, or manually ordered by any concerned provider. We aimed to determine the frequency of recommended precautions given for those automatically flagged versus flagged by provider, rate of each specific precaution, and whether the SAR program was effective in eliminating SCIs.

Methods: We performed a retrospective chart review for all patients with an SAR alert within 2011-2019, and categorized whether the patient was flagged by the EMR based on an at-risk diagnosis or assigned an SAR alert by a provider. We recorded which specific recommended precautions were made, and reviewed data for intra-operative SCIs at our institution in non-spinal operations during this period.

Results: Of the 3,442 patients in the study, 1,953 had an SAR alert activated due to a diagnosis and 1,489 had an alert added by a provider. The system was 63% better than providers at identifying patients who were given precautions after evaluation ($p < 0.001$). For the diagnosis-flagged patients, 39% received at least one recommended precaution, while 24% of provider-flagged patients required a precaution. For those with precautions, rates for specific recommendations were greatest for c-spine positioning restrictions (87% of diagnosis-flagged; 30% of provider-flagged), spinal cord monitoring (25%; 6%), fiberoptic intubation (14%; 6%), and thoracolumbar positioning restrictions (16%; 8%). No intraoperative SCIs occurred in non-spine procedures during the study.

Conclusions: This study provides a long-term look at a novel safety program that was designed to prevent devastating SCIs in high-risk pediatric patients during non-spine anesthetized procedures. It was found that the system was better than providers at identifying patients who needed precautions; c-spine positioning precautions were the most common recommendation; and no intraoperative SCIs occurred during the study period. Future work aims to narrow the at-risk diagnoses for improved specificity.

Significance: This EMR-based SAR program may serve as a model for others to help avoid SCI in at-risk patients.

Reducing Opioid Consumption in a Pediatric Orthopedic Practice

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Mayo Clinic, Rochester, MN

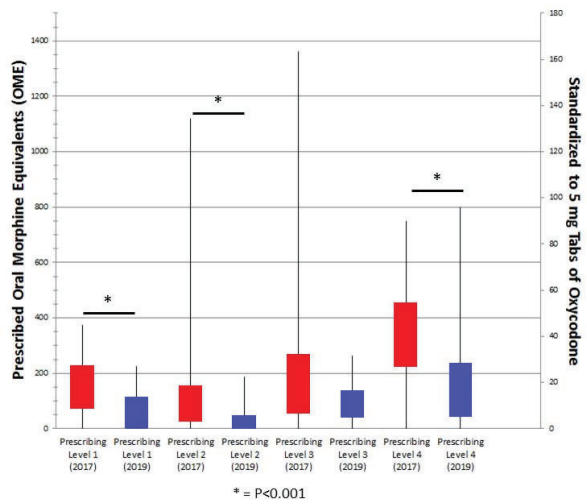
Purpose: Responsible opioid prescribing practices are a primary concern for all orthopedic surgeons. Relatively little is known regarding opioid prescribing patterns following pediatric orthopedic procedures. The aim of this work was to evaluate homegoing opioid consumption before and after implementation of tiered post-operative narcotic prescribing guidelines for pediatric orthopedics.

Methods: This retrospective cohort study was conducted from January 2017 through December 2019 at a single academic institution. Guidelines for home going opioid prescriptions were implemented January 2018 and established four graduated tiers of increasing invasiveness for 28 common pediatric orthopedic procedures. Patients who underwent these procedures in 2017 comprised the pre-guideline cohort (N = 258), while patients treated in 2019 comprised the post-guideline cohort (N=212). Opioid prescriptions were reported as oral morphine equivalents (OME) for the entire cohorts. Univariate tests were performed to assess statistical differences across guideline cohorts.

Results: There were no significant differences in age, sex, number of opioid naive patients, or overall distribution of procedures between the two cohorts (all P >0.05). There was a significant decrease in OME prescribed for the entire cohort between the pre- and post-guideline cohorts (median OME 97.5 vs 37.5, P<0.01). When analyzed according to surgery tiers, tiers 1, 2 and 4 all showed significant decreases in OME prescribed between 2017 and 2019 (all P <0.01) while level 3 showed a clinical decrease prescribed but did not reach statistical significance (P =0.08) (Figure 1). The rate of no opioids prescribed at discharge increased significantly from 13% to 23% between pre and post-guideline cohorts (P<0.01). The 30-day refill rate did not significantly change, from a rate of 6.2% pre-guideline to 8.0% post-guideline (P=0.44). In level 4 procedures specifically—which included major spine surgery and had the greatest opioid utilization—median OME prescribed decreased significantly from 375 pre-guideline to 188 post-guideline (P<0.01), but was associated with an increase in opioid refills within 30 days of discharge (10.2% pre-guideline versus 28.8% post-guideline, P=0.02).

Conclusions: A tiered opioid prescribing guideline can significantly decrease prescribed narcotic doses in the pediatric population undergoing orthopedic procedures. Such guidelines can be rapidly implemented and can improve pediatric orthopedists' abilities to responsibly treat postoperative pain while potentially limiting complications of narcotic use.

Significance: Effective decreases in homegoing narcotic prescriptions for pediatric orthopedic surgery can be achieved through tiered prescribing guidelines.



Earlier Bowel Movements and Decreased Length of Stay with Oral Methylnaltrexone Following Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis

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Purpose: Methylnaltrexone, a peripheral opioid antagonist, is used to decrease opioid-induced constipation; however, there is limited evidence for its use in children. The primary objective of the study is to assess the efficacy of PO methylnaltrexone in inducing bowel movements (BM) in patients with adolescent idiopathic scoliosis (AIS) who underwent a posterior spinal fusion and instrumentation (PSFI). Secondary outcomes include hospital length of stay, post-operative pain scores, and post-operative opioid usage.

Methods: Retrospective chart review identified all AIS patients >10 years of age who underwent PSFI with a minimum of 24 hours of post-operative opioid analgesia after the initiation of the new bowel regimen protocol. The bowel regimen included daily administration of PO methylnaltrexone starting on postoperative day POD#1 until BM is achieved. A case-matched cohort was obtained with patients who did not receive PO methylnaltrexone and otherwise had the same bowel function regimen. Case-matched controls were also matched for age, sex, BMI, and curve severity. T-tests and Pearson's chi-squared tests were used for statistical analysis.

Results: 52 patients received oral methylnaltrexone (14 ± 2.6 years) and 52 patients were included in the case-matched control group (14 ± 2.1 years). The methylnaltrexone group had a significantly shorter hospital length of stay ($3.09 \pm .66$) compared to controls ($3.69 \pm .80$) ($p < 0.01$). 59% (31 of 52) of the methylnaltrexone group had a BM by post-operative day POD#2, compared to 30% (16 of 52) of the control group ($p < .01$). In the methylnaltrexone group, 44% (23 of 52) of the patients required a Dulcolax suppository and 11% (6 of 52) required an enema, compared to 50% (26 of 52) and 33% (12 of 52) of the control group respectively ($p = 0.43$ and $p = 0.12$). In addition, significantly less patients had abdominal distension during their post-operative stay in the methylnaltrexone group (17%, 9 of 52) compared to the control group (40%, 21 of 52) ($p < 0.01$). There was no significant difference in self-reported average FACES pain score ($p = 0.39$) or in opioid morphine equivalents required per hour ($p = 0.18$).

Conclusions: Patients who received PO methylnaltrexone after PSFI had decreased length of stay and improved bowel function. Administration of methylnaltrexone did not increase maximum self-reported FACES pain values or opioid consumption compared to controls.

Significance: The use of oral methylnaltrexone after PSFI reduces post-operative constipation, which has implications for reducing hospital length of stay and overall morbidity.

Do Children’s Hospitals Present Opportunities for Appropriate Disposal of Opioid Medications?

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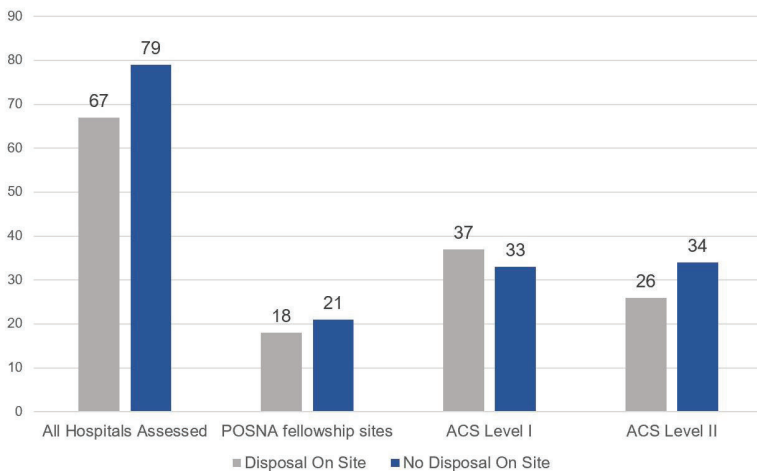
Purpose: The opioid epidemic in the United States is an ongoing public health crisis. Eighty percent of high schoolers who report non-medical use of prescription opioids obtained these medications from a previously legitimate prescription. Appropriate disposal of excess opioids prescribed to children is essential. The POSNA advocacy committee recommends surgeons should educate patients and families about locations for appropriate leftover drug disposal. This investigation sought to identify whether publicly accessible opioid disposal opportunities exist at or near major pediatric hospitals.

Methods: A database of major pediatric hospitals was established by identifying medical centers that serve as POSNA accredited fellowship training centers or are designated by the American College of Surgeons (ACS) as Level I or II pediatric trauma centers. The presence a of Drug Enforcement Agency (DEA) recognized Controlled Substance Public Disposal (CSPD) site located on a hospital’s campus was assessed using the DEA Diversion Control Division website. The number of CSPD locations within ten miles of each hospital was determined. The number of pediatric opioid overdose deaths occurring in each respective hospital’s county and state from 1999-2017 was ascertained using the CDC WONDER database. Fixed-effects modeling was used to assess relationships between a hospital’s on-site CSPD status and its county and state pediatric overdose mortality rate.

Results: A total of 146 hospitals were studied, including 39 POSNA fellowship sites. An on-site public opioid disposal location is offered by 45.8 % (N=67) of major pediatric hospitals. Similarly, 46.1% (N= 18) of POSNA fellowship institutions and 52.8% (N=37/70) of ACS level I pediatric trauma centers offer CSPD. 98.6% (N=144/146) of hospitals have a CSPD location within ten miles. Children’s hospitals have an average of 24 CSPD sites in the surrounding ten miles (SD: 23.8). Average distance to the nearest CSPD location is 2.2 miles (SD: 3.1 miles). The likelihood of a hospital offering on-site CSPD is statistically unrelated to the rate of pediatric opioid overdose deaths in each hospital’s county (p=0.85) or state (p=0.63).

Conclusions: Less than 50% of major children’s hospitals in the United States publicly offer on-site controlled substance disposal. The number of pediatric opioid overdose deaths in the surrounding county or state is not related to a hospital offering narcotics disposal.

Significance: Offering patients the ability to dispose of leftover opioid medications at their point of care is a prime opportunity to prevent drug diversion. However, it is currently offered at less than half of major children’s hospitals.



Study Groups and POSNA: A Review of Podium Presentations from 2006-2020

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Children's Hospital of Philadelphia, Philadelphia, PA

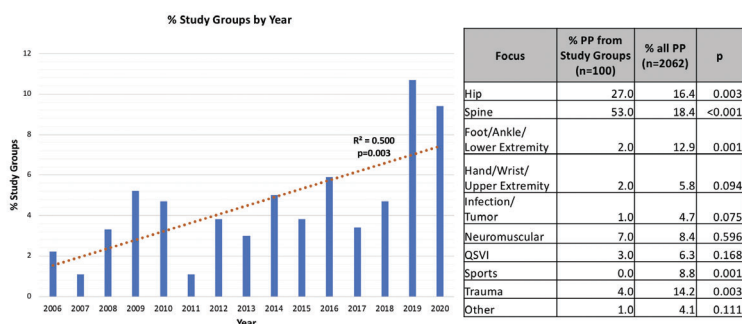
Purpose: Study groups are multicenter collaborations aimed at improving orthopaedic decision-making through higher-powered, more generalizable studies. The Pediatric Orthopaedic Society of North America (POSNA) annual meeting is a key venue for dissemination of study group research. The goal of this study was to identify trends in podium presentations (PP) at the POSNA annual meeting resulting from multicenter study groups over a 15-year period.

Methods: 2062 PP from the 2006-2020 POSNA annual meetings were identified. The abstracts of each PP were reviewed to determine if they resulted from a multicenter study group and for sub-specialty topic. PP from 2006-2018 were further reviewed for publication in academic journals. Pearson correlation was used to assess change in the number of PP resulting from study groups over time. Univariate analysis was used to compare characteristics of PP based on if they resulted from study groups (significance $p < 0.05$).

Results: The proportion of PP resulting from study groups increased from 2.2% ($n=2$) in 2006 to 9.4% in 2020 ($n=16$) ($r^2=0.500$, $p=0.003$). Amongst the 100 PP resulting from study groups, the distribution by subspecialty was 53% spine, 27% hip, 4% trauma, and 0% sports. This compared to a distribution of 18.4% ($p < 0.001$) spine, 16.4% ($P=0.003$) hip, 14.2% ($p=0.003$) trauma, and 8.8% ($p=0.001$) sports amongst all 2062 PP over the 15-year period. There was no difference in publication rate of PP resulting from study groups than those that were not (68.2% v 66.2%, $p=0.739$).

Conclusions: In the 15-year period from 2006-2020, there was a nearly 5-fold increase in the proportion of POSNA PP resulting from study groups. Spine surgery is disproportionately represented in PP supported by study groups, suggesting that pediatric spine research is more likely to include studies based upon multicenter, prospective databases.

Significance: Although the number of PP resulting from study groups has increased significantly since 2006, the focus of these groups is largely on spine surgery and is not representative of the breadth of pediatric orthopaedics. The publication rate from POSNA PP is not greater when supported by a study group.



High Volume Surgeons Have Better Surgical Outcomes and Lower Costs

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Purpose: Increased surgical volume has been associated with improved perioperative outcomes after spinal deformity correction. However, there is a lack of information on how this may affect hospital costs.

Methods: A retrospective study of adolescent idiopathic scoliosis (AIS) patients undergoing PSF from 2013 – 2019 was performed. Demographic, XR, chart review and hospital costs were collected and compared between high-volume (HV) surgeons (>50 AIS cases/yr) and low-volume (LV) surgeons (\leq 50/yr). Comparative analyses were computed using Wilcoxon Rank-Sum, Kruskal-Wallis, and Fisher's exact tests. Median values with corresponding IQRs were reported.

Results: A total of 335 patients (HV: 198, LV: 137) operated by 4 surgeons (1 HV, 3 LV). Radiographic parameters were similar between the groups. HV surgeons had significantly lower EBL (325v600 mL, $p<0.001$), fewer intraoperative transfusions (9.1%v17.5%, $p<0.022$), and shorter surgery time (232min v304min, $p<0.001$), radiation from intraoperative fluoroscopy(2.81mGyv1.64mGy, $p<0.001$). HV patients were more likely to be extubated in the OR (98.5%v86.1%, $p<0.001$) and perioperative complications (within 30 days)(0.5%v5.8%, $p = 0.004$). HV surgeons had significantly lower total costs (\$63,793.50v\$59,480.30, $p<0.001$). This included lower transfusion costs ($p = 0.022$), OR costs (\$14,779.80v\$11,205.60, $p<0.001$), and costs associated with a 30-day emergency department (ED) return ($p=0.019$). Postoperative hospital stay (\$34,400v\$34,400, $p=0.600$) and screw costs(\$14,720v\$14,080, $p= 0.491$) were similar.

Conclusions: High Volume surgeons had lower transfusion rates, shorter surgery time and were more likely to be extubated in the OR than their low volume counterparts. In addition, high volume surgeons had lower overall costs compared to low volume surgeons.

Significance: High volume surgeons have better surgical outcomes and lower costs than low volume surgeons.

Teaching Effective Management of Protective Equipment for Surgical Teams - Managing the COVID-10 Tempest

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Purpose: Proper use of personal protective equipment (PPE) is critical to prevent spread of COVID-19 and protect our patients and workforce. Our purpose was creating donning and doffing simulation, identifying learning gaps, providing deliberate practice with interactive feedback, and assessing post-simulation performance.

Methods: A simulation curriculum was developed in our Simulation center. All orthopedic attendings, advanced practice providers, nurses, and trainees participated in simulation over one week. Participants completed a pre and post simulation questionnaire. Prior to participation, all participants were instructed to review a learning module on donning and doffing. The sequence of donning was categorized into Gown and gloves, Respirator, Face Shield. The sequence for doffing was categorized into steps performed In room and Out of Room. Simulation was recorded and subsequently reviewed independently by two PPE experts, scoring performance against a gold-standard 15-step 9-step donning and doffing sequence. Inter-rater reliability was calculated using intraclass correlation coefficient (ICC) and confirmed to be high for both donning and doffing with ICC 0.71-0.94 and 0.89-1.0 respectively. Comparisons in pre- and post-simulation survey responses were conducting using paired Wilcoxon signed rank test or McNemar's test, as appropriate.

Results: 66 orthopedic providers participated in simulation. Participants had limited experience with N95 respirators, with 39 (59%) having used them 0-1 times. 55 (83%) participants viewed the video on average 1-2 times, yet only 23 (35%) and 18 (28%) felt prepared to don and doff PPE, respectively. After simulation, confidence improved for donning (94%) and doffing (92%) ($p < 0.001$). The majority of participants (54, 82%) felt less anxious after simulation training. Gown and glove donning sequence completion improved from 71% to 85% ($P < 0.001$), respirator donning completion improved from 69% to 83% ($P < 0.001$), and face shield donning sequence completion improved from 34% to 79% ($P < 0.001$). In room doffing sequence completion improved from 74% to 88% ($P < 0.001$), out of room N95 doffing sequence completion improved from 55% to 78% ($P < 0.001$), and out of room face shield step completion improved from 58% to 89% ($P < 0.001$).

Conclusions: Simulation can be an effective tool in teaching safe donning and doffing of PPE, and empower providers with knowledge, thereby reducing anxiety regarding PPE. While significant improvement were seen, there were still areas for continued improvement regarding PPE application.

Significance: This novel study demonstrates the efficacy of simulation for safely donning and doffing PPE during the COVID 19 pandemic, and highlights the ability for rapid simulation training in response to an urgent crisis for all provider levels.

Patient Factors and Small Area Variations Impact Opioid Prescription after Surgical Treatment of Supracondylar Humerus Fractures

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Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

Purpose: Over-prescription of opioids in children has been associated with increased opioid diversion and misuse. We sought to characterize small area variations and the impact of patient factors on opioid prescription patterns following surgical treatment of supracondylar humerus fractures (SHFx) in a large sample of US children's hospitals.

Methods: Patients aged 0-18 years that underwent surgical treatment of a SHFx across 47 children's hospitals in the United States between 2004-2017 were identified using the Pediatric Health Information System (PHIS). Opioid prescription rates across hospitals and over time were characterized. A hierarchical logistic model was developed to estimate the probability of receiving an opioid prescription by using patient age, sex, ethnicity, and race. Hospital-level random intercepts and linear time trends were included to allow for differences in overall prescribing trends.

Results: 42,497 patients (48.2% female) that underwent surgical treatment of a supracondylar humerus fracture were identified with a mean age of 5.0 ± 2.8 . In this cohort, 25,040/42,497 (58.9%) were prescribed opioids following surgery, ranging from 15.8% to 100% across the 47 hospitals ($p < 0.001$, Figure 1). The overall rate of opioid prescription decreased significantly over the study period from 69.0% in 2004 to 48.3% in 2017 (Year Odds Ratio=0.93, 95% Credible Interval [0.90, 0.97]) (Figure 1). There was no difference in prescription rate based on patient sex. Infants and young children (ages 0-1 and 1-4 years old, respectively) were less likely to be prescribed opioids than adolescents (36.4% vs. 61.3%, OR=0.32 CI [0.23, 0.44] and 55.8% vs. 61.3%, OR=0.83 CI [0.07, 0.93], respectively). African-American and Hispanic children were less likely to be prescribed opioids than white children (55.9% vs. 61.2%, OR=0.68 CI [0.64, 0.73] and 55.0% vs. 58.2%, OR=0.91 CI [0.85, 0.98], respectively).

Conclusions: There is tremendous variation in opioid prescription rates across US children's hospitals. There is also unexplained variation in opioid prescription rates based on race and ethnicity. Further prospective investigation on the value of post-operative opioids following surgical treatment of SCFx is required to reduce these unexplained variations in prescription patterns.

Significance: Variation in opioid prescription rates across hospitals suggests a lack of consensus regarding optimal post-operative analgesia for SCFx. Variations in prescription rates based on race and ethnicity may be a result of structural barriers and bias, and could result in over-prescription to white children and under-prescription to African American and Hispanic children.

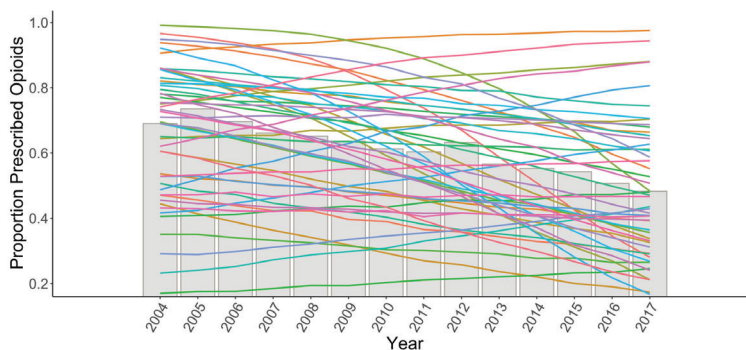


Table 1: Opioid prescribing rates after supracondylar fracture surgery by hospital. The bar chart represents the proportion of patients prescribed opioids at the typical hospital. Each line represents the patient-adjusted prescribing rate of a specific hospital in the sample.

Three-dimensional predictors of FAI disease progression in the contralateral hip

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Purpose: Bony morphologies contributing to femoroacetabular impingement (FAI) are relatively common in the general population, but drivers of symptom development and disease progression are not well understood. The study purpose was to determine the role of three-dimensional bony morphology in symptom development (disease progression) in the contralateral hip in patients undergoing ipsilateral surgical treatment for FAI.

Methods: The study included a prospective cohort of 161 consecutive patients (101 females, 60 males) who presented for ipsilateral FAI surgical treatment from 2013-2018. The average age was 29.1 years. The mean follow-up was 2.3 years (range, 1-6 years). Low-dose CT scans were obtained prior to surgical treatment. Three-dimensional hip analysis of the contralateral hip was performed relative to normative data and allowed measurements of 15 key parameters. Prior to surgery and at routine follow-up, patients completed standardized questionnaires that included pain in the contralateral hip. Univariate and multivariate analyses were performed to identify independent predictors.

Results: There were 133 patients (83%) with follow-up. Significant levels of pain in the contralateral hip were reported in 25 (18.8%) patients at presentation and 50 (35.3%) patients at follow-up. Twenty-six (19.5%) patients progressed to surgery at an average of 1.1 years. Significant predictors of symptom development were alpha angle $>55^\circ$ at 1:00 ($p=0.037$), femoral version $<0^\circ$ or $>20^\circ$ ($p=0.027$), and decreased central acetabular version at 3:00 ($p=0.048$). Significant predictors of surgery were age <30 years ($p=0.023$) and alpha angle $>55^\circ$ at 1:00 ($p=0.005$).

Conclusions: We found that roughly 1 in 5 patients undergoing surgical treatment for ipsilateral FAI experienced pain in the contralateral hip at presentation, over one-third reported pain at follow-up, and 1 in 5 progressed to surgery. Higher alpha angle, abnormal femoral version, and decreased acetabular version were correlated with symptom development, while higher alpha angle and age under 30 were associated with progression to surgery.

Significance: The role of bony morphology in the pathophysiology of FAI is poorly understood. Our study aimed to determine independent predictors of symptom development and progression to surgery.

VIDEO ABSTRACTS

Video Abstract 1

Transcapitellar pinning for proximal radius shaft fracture

*Barbara Minkowitz, Jennifer Ristic, Eytan Mendelow
Morristown Medical Center, Morristown, NJ*

Video Abstract 2

Open Reduction Internal Fixation of Displaced Pediatric Radial Neck Fractures using Intramedullary Nailing

*Kamil Amer, Michael Fields, Folorunsho Edobor-Osula
Rutgers New Jersey Medical School, Newark, NJ*

Video Abstract 3

Reconstruction of a Congenital Patellar Dislocation

*Lauren Hyer, David Westberry, Franklin Gettys
Shriners Hospitals for Children, Greenville, Greenville, SC*

Video Abstract 4

Patellar Tendon Imbrication for Correction of Crouch Gait

*Lauren Hyer, David Westberry, Jon Davids
Shriners Hospitals for Children, Greenville, Greenville, SC*

Video Abstract 5

Lateral Epicondyle Avulsion in a Skeletally Mature Adolescent

*Barbara Minkowitz, Jennifer Ristic, Alice Chu, Allie Davanzo, Kelsey Kaplowitz,
Eytan Mendelow
Morristown Medical Center, Morristown, NJ*

Video Abstract 6

Tibial Spine/Eminence Fracture – Suture Fixation

*Indranil Kushare, R Mistovich, John Shilt, Aristides Cruz
Texas Children’s Hospital, Houston Texas*

Video Abstract 7

Radial Neck Fractures: Metaizeau Intramedullary Technique

*Philip Nowicki
Helen DeVos Children’s Hospital, Grand Rapids, MI*

Video Abstract 8

Waterproof Mehta Casting for Early Onset Scoliosis

*Todd Ritzman, Jaysson Brooks, Lorena Floccari, Ryan Fitzgerald
Akron Children’s Hospital, Akron, OH*



VIDEO ABSTRACTS

Video Abstract 9

The Metaizeau Technique For Displaced Pediatric Radial Neck Fractures

Jay Patel, Jeremy Hreha, Folorunsho Edobor-Osula

Rutgers-New Jersey Medical School, Newark, New Jersey

Video Abstract 10

Pediatric Trigger Finger Release

Matthew Michel, Dominick Congiusta,

Folorunsho Edobor-Osula

Rutgers- New Jersey Medical School, Newark, New Jersey

Video Abstract 11

Posterior Approach to Knee and Contracture Release for Arthrogryposis

Brian Batko, Steven Rivero, Folorunsho Edobor-Osula

Rutgers New Jersey Medical School, Newark, NJ

Video 1**Transcapitellar pinning for proximal radius shaft fracture**

*Barbara Minkowitz MD; Jennifer Ristic; Eytan Mendelow
Morristown Medical Center, Morristown, NJ*

Trauma (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

5 year-old injured his elbow after he fell from the swings. Forearm x-rays show a proximal third greenstick radius shaft fracture with 25° volar apex angulation. The patient was indicated for surgery due to unacceptable fracture angulation. Radius shaft canal measured 2 mm at the smallest area which prompted the surgeon to proceed with percutaneous anterograde pinning of the radius using trans capitellar approach. This technique was used instead of intramedullary nailing due to size of the canal. This technique is described in the literature to fix radial head fractures but has not been described for proximal radius shaft fractures.

Video 2

Open Reduction Internal Fixation of Displaced Pediatric Radial Neck Fractures using Intramedullary Nailing

*Kamil Amer; Michael Fields; **Folorunsho Edobor-Osula MD**
Rutgers New Jersey Medical School, Newark, NJ*

Trauma (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

This video describes the surgical technique for placement of a retrograde intramedullary nail (Metaizeau Technique) to treated displaced pediatric radial neck fractures. In addition, we discuss complicaitions and outcomes of the Metaizeau Technique.

Video 3

Reconstruction of a Congenital Patellar Dislocation

*Lauren Hyer MD; David E. Westberry MD; Franklin Keith Gettys MD
Shriners Hospitals for Children--Greenville, Greenville, SC*

Anatomic Disorder (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

Congenital dislocation of the patella is a rare malformation of the extensor mechanism. Reconstruction of the congenital patella dislocation requires extensive release of the lateral structures, realignment of the extensor mechanism to allow for tracking of the patella in the femoral groove, and stabilization of the medial soft tissues. This video describes the etiology, clinical exam findings, and diagnostic work-up, as well as illustrates the principles of surgical management for congenital patellar dislocation.

Video 4**Patellar Tendon Imbrication for Correction of Crouch Gait**

*Lauren Hyer MD; David E. Westberry MD; Jon R. Davids MD
Shriners Hospitals for Children--Greenville, Greenville, SC*

Systemic Disorder (Bone Disorder, Cerebral Palsy, Myelomenigocele, Syndromes)

Crouch gait is a common gait abnormality in patients with cerebral palsy. While a variety of treatment options exist, the static knee flexion contracture is commonly corrected with a distal femoral extension osteotomy. To correct quadriceps insufficiency and patella alta, current described techniques include patellar tendon advancement, patellar tendon shortening, or patellar tendon imbrication. Advantages of imbrication over advancement or shortening are maintaining an intact extensor mechanism, eliminating hardware in the anterior knee, and improved scar cosmesis. We present a simplified technique for patellar tendon imbrication to address quadriceps insufficiency in children with cerebral palsy and crouch gait.

Video 5

Approaching a Humeral Avulsion of the LCL in a Skeletally Mature Adolescent

*Barbara Minkowitz MD; Jennifer Ristic; Alice Chu MD; Allie Davanzo; Kelsey Kaplowitz; Eytan Mendelow
Morristown Medical Center, Morristown, NJ*

Trauma (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

Lateral epicondyle fractures are an uncommon injury in adults and skeletally mature adolescents. 15 y/o female presents with right elbow injury after fall off her bike. Elbow x-ray shows acute avulsion of the lateral humeral epicondyle. This patient was brought to the OR for anatomic repair of the lateral collateral ligament with attached bony fragment and examination under anesthesia to assess elbow stability. Surgical technique is shown and pearls discussed.

Video 6

Tibial Spine/Eminence Fracture – Suture Fixation

Indranil Kushare MD; R Justin Mistovich MD; John A. Shilt; Aristides I. Cruz MD
Texas Children's Hospital, Houston Texas

Sports (General, Elbow & Wrist, Shoulder, Hip, Knee, Ankle)

Tibial spine fractures are a bony avulsion of the anterior cruciate ligament - ACL- from the tibial eminence Aim: Reduction of the fracture, restoring the ACL length. Our video demonstrates arthroscopic suture fixation technique with pearls, technical tricks, and tips Indications for Surgery: Displaced , comminuted or rotated fracture fragment Physical exam: Hemarthrosis , positive Lachman test Technique - Diagnostic knee arthroscopy, debridement of fracture base, removing obstructions to reduction, reducing the fracture , passing sutures through base of ACL and tying them over anterior tibia. Conclusion : Suture fixation leads to early knee range of motion can be initiated to prevent arthrofibrosis.

Video 7

Radial Neck Fractures: Metaizeau Intramedullary Technique

Philip D. Nowicki MD

Helen DeVos Children's Hospital, Grand Rapids, MI

Trauma (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

Radial neck fractures are a challenging injury to treat, with a variety of methods used for reduction. The Metaizeau intramedullary technique is a safe closed reduction method that avoids the risk of avascular necrosis, provides stable fixation to prevent re-displacement, and offers good to excellent post-operative results in the majority of radial neck fracture cases.

Video 8

Waterproof Mehta Casting for Early Onset Scoliosis

*Todd F. Ritzman MD; Jaysson T. Brooks MD; Lorena Floccari MD; Ryan Fitzgerald MD
Akron Children's Hospital, Akron, OH*

Spine (Congenital, Early Onset, Kyphosis, Scoliosis, Trauma)

Serial waterproof Mehta casting is safe and efficacious when compared to published literature of traditional Mehta casting, with the advantages of clearance for bathing, avoidance of cast holidays between casting intervals, 53% likelihood of maintaining curve correction $<25^\circ$, and 82% likelihood of avoiding surgery at 5.1 years follow-up. This video reviews the indications, casting technique, and outcomes of this procedure.

Video 9

The Metaizeau Technique For Displaced Pediatric Radial Neck Fractures

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Trauma (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

Background: Radial neck fractures are pediatric injuries that require accurate management and treatment to preserve elbow function. We outline the Metaizeau technique, a percutaneous method to treat displaced pediatric radial neck fractures. Methods: 9 year-old with displaced radial neck fracture underwent operative intervention with the Metaizeau technique. Post-operatively she was immobilized for two weeks in a long arm cast and transitioned to a hinged elbow brace. Results: Patient has full range of motion at 3 months. Conclusion: Metaizeau technique is an effective treatment option for displaced pediatric radial neck fractures. We demonstrate the key steps and considerations of the technique.

Video 10

Pediatric Trigger Finger Release

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Anatomic Disorder (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

a) This video aims to outline the surgical technique of trigger finger release, and the unique technical considerations associated with it. b) 3 year-old male with triggering of multiple digits who underwent release of his right trigger thumb A1 pulley and middle finger A1 pulley as well as an ulnar slip of FDS, left middle finger A1 pulley c) Patient saw increased range of motion, and cessation of triggering bilaterally. d) Trigger finger release can be an effective and safe treatment option for pediatric patients with trigger finger e) This video demonstrates the key steps and considerations of the technique.

Video 11**Posterior Approach to Knee and Contracture Release for Arthrogyrosis**

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Anatomic Disorder (Upper Extremity, Hip & Pelvis, Lower Extremity, Foot & Ankle)

This video discusses the case presentation of a 3-year-old patient with amyoplasia and a knee flexion contracture of 70 degrees, which carries a significant impact on ambulation capacity. The patient underwent a posterior capsulotomy, posterior PCL transection, hamstrings lengthening and gastrocnemius tenotomy. Although this procedure is associated with maximal improvements in knee extension, it does not preclude recurrence, hamstring weakness and the potential for neurovascular complications. By implanting careful surgical techniques and identifying structures at risk, the patient receives immediate symptomatic relief following release of posterior knee structures.