35th Annual Scientific Meeting

Limb Lengthening and Reconstruction Society:

ASAMI–North America

July 17 & 18, 2026

Sofitel Golden Mile

Montreal, Quebec, Canada

www.llrs.org

LLRS
Limb Lengthening and Reconstruction Society
ASAMI NORTH AMERICA

LLRS: ASAMI–North America

Future Meetings

Essentials of Lower Extremity Reconstruction (ELER)

January 22 & 23, 2027

Atlanta, GA

LLRS/POSNA Specialty Day

March 6, 2027

Las Vegas, NV

LLRS 2026 Pre–course and 36th Annual Scientific Meeting

July 22–24, 2027

The Westin Michigan Avenue

Chicago, IL

Upcoming AAOS Meeting

March 3–6, 2027

Las Vegas, NV

For more information:

Karen R. Syzdek, Executive Director

info@llrs.org

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

LLRS: ASAMI–North America
Meetings & Presidents

Year	Location	President
1990	Baltimore, MD	Dror Paley, MD
1991	Kiawah, SC	Stuart A. Green, MD
1993	San Francisco, CA	Alfred D. Grant, MD
1994	New Orleans, LA	Deborah Bell, MD
1995	Orlando, FL	Jason Calhoun, MD
1996	Atlanta, GA	Mark T. Dahl, MD
1997	San Francisco, CA	John Herzenberg, MD
1998	New Orleans, LA	James Aronson, MD
1999	Dana Point, CA	J. Charles Taylor, MD
2000	Lake Buena Vista, FL	Charles T. Price, MD
2001	Berkeley, CA	Richard S. Davidson, MD
2002	Las Colinas, TX	John J. Gugenheim, MD
2003	Boston, MA	James C. Binski, MD
2004	Toronto, Ontario, CANADA	John G. Birch, MD
2005	New York, NY	William G. Mackenzie, MD
2006	San Diego, CA	James. J. Hutson, Jr., MD
2007	Chicago, IL	David W. Lowenberg, MD
2008	Albuquerque, NM	George Cierny, III, MD
2009	Louisville, KY	Paul T. Freudigman Jr., MD
2010	New York, NY	John K. Sontich, MD
2011	Chicago, IL	Doreen DiPasquale, MD
2012	Cincinnati, OH	James J. McCarthy, MD
2013	New York, NY	S. Robert Rozbruch, MD
2014	Montreal, Quebec CANADA	Sanjeev Sabharwal, MD
2015	Miami, FL (ILLRS Congress)	Reggie C. Hamdy, MD
2016	Charleston, SC	Joseph R. Hsu, MD
2017	Park City, UT	Karl Rathjen, MD
2018	San Francisco, CA	Kevin W. Louie, MD
2019	Boston, MA	J. Spence Reid, MD
2020	Virtual	Austin T. Fragomen, MD
2021	New York, NY	Austin T. Fragomen, MD
2022	Portland, OR	Raymond W. Liu, MD
2023	Olympic Valley, CA	L. Reid Nichols, MD
2024	Hollywood, FL	Stephen M. Quinnan, MD
2025	Philadelphia, PA	Christopher A. Iobst, MD
2026	Montreal, Quebec CANADA	Mitchell Bernstein, MD

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

President and Program Chair

Mitchell Bernstein, MD, FRCSC

Associate Professor, Surgery & Pediatric Surgery (Orthopaedics), McGill University

Head, Pediatric Orthopaedic Trauma, Montreal Children's Hospital

Co–Director, Limb Deformity Unit, Shriners Hospital for Children – Canada

Adult Orthopaedic Trauma & Limb Deformity Surgery, Montreal General Hospital

1+ (514) 282–7219, mitchell.bernstein@mcgill.ca

Program Committee

Mitchell Bernstein, MD

Jill C. Flanagan, MD

David A. Podeszwa, MD

Karen R. Syzdek, Executive Director

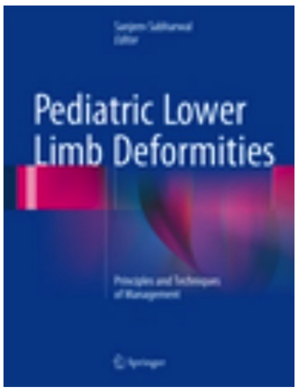
Pediatric Lower Limb Deformities

and

Limb Lengthening and Reconstruction Surgery Case Atlas Series

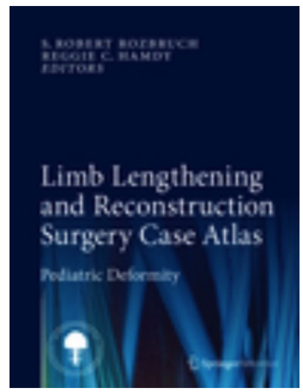
Pediatric Lower Limb Deformities

Sanjeev Sabharwal (Ed.)



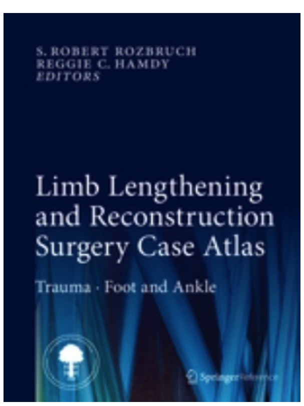
Pediatric Deformity

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



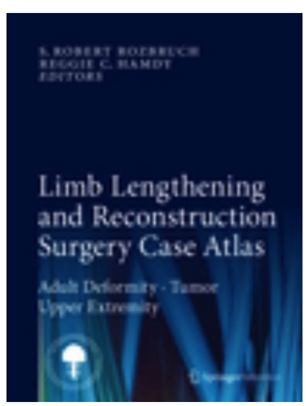
Trauma •
Foot and Ankle

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



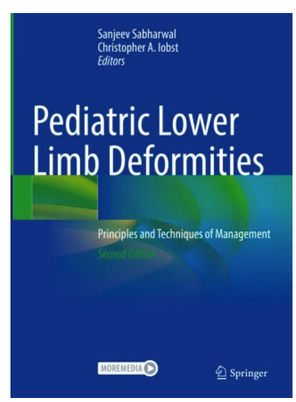
Adult Deformity •
Tumor • Upper Extremity

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



Pediatric Lower Limb
Deformities (2024)

Sanjeev Sabharwal and
Christopher A. Iobst (Eds.)



To order, go to www.springer.com • Search "limb lengthening"

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Please join us!

LLRS
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ASAMI NORTH AMERICA

36th Annual Scientific Meeting

Pre-course:

Beyond the Frame: Intramedullary Solutions for Complex Limb Reconstruction

Thursday, July 22, 2027

Scientific Meeting

Friday & Saturday, July 23 & 24, 2027

The Westin Michigan Avenue

Chicago, IL

Visit www.llrs.org for more information.

Helpful Web Sites

LLRS: ASAMI–North America

http://www.llrs.org

American Academy of Orthopaedic Surgeons (AAOS)

http://www.aaos.org

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

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Jaclyn F. Hill, MD

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

35th Annual Scientific Meeting

Objectives

Upon completion of LLRS's 35th Annual Scientific Meeting, physicians will be able to:

- apply the latest developments in the orthopedic subspecialties of limb lengthening and reconstruction;
- discuss the principles of tissue generation by distraction (distraction histogenesis); and
- understand surgical techniques of distraction histogenesis.

Selection of Content

Selection of material for presentation during the 35th Annual Scientific Meeting was based on scientific and educational merit. The selection process does not imply the treatment modality or research methodology is necessarily the best or most appropriate available.

LLRS disclaims formal endorsement of methods or research methodology used and further disclaims any and all liability for claims which may arise out of the use of techniques discussed or demonstrated whether those claims shall be asserted by a physician or another person.

Food and Drug Administration

LLRS notes that approval of the FDA or national equivalent of its lists from other countries, is required for procedures and drugs that may be considered experimental. Instrumentation and procedures presented during the Virtual Meeting may not have received the approval of the appropriate federal authority, LLRS supports the use of techniques with requisite government approval only.

Faculty Disclosure

Faculty members are required to disclose whether they have a financial arrangement or affiliation with a commercial entity related to their presentation(s). Disclosures are available at llrs.org.

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

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International Limb Differences Registry

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Baltimore Limb Deformity Course

Congenital Limb Deficiencies Deformity Course

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Exhibitors

(listed in alphabetical order)

The LLRS thanks the following entities for their generous support.

ALM Ortho combines next-generation digital design with 3D-printed titanium manufacturing to deliver optimized implants engineered for osseointegration. Every implant is purpose-built through direct surgeon collaboration, addressing the complex demands of limb lengthening & reconstruction, trauma, oncology, and revision cases where standard solutions simply do not exist.

Baltimore Limb Deformity Course – Register for an intensive course covering deformity correction planning and limb lengthening. An internationally renowned faculty will provide didactic and hands–on lab instruction. Learn about fellowship opportunities. 410–601–9798; click here for the BLDC website

Biocomposites is an international medical device company that engineers, manufactures and markets world leading products for use in infection management. Based in Keele, UK with operations around the world, Biocomposites is a leading developer of innovative calcium compounds and specialty polymer products for surgical use. Today our products are used in over 1 million procedures every year. https://www.biocomposites.com/

Bodycad, Your Partner in Precision Orthopedics

Bodycad is a medical technology company dedicated to transforming orthopedic care through personalized solutions. Our Personalized Restoration™ technology supports orthopedic surgeons in customizing deformity correction to each patient's anatomy, improving surgical planning, precision, and consistent results.

The mission of the Paley Foundation (West Palm Beach, Florida) is to educate and mentor orthopedic surgeons worldwide in the application of innovative medical techniques to assess, treat, and rehabilitate children and adults who suffer from rare and neglected bone diseases, limb deficiencies, and skeletal abnormalities. The Foundation supports four upcoming orthopedic courses:

*Advanced Rehabilitation Techniques for Limb Lengthening & Deformity Correction (September 26 – 30, 2026)
*Pediatric Foot & Ankle Deformities Course (November 2026)
*Congenital Limb Deficiencies & Deformities Live Surgery Course (January 18 – 22, 2027)
*Orthopedic Management of Rare Conditions Symposium (February 2027)

Proceeds from the sale of the textbook, CFD: Congenital Femoral Deficiency, an orthopedic surgeon's systematic guide for the diagnosis and treatment of CFD in children and young adults are committed to supporting the Paley Foundation's efforts. Please visit: www.ThePaleyFoundation.org for more information.

DePuy Synthes provides one of the most comprehensive orthopaedics portfolios in the world that helps heal and restore movement for the millions of patients we serve. DePuy Synthes solutions, in specialties including joint reconstruction, trauma, extremities, craniomaxillofacial, spinal surgery and sports medicine, in addition to the VELYS™ Enabling Tech portfolio, are designed to advance patient care while delivering clinical and economic value.

Globus Medical, Inc. is a leading musculoskeletal technology company that is relentlessly focused on solving unmet customer and patient needs to enable surgeons to promote healing in patients with musculoskeletal disorders. https://www.globusmedical.com/

Induce Biologics offers a family of bioimplants that include Natural Matrix Protein, which replicates the body's natural healing capabilities in order to create natural bone regeneration.

International Limb Differences Network is a global network of orthopedic surgeons, researchers and allied healthcare professionals with a common goal to improve the health related quality of life of patients with limb differences. https://www.limbnetwork.com/

The newly merged Orthofix–SeaSpine organization is a leading global spine and orthopedics company with a comprehensive portfolio of biologics, innovative spinal hardware, bone growth therapies, specialized orthopedic solutions and a leading surgical navigation system. Its products are distributed in approximately 68 countries worldwide. The company is headquartered in Lewisville, Texas and has primary offices in Carlsbad, CA, with a focus on spine and biologics product innovation and surgeon education, and Verona, Italy, with an emphasis on product innovation, production, and medical education for orthopedics. The combined company's global R&D, commercial and manufacturing footprint also includes facilities and offices in Irvine, CA, Toronto, Canada, Sunnyvale, CA, Wayne, PA, Olive Branch, MS, Maidenhead, UK, Munich, Germany, Paris, France and São Paulo, Brazil. To learn more, visit Orthofix.com.

Founded in 2006, OrthoPediatrics is an orthopedic company focused exclusively on advancing the field of pediatric orthopedics. As such it has developed the most comprehensive product offering to the pediatric orthopedic market to improve the lives of children with orthopedic conditions. OrthoPediatrics currently markets 46 surgical systems that serve three of the largest categories within the pediatric orthopedic market. This product offering spans trauma and deformity, scoliosis, and sports medicine/other procedures. OrthoPediatrics' global sales organization is focused exclusively on pediatric orthopedics and distributes its products in the United States and over 70 countries outside the United States. For more information, please visit www.orthopediatrics.com.

Paragon 28, a Zimmer Biomet company, works relentlessly to advance the science behind foot & ankle surgery. We are passionate about blending different surgical philosophies from various global thought leaders to develop biomechanically and clinically relevant surgical solutions, we are committed to creating complete surgeon–centric systems, specialty instruments and next generation implants designed to solve real world issues faced by foot & ankle surgeons. From subchondral lesions to ankle reconstruction, we are constantly innovating our robust product portfolio to address forefoot, midfoot and hindfoot deficiencies, designed to drive efficiency and optimize patient care. Now, as part of Zimmer Biomet, the leader in musculoskeletal care, we are aligned in their Mission to alleviate pain and improve quality of life for patients around the world.

Response Ortho is a global orthopedic trauma solutions manufacturer offering premium products created under its founding principles of innovation, excellence by design, and functional superiority.

Smith+Nephew prides itself on being a partner to the Limb Reconstruction surgeon and an innovator in circular fixation technology. We help you push the boundaries in limb restoration and allow your patients to rediscover the joy of Life Unlimited. Visit www.smith–nephew.com to learn about our products.

Stryker is one of the world's leading medical technology companies and together with our customers, we are driven to make healthcare better. The Company offers a diverse array of innovative products and services in Orthopaedics, Medical and Surgical, and Neurotechnology, which help improve patient and hospital outcomes. https://www.stryker.com/

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Meeting Evaluation

The meeting evaluation is online. Please go to the following link and complete the evaluation by **Friday, August 1, 2026**. *Your responses are needed for CME credit to be valid.*

https://www.surveymonkey.com/r/LLRS2026AM

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Continuing Medical Education

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

The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of 9.25 AMA PRA Category 1 Credits™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Please complete the evaluation online at

https://www.surveymonkey.com/r/LLRS2026AM

on or before **August 1, 2026.**

Join us next year!

36th Annual Scientific Meeting

July 22–24, 2027

The Westin Michigan Avenue

Chicago, IL


SAVE THE DATE
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DEFORMITY COURSE
August 19-23, 2026
Four Seasons Hotel
Baltimore, Maryland, USA
DeformityCourse.com
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January 22 & 23, 2027
Arthur M. Blank Hospital
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Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Agenda
Subject to change

Friday, July 17, 2026

6:30–7:15 a.m.	5K Run led by Jill C. Flanagan, MD – meet in hotel lobby
7:00 a.m.	Meeting Registration/Check–In Opens
7:15–8:00 a.m.	Continental Breakfast – Monet/Chagall **Visit Corporate Partners***
8:00–8:04 a.m.	Welcome/Introduction/Disclosure* – Picasso Ballroom *Mitchell Bernstein, MD*
8:05–8:35 a.m.	**Session I: Pediatrics Part 1** Moderator: David B. Frumberg, MD
8:05–8:11 a.m.	Complications Following Surgical Correction of Knee Flexion Contractures in Arthrogryposis – *Aaron J. Huser, DO*
8:12–8:18 a.m.	It's Not Just Knock Knees: Joint Line Obliquity and Coronal Plane Knee Subluxation are Associated with Lateral Femoral Condyle Osteochondritis Dissecans – *Christine M. Goodbody, MD*
8:19–8:25 a.m.	Crossing A New Bridge: Understanding the Abyss of Transition of Care for Teenagers and Young Adults with Osteogenesis Imperfecta *Jeanne M. Franzone, MD*
8:26–8:35 a.m.	Discussion
8:36–9:16 a.m.	**Session II: Trauma** Moderator: Geoffrey Marecek, MD
8:36–8:42 a.m.	Scatter Matters: Simulation Study to Quantify Radiation Exposure during Circular External Fixator Application – *Ryan Guilbault, MD*
8:43–8:49 a.m.	Impact of Long–Term Steroid Use on Outcomes Following Nonunion Repair *Amir Human Hoveidaei, MD, MBA*
8:50–8:56 a.m.	Impact of Bone Grafting on Outcomes in Infected and Non–Infected Nonunion Repair: A 1:1 Matched Analysis Using the PearlDiver National Database – *Amir Human Hoveidaei, MD, MBA*
8:57–9:03 a.m.	Factors Associated with "Surprise Positive" Cultures After Nonunion Surgery *Ashlyn Callan, MS*
9:04–9:16 a.m.	Discussion

**No CME awarded*

9:17–10:07 a.m.	**Session III: Pediatrics Part 2** Moderator: Jill C. Flanagan, MD
9:17–9:23 a.m.	Lessons from the Learning Curve: Hip Reconstruction for Congenital Femoral Deficiency – *David A. Podeszwa, MD*
9:24–9:30 a.m.	Patellar Instability in Fibular Hemimelia: High Prevalence with Surgical Consequences – *Elia Newman, MD*
9:31–9:37 a.m.	Ulnarization for Radial Aplasia: A Retrospective Radiographic and Clinical Analysis – *Dror Paley, MD*
9:38–9:44 a.m.	Pubic Rami Distraction Osteogenesis and Staged Innominate Rotational Osteotomies for Salvage of Failed Cloacal Exstrophy Reconstruction *David A. Podeszwa, MD*
9:45–9:51 a.m.	Rigid Intramedullary Fixation for Pediatric Tibia Fractures in Low– and Middle–Income Countries – *Kira L. Smith*
9:52–10:07 a.m.	Discussion
10:08–10:28 a.m.	Wellness Break – Monet/Chagall **Visit Corporate Partners***
10:29–11:19 a.m.	**Session IV: Limb Reconstruction Part 1** Moderator: Mani D. Kahn, MD
10:29–10:35 a.m.	How Much Acute Correction Can Be Done Safely When Performing a Distal Femoral Osteotomy in Pediatric Patients with Genu Valgum? *Christopher A. Iobst, MD*
10:36–10:42 a.m.	Is Limb Lengthening Safe in Ollier Disease? A Multicenter Retrospective Study *Halil Äbrahim Balci*
10:43–10:49 a.m.	Safety Profile of Trochanteric Entry Intramedullary Lengthening Nails in Skeletally Immature Patients – *S. Robert Rozbruch, MD*
10:50–10:56 a.m.	The Use of Circular External Fixation for Gradual Correction of Ankle and Hindfoot Contractures – *Evelyn Murphy, MD*
10:57–11:03 a.m.	Corticotomy Location Increases Biomechanical Failure Risk During Transverse Tibial Transport – *Ayana M. Shrestha*
11:04–11:19 a.m.	Discussion
11:20 a.m.–12:13 p.m.	**Session V: Patient Reported Outcomes** Moderator: Elizabeth Hubbard, MD
11:20–11:26 a.m.	Prevalence of Psychological Morbidity in a Limb Reconstruction Practice and the Impact of an Embedded Psychiatrist–Led Liaison Clinic *Asanka Wijendra, MD*

**No CME awarded*

11:27–11:33 a.m.	RECONS: An International, Multi–Stage Consensus Study Establishing a Core Outcome Domain Set for Lower–Limb Lengthening Surgery *Ali Yalcinkaya*
11:34–11:40 a.m.	The International Osteogenesis Imperfecta Registry: A Collaborative Platform to Advance Orthopaedic Outcomes Research in Osteogenesis Imperfecta *Jill C. Flanagan, MD*
11:41–11:46 a.m.	Patient–Reported Outcomes and Mobility in Young Adults Treated by Amputation for Severe Congenital Fibular Deficiency *John G. Birch, MD*
11:47–11:53 a.m.	Measuring What Matters Beyond Function: Implementing LIMB–Q Kids for Longitudinal Outcome Assessment in Patients with Lower Limb Differences *Harpreet Chhina, PhD*
11:54 a.m.–12:13 p.m.	Discussion
12:14–1:05 p.m.	Lunch – Monet/Chagall & Foyers **Visit Corporate Partners***
1:06–1:46 p.m.	**Session VI: Limb Reconstruction Part 2** Moderator: Stephen M. Quinnan, MD
1:06–1:12 p.m.	Does Patient Age Affect Outcomes of Osseointegration Limb Replacement Surgery? – *S. Robert Rozbruch, MD*
1:13–1:19 p.m.	Stoma Creation for Osseointegration Patients Based on Seventeen Years of Experience – *Prof. Munjed Al Muderis*
1:20–1:26 p.m.	Deep Learning–Based Classification of Femoral Rotational Abnormalities from Standing AP X–rays – *Tanush Soni*
1:27–1:33 p.m.	Evaluation of the LLRS Traveling Fellowship: A Survey–Based Analysis of Adult and Pediatric Fellows – *Stephen Wallace, MD*
1:34–1:46 p.m.	Discussion
1:47–2:27 p.m.	**Presidential Guest Lecture** Introduction by Mitchell Bernstein, MD The Privileges of Being a Limb Reconstruction Surgeon – To Reach What You Cannot and Be a Sparking Plug *Reggie C. Hamdy, MBBS* *Chief of Staff, Shriner Children's Hospital Canada* *McGill University Health Centre* *LLRS: ASAMI–NA President, 2014–2015*

**No CME awarded*

2:28–2:48 p.m. **Traveling Fellowship Presentation**
Introduction by Jaclyn F. Hill, MD

2025 Adult Fellows
Elizabeth Wellings, MD, PhD
Asanka Wijendra, MD

2026 Pediatric Fellows
Erin Honcharuk, MD
Daniela Alessia Marletta, MD

2:49–3:29 p.m. **Session VII: Torsion**
Moderator: S. Robert Rozbruch, MD

2:49–2:55 p.m. The Acetabulum Doesn't Matter: Relationship Between Clinical Examination and Radiographic Measurements for Planning Torsional Corrections in The Lower Extremity – *David Burns, MD, PhD*

2:56–3:02 p.m. For Rotational Guided Growth Surgery the Sagittal Plane Angle Between the Constructs is Representative of Rotational Correction
Elizabeth A. Simmons, DO

3:03–3:09 p.m. Effects of Femoral De–Rotation on Lower Limb Alignment Using Patient–Specific Guides with Reliance on EOS scan, A Retrospective Study
Prof. Munjed Al Muderis

3:10–3:16 p.m. Rotational Guided Growth: Biomechanical Analysis of Asymmetrical Construct Length, Angle, and Fixation Tensioning – *Anjelyna L Siamphone*

3:17–3:29 p.m. Discussion

3:30–3:50 p.m. Wellness Break – Monet/Chagall
Visit Corporate Partners*

3:51–4:26 p.m. **Deborah F. Stanitski Diversity Presentation**
Confidence, Imposter Syndrome, and Perfectionism in Surgery
Julie B. Samora, MD, PhD, MPH
Chair, Department of Orthopedics
Akron Children's Hospital

4:27–5:30 p.m. Business Meeting* – **LLRS Members only**

6:30–9:00 p.m. President's Reception*

**No CME awarded*

Saturday, July 18, 2026

6:30–7:15 a.m.	5K Run led by Jill C. Flanagan, MD* – meet in hotel lobby
7:15 a.m.	Meeting Registration/Check–In Opens
7:15–8:00 a.m.	Continental Breakfast – Monet/Chagall **Visit Corporate Partners***
8:00–8:05 a.m.	Welcome, Announcements* – Picasso Ballroom *Mitchell Bernstein, MD*
8:06–8:56 a.m.	**Session VIII: Limb Reconstruction Part 3** Moderator: Aaron J. Huser, DO
8:06–8:12 a.m.	Intraoperative Neuromonitoring in Setting of Peripheral Nerve Blocks for Lower Extremity Deformity Corrections *Rajiv Siddhartha Vasudevan*
8:13–8:19 a.m.	Exploring Perceptions of Body Image and Eating Behaviour in Adolescents with Lower Limb Differences – *Michaela Ironside*
8:20–8:26 a.m.	Defining Early Postoperative Weight Trends in Patients Undergoing Limb Reconstruction Surgery by Distraction Osteogenesis *Christopher A, Iobst, MD*
8:27–8:33 a.m.	An Assessment of the Pre–Operative Vitamin D Levels in Patients Undergoing Limb Lengthening Surgery – *Ali Yalcinkaya*
8:34–8:40 a.m.	The International Limb Differences Registry: A Global Collaboration to Advance Limb Reconstruction Outcomes – *Anthony Cooper, MD*
8:41–8:56 a.m.	Discussion
8:57–9:47 a.m.	**Session IX: Award Nominated Papers Part 1** Moderator: Jessica C. Rivera, MD, PhD
8:57–9:03 a.m.	Effect of Tibiofibular Screw Angle on Distal Fibular Migration in Tibial Distraction Osteogenesis: A Finite Element Analysis *İsmail Tarık Atasoy*
9:04–9:10 a.m.	Does Calcium Sulfate affect Post–Injury Local Immune Environment? *Jessica C. Rivera, MD, PhD*
9:11–9:17 a.m.	Comparative Analysis of Hindfoot Arthrodesis Using Dynamic Compression Nails Versus Static Nails – *Taylor Reif, MD*
9:18–9:24 a.m.	Comparison of Outcomes at Skeletal Maturity of Treatment for Severe Congenital Fibular Deficiency by Amputation vs. Staged Limb Reconstruction *John G. Birch, MD*

9:25–9:40 a.m.	Discussion
9:41–10:01 a.m.	Wellness Break – Monet/Chagall **Visit Corporate Partners***
10:02–10:48 a.m.	**Alessandro Codivilla and Wellness Presentation*** Introduction by Mitchell Bernstein, MD The Surgeon Health Paradox: Performance vs. Health *Harley Pasternak* *Celebrity Personal Trainer* *Commercial Gym Designer* *Bestselling Author*
10:49–11:19 a.m.	**Hall of Fame Induction*** John G. Birch, MD – Introduced by Mikhail Samchukov, MD Mark T. Dahl, MD – Introduced by Kevin Louie, MD
11:20 a.m.–12:10 p.m.	**Session X: Award Nominated Papers Part 2** Moderator: David B. Frumberg, MD
11:20–11:26 a.m.	Natural History of Leg Length Discrepancy in Posteromedial Bowing of the Tibia: A Multicenter Longitudinal Analysis – *Sarah Nossov, MD*
11:27–11:33 a.m.	Biomimetic Hematoma–Mediated mRNA Delivery Restores Structure and Function in Volumetric Muscle Loss – *Vaida Glatt, PhD*
11:34–11:40 a.m.	Lower Extremity Rotational and Coronal Plane Parameters Are Relatively Stable After Eight Years of Age Using CT Scanning in a Random Cohort – *Moiz Nasir*
11:41–11:47 a.m.	Artificial Intelligence–Assisted Lower Extremity Deformity Analysis on Long–Leg Radiographs: Validation Across Experience Levels – *Oğuzhan Günbatar*
11:48–11:54 a.m.	Implant Fracture Following Lower Limb Osseointegration: Clinical Outcomes and Material Considerations – *Prof. Munjed Al Muderis*
11:55 a.m.–12:10 p.m.	Discussion
12:11–12:53 p.m.	**Session XI: Best Practice in Limb Reconstruction Surgery: Perspective from the British Limb Reconstruction Society** Moderators: David A. Podeszwa, MD & Amir Qureshi, MBChB
12:54–1:30 p.m.	President's Remarks and Introduction of 2026–2027 President* *Mitchell Bernstein, MD* and *Jill C. Flanagan, MD*

**No CME awarded*

Session I:

Pediatrics Part 1

Moderator – David B. Frumberg, MD

Complications Following Surgical Correction of Knee Flexion Contractures in Arthrogryposis

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What was the question?
What are the rates, types, and predictors of complications and reoperations, across all follow–up periods, following femoral shortening, posterior capsular release, and peroneal nerve decompression for knee flexion contractures in patients with arthrogryposis multiplex congenita (AMC)?

How did you answer the question?
A retrospective review of all patients with arthrogryposis was performed between January 1 of 2015 and July 1 of 2025. Patients were included if they had a diagnosis of arthrogryposis and underwent our established surgical procedure for knee flexion contracture, consisting of femoral shortening, posterior capsular release, and peroneal nerve decompression. Skeletally mature patients were excluded, and no minimum follow–up time was required. Demographic, clinical, radiographic, and complication data were reviewed. The need for secondary osteotomies, revision posterior release and length equalization was also included. Two logistic regression models were created: one to analyze perioperative complications (neuritis, wound infections/dehiscence, physeal fractures, physeal bars, etc) and one to analyze the need for a second surgery to treat a recurrent contracture.

What are the results?
One hundred patients with 180 knees were included. The median age at surgery was 5.36 (3.24–9.54) years, initial contracture 58.5 (45.0–80.0) degrees and follow–up of 2.96 (0.98–4.86) years. There were a total of 100 complications with seventy–one knees (41%) experiencing at least one complication. Table 1 lists the complications and their percentages. The majority of complications (69%) were treated non–operatively. There were 22 (12.2%) knees that required a second operation for recurrence of the contracture. Interventions included: 7 distal femoral osteotomies, 14 revision posterior releases and 2 anterior guided growth procedures. Twelve patients required surgery for limb length discrepancies. Logistic regression found initial deformity ($p<0.0001$, OR 1.02/degree of deformity) to be predictive of perioperative complications. The second logistic regression model found follow–up time ($p<0.0001$, OR 1.78/year of follow–up) to be predictive of the need for a second operative to treat recurrent contracture.

What are your conclusions?
This is the first study to perform a large–scale analysis of complications associated with femoral shortening, posterior capsular release and peroneal nerve decompression in patients with knee flexion contractures and arthrogryposis. There is an increased risk of perioperative complications with greater degrees of initial flexion contracture magnitude. Need for revision surgery is associated with follow–up time. These findings provide essential information for surgeons performing this procedure and for families considering it as a treatment option.

Complication	Number of Cases	% (Cases/Total Knees)
Transient Neuritis	29	16.11%
Superficial Infection of Wound	27	15.00%
Post-op Fracture	10	5.55%
Manipulation Under Anesthesia	7	3.89%
Pressure Ulcer	6	3.33%
Physeal Bar	6	3.33%
Deep Infection of Wound	5	2.77%
Patellar Dislocation	4	2.22%
Intraop Physeal Fracture	3	1.67%
Nonunion	3	1.67%
	Total Complications: 100	

Table 1. List of complications, number of cases, and percentages.

It's Not Just Knock Knees: Joint Line Obliquity and Coronal Plane Knee Subluxation are Associated with Lateral Femoral Condyle Osteochondritis Dissecans

Christine M. Goodbody; Colby M. Freeman; Kevin Xu; Akbar N. Syed; Michael Read; Monika Thothadri; Theodore Ganley
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What was the question?
Osteochondritis dissecans (OCD) of the femoral condyle is a common condition among pediatric patients with unclear etiology. Recent evidence suggests varus and valgus alignment of pediatric knees is commonly observed with medial femoral condyle (MFC) and lateral femoral condyle (LFC) OCDs, respectively. We have clinically suspected that, in addition to genu valgum, joint line obliquity and articular alignment may be contributing factors to this pathology. Yet, the relationship between detailed limb alignment parameters, OCD development, and lesion location remains unclear. This study aims to comprehensively evaluate the association between limb and joint alignment parameters with this pathology.

How did you answer the question?
Patients <18 years old who presented to a large pediatric tertiary care institution with an OCD lesion of the femoral condyle and an orthoroentgenogram were retrospectively reviewed from 2015–2025. Patient knees with bicondylar lesions, concomitant ligamentous injuries, lesions secondary to trauma, or prior growth altering surgery were excluded. Healthy patients without an OCD lesion, lower limb alignment deformity, or leg length discrepancy were screened, and a singular knee was randomly chosen for analysis. MFC, LFC, and control patients were age–& BMI–matched in a 1:1:1 fashion using propensity score matching. Limb and joint alignment parameters were measured on orthoroentgenograms with PACS software (Table 1).

What are the results?
Among 107 eligible OCD patients and 199 controls, 96 knees were measured from three cohorts of 32 patients, with a mean age of 13.24 ± 2.09. Of these, 32 (33.3%) were female. When comparing LFC subjects to MFC and control subjects, they had a significantly more lateral MAD, indicating overall increased knee valgus alignment, and were significantly more valgus in their mLDFA, aLDFA, and mFTA. Moreover, they had increased joint line obliquity as measured by tKJLO, and fKJLO. The joint center, as measured by TFJCD, was more medially offset among LFC knees than in MFC. Medial coronal plane subluxation was greater in LFC knees than MFC or controls while lateral coronal plane subluxation in LFC knees was only greater than controls. (Table 1). The only significant difference between MFC subjects and controls was LLD.

What are your conclusions?
This study confirms the association between valgus malalignment and LFC OCD lesions, establishing that joint line obliquity and medial tibiofemoral subluxation are risk factors for this pathology. We hope these findings prompt further study into the role that joint line inclination and subluxation have on the biomechanical and shear forces about the knee which may predispose certain individuals toward developing LFC OCD lesions. This may lead to changes in practices toward assessing limb and joint alignment in all patients presenting with this pathology.

Table 1: Limb Alignment Parameters

Pairwise Comparisons-Radiographic Measurements	LFC (n=32)[1]	MFC (n=32)[1]	LFC vs MFC P-value[2]	Control (n=32)[1]	LFC vs Control P-value[2]	MFC vs Control P-value[2]
LLD (mm)	4.30 (1.65-8.30)	3.50 (2.30-4.60)	0.9637	7.55 (3.05-10.25)	0.3678	**0.03365**
Tibial Plateau Width (TPW)	73.19 ± 10.56	69.47 ± 7.17	0.2389	69.46 ± 7.82	0.2374	1.0000
MAD	10.95 (6.45-17.85)	0.0 (-5.1-5.55)	**<.0001**	-5.54 (-9.8-5.55)	**<.0001**	1.0000
mLDFA	84 (83-85)	87 (86.5-89)	**<.0001**	86 (85-88)	**0.0004**	0.1950
mLPFA	92 (90-93)	90 (88-91)	**0.0172**	91 (90-92)	0.5079	0.4953
MPTA	88 (87-89)	88 (86.5-90)	1.0000	88 (86-90)	1.0000	1.0000
LDTA	88 (86-89)	87 (86-89)	1.0000	89 (88-90.5)	0.0790	0.0670
AMA	6 (5-6)	6 (5.5-7)	0.1872	6 (6-7)	0.0912	1.0000
aMPFA	83 (81.5-84)	84 (82-85)	0.5555	82.5 (81-84.5)	1.0000	1.0000
aLDFA	78 (76.5-79.5)	81.5 (80-83)	**<.0001**	80.5 (79-82)	**0.0027**	0.4635
mFTA	-3.00 (-4.50- -2.00)	0.00 (-1.00-1.00)	**<.0001**	0.00 (-2.00-2.00)	**<.0001**	1.0000
JLCA	-1 (-2-0)	-1 (-3- -1)	0.2214	-2 (-3- -0.5)	0.2181	1.0000
tKJLO	4.09 ± 2.42	0.97 ± 2.91	**<.0001**	1.65 ± 2.86	**0.0009**	0.9264
fKJLO	5 (3-6.5)	2.5 (1-4)	**0.0038**	3 (1-5)	0.0947	0.8518
Tibial Plateau Width (TPW)	73.19 ± 10.56	69.47 ± 7.17	0.2389	69.46 ± 7.82	0.2374	1.0000
C-sub	11.85 ± 5.75	9.57 ± 7.92	0.5241	11.94 ± 6.63	1.0000	0.4729
C-sub/TPW	16.37 ± 7.80	13.98 ± 11.27	0.9355	17.38 ± 9.43	1.0000	0.4535
L-sub	-3.09 ± 2.23	-0.94 ± 1.72	**<.0001**	-1.92 ± 1.67	**0.0355**	0.1048
L-sub/TPW	-3.99 (-5.81- -2.20)	-1.23 (-3.19-0.00)	**0.0004**	-2.40 (-3.94- -1.30)	0.1699	0.1547
M-sub	8.96 ± 2.28	6.86 ± 2.89	**0.0020**	6.47 ± 2.33	**0.0002**	1.0000
M-sub/TPW	12.43 ± 3.56	10.03 ± 4.26	**0.0360**	9.47 ± 3.77	**0.0059**	1.0000
TFJCD	4.93 ± 1.87	3.27 ± 2.54	**0.0036**	4.03 ± 1.80	0.2400	0.4107
TFJCD/TPW	6.88 ± 2.87	4.77 ± 3.57	**0.0173**	5.93 ± 2.82	0.6506	0.3817

[1]mean ± SD or mean (IQ1-IQ3)
[2]Adj. Bonferroni

Abbreviations: LLD (leg length difference; + = R>L), MAD (mechanical axis deviation; + = joint line is medial of mechanical axis), mLDFA (mechanical lateral distal femoral angle), LPFA (lateral proximal femoral angle), MPTA (medial proximal tibial angle), LDTA (lateral distal tibial angle), AMA (anatomic-mechanical femur angle), JLCA (joint line congruence angle; + = joint lines intersect laterally (i.e. valgus)), aMPFA (anatomic medial proximal femoral angle), aLDFA (anatomic lateral distal femoral angle), mFTA (mechanical femorotibial angle, + = valgus), t/f-KJLO (tibial/femoral knee joint line obliquity; + = lateral inclination), TFJCD (tibio-femoral joint center distance; + = medially offset (i.e. valgus), C-sub (central- subluxation; + = medial intersection of tibial and femoral anatomic axes on the tibial plateau), M-subluxation (medial-subluxation; + = femoral condyle more medial than tibial plateau); L-subluxation (lateral-subluxation; + = femoral condyle more lateral than tibial plateau).

Crossing A New Bridge: Understanding the Abyss of Transition of Care for Teenagers and Young Adults with Osteogenesis Imperfecta

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What was the question?
Osteogenesis imperfecta (OI) is a genetic condition characterized by inadequately or improperly produced Type I collagen. It is characterized by bowing of the long bones as well as non–orthopaedic extraskeletal manifestations. OI care is best performed by a specialized multidisciplinary team most commonly seen in pediatric hospitals. Transition of care to the adult system has been recognized as a challenge and limitation of OI care. At our pediatric center we care for patients with OI through age 35 years and here seek to define 1) what orthopaedic surgical procedures are needed from age 18–35 and 2) how does the complication rate compare to the less than 18 age group?

How did you answer the question?
This single–center retrospective study included patients 18–35 with OI undergoing orthopaedic surgeries from 2018–2024 with minimum one–year follow–up. Patients were matched with an OI patient less than 18 years by bone segment and OI severity moving retrospectively, going back no further than needed. Chart review identified patient demographics and surgical data. Comparisons were evaluated by chi–square test.

What are the results?
Twenty–one patients with OI ages 18–35 (11 females, 10 males, average age 22.0, SD 3.7), OI Type I–1, III–12, IV–7, VIII–1) underwent the following 29 procedures: Realignment and rodding of the femur–7, tibia–4, humerus–11; olecranon ORIF–1, femoral neck fixation–1, removal prominent screw/part of rod–3, greater trochanteric resection–1, rod back–up–1. Seventeen of the 23 intramedullary rodding procedures were revisions. Of the 29 young adult procedures, 6 were for acute fracture, 4 for subacute fracture and 19 electively for discomfort, deformity and/or nonunion. Matches were made for 23 of the procedures for which new implants were placed (average age 13.3, SD 2.5). The young adult group demonstrated 13/23 complications (see Table) and 6/23 required re–operation versus the matches with 6/23 complications ($p<0.05$) and 2/23 reoperations ($p=0.12$). Nonunion or delayed union was observed in 7 individuals in the 18–35 group, and 1 in the matched group ($p<0.05$).

What are your conclusions?
Patients with OI in the age 18–35 category continue to require both urgent and elective orthopaedic surgeries with a higher complication rate, highlighting the need to improve transition of OI care into young adulthood and electively perform indicated OI rodding and revision procedures prior to the age of 18. This investigation sheds new light on the orthopaedic needs of OI patients approaching age 18 and in their young adult years who continue to require multidisciplinary OI surgical care with higher complication rates.

Session II:

Trauma

Moderator – Geoffrey Marecek, MD

Scatter Matters: Simulation Study to Quantify Radiation Exposure during Circular External Fixator Application

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What was the question?
Circular external fixators (CEF) are widely used in pediatric and adult limb deformity correction, fracture stabilization, and bone transport procedures. While these devices provide unparalleled versatility in multiplanar correction, their application often requires repeated fluoroscopic imaging to confirm wire, pin, and frame placement. Prolonged fluoroscopy increases radiation exposure not only to patients but also to surgical team members, particularly the operating surgeon and assistants. To date, limited data exists quantifying the radiation exposure associated with different CEF constructs, variations in team member positioning, or differences between automatic and manual c–arm settings or c–arm position. A systematic understanding of these factors is critical to optimizing workflow, reducing unnecessary radiation, and promoting occupational safety in the operating room. Thus, the aim of this study was to compare radiation exposure between various CEF constructs, simulated surgical team positions, and varied c–arm positions and settings.

How did you answer the question?
A simulation study was conducted using standardized phantom limb models instrumented with circular external fixators. One control (phantom limb alone) and four frame constructs around the phantom limb were tested: (1) single–ring threaded rod external fixator, (2) double–ring block threaded rod external fixator, (3) single–ring adjustable strut hexapod external fixator and (4) double–level adjustable strut hexapod external fixator. Each construct was positioned under a c–arm fluoroscopy unit. Fluoroscopy imaging was performed under both automatic and manual c–arm settings to compare dose rate differences. Each CEF construct was imaged using both "AP" and "Lateral" c–arm configurations. Radiation exposure was measured using dosimeters placed at multiple intraoperative team simulated locations: (a) primary surgeon, (b) assistant, (c) scrub nurse and (d) anesthesiologist (head of table). Each scenario was repeated at seven simulated anatomic heights. Each height was completed three times with average cumulative dose rates measured in millisievert per hour (mSv/h) recorded using a solid–state survey sensor dosimeter (X2 Survey Sensor, Unfors RaySafe, Sweden). Radiation exposure was then compared between scenarios using descriptive statistics and multivariable ANOVA testing with p–value significance of $p<0.05$.

What are the results?
Radiation exposure differed significantly by team member location, measurement height, imaging protocol, and projection. In multivariable analysis, role ($F=69.9$, $p<0.001$), height ($F=30.7$, $p<0.001$), imaging protocol ($F=89.9$, $p<0.001$), and projection ($F=78.1$, $p<0.001$) were all significant predictors of radiation dose. The construct main effect was not independently significant ($F=1.68$, $p=0.153$), though a significant interaction between construct and imaging protocol was observed ($F=3.61$, $p<0.001$).
The surgeon location demonstrated the highest exposure (0.151 mSv/h), followed by the assistant (0.061 mSv/h) and scrub nurse (0.015 mSv/h), representing a nearly 10–fold difference between surgeon and scrub nurse. Radiation exposure peaked at table level (0 cm: 0.173 mSv/h) and decreased progressively with increasing height to 0.047 mSv/h at 60 cm. Imaging protocol significantly influenced exposure, with "normal" 7.5 pps producing the highest dose (0.236 mSv/h) and "manual" 50 kV the lowest (0.029 mSv/h), representing an 8.1–fold difference. Posterior–anterior imaging resulted in significantly higher radiation exposure compared to both lateral detector–side and tube–side projections ($p<0.001$), with no difference between lateral orientations.

Scatter Matters: Simulation Study to Quantify Radiation Exposure during Circular External Fixator Application *continued*

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What are your conclusions?

Radiation exposure during CEF application is influenced by team member positioning, anatomic location, and c–arm settings. CEF construct, while alone does not significantly influence radiation exposure, when combined with automatic c–arm settings does significantly increase radiation dose with increasing construct complexity. Radiation exposure increases as anatomic location and position around the operating table approaches the c–arm detector. These findings underscore the importance of protective strategies, including optimized positioning, collimation, pulsed fluoroscopy, and minimizing beam–on time. Awareness of these relative risks may guide surgical teams in optimizing workflow and adopting protective measures to reduce cumulative radiation dose. These findings provide a foundation for future studies aimed at developing standardized protocols that balance accurate fixator placement with occupational safety.

Impact of Long–Term Steroid Use on Outcomes Following Nonunion Repair

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What was the question?
Does long–term steroid use affect surgical outcomes, medical complications, and healthcare utilization following surgical repair of non–infected fracture nonunion?

How did you answer the question?
A retrospective cohort study was performed using a large administrative database to identify patients undergoing repair of non–infected nonunion. Patients were stratified by long–term steroid use. Before matching, 224 patients with long–term steroid use and 12,101 patients without long–term steroid use were identified. A 1:1 matched analysis was then performed, matching for age, sex, diabetes, obesity, tobacco use, and alcohol use disorder, yielding 216 matched patients in each cohort. Outcomes were grouped into three categories: surgical outcomes, including reoperation and surgical site infection; medical complications, including pneumonia, deep vein thrombosis, pulmonary embolism, and chronic pain; and healthcare utilization, measured by postoperative emergency room visits.

What are the results?
After matching, long–term steroid use was associated with a higher rate of deep surgical site infection at 1 year compared with no steroid use (12.5% vs. 6.0%, p=0.031). Reoperation rates at 1 and 2 years were similar between groups. Long–term steroid users also had higher rates of pneumonia at 90 days and 1 year. No significant differences were observed in superficial surgical site infection, wound complications, deep vein thrombosis, pulmonary embolism, or chronic pain. In addition, long–term steroid users had higher rates of emergency room visits at 30 days (14.4% vs. 7.4%, p=0.007), 90 days (26.9% vs. 13.0%, p<0.001), and 1 year (42.1% vs. 25.9%, p=0.001).

What are your conclusions?
Long–term steroid use is associated with increased postoperative complications following surgical repair of non–infected nonunion. Compared with matched controls, chronic steroid users experienced higher rates of deep surgical site infection (12.5% vs. 6.0%, p=0.031), increased rates of pneumonia, and greater emergency room utilization at all time points through 1 year postoperatively. These findings have important clinical implications. Patients on chronic steroids should be counseled regarding their elevated risk of infection and postoperative complications. Enhanced perioperative optimization, closer postoperative surveillance, and a lower threshold for intervention may be warranted in this population. While long–term steroid use should not preclude nonunion repair, it identifies a higher–risk cohort that may benefit from tailored perioperative management strategies to improve outcomes.

Table. Demographics and comorbidities in infected nonunion patients

Variable	Pre-match			Post-match		
	Long-term Steroid use (n = 12)	**No Long steroid use (n = 580)**	***P*-value**	**Long-term Steroid use (n <11)**	**No Long-term steroid use (n <11)**	***P*-value**
Age	57.3 (13.9)	47.9 (15.4)	0.039	NA	NA	NA
Gender (F)	<11	191 (32.9%)	0.124	<11	<11	1
Diabetes	<11	208 (35.9%)	0.174	<11	<11	1
Tobacco Use	<11	407 (70.2%)	0. 571	<11	<11	1
Alcohol Use Disorder	<11	164 (28.3%)	0.951	<11	<11	1
Obesity	<11	264 (45.5%)	0.245	<11	<11	1

Table. Demographics and comorbidities in non-infected nonunion patients

Variable	Pre-match			Post-match		
	Long-term Steroid use (n = 224)	**No Long steroid use (n = 12,101)**	***P*-value**	**Long Steroid use (n = 216)**	**No Long-term steroid use (n = 216)**	***P*-value**
Age	55.5 (15.3)	49.5 (17.0)	**< 0.001**	55.7 (14.6)	55.7 (14.6)	1
Gender (F)	150 (48.9%)	6,487 (53.6%)	**< 0.001**	144 (66.7%)	144 (66.7%)	1
Diabetes	108 (29.8%)	3,750 (31%)	**< 0.001**	102 (47.2%)	102 (47.2%)	1
Tobacco Use	140 (55.2%)	6,536 (54%)	**0.014**	135 (62.5%)	135 (62.5%)	1
Alcohol Use Disorder	45(55.2%)	2,152 (17.8%)	0.421	40 (18.5%)	40 (18.5%)	1
Obesity	146 (47.0%)	5,879 (48.6%)	**< 0.001**	139 (64.4%)	139 (64.4%)	1

Table. Postoperative outcomes of nonunion repair in non-infected nonunion patients

Variable	Non-Infected			
	OR [95%CI] (No Long Steroid Use)	**Long-term Steroid use (n = 216)**	**No Long-term Steroid Use (n = 216)**	***P*-value**
Reoperation, 1-year	1.67 [0.68, 4.10]	<11	13 (6.0%)	0.371
Reoperation, 2-year	1.17 [0.54, 2.51]	13 (6.0%)	15 (6.9%)	0.845
Superficial SSI, 30-day	NA	<11	0	0.479
Superficial SSI, 90-day	0.50 [0.09, 2.73]	<11	<11	0.681
Deep SSI, 90-day	0.48 [0.20, 1.15]	16 (7.4%)	<11	0.142
Deep SSI, 1-year	**0.45 [0.22, 0.89]**	**27 (12.5%)**	**13 (6.0%)**	**0.031**
Chronic Pain, 30-day	NA	0	<11	1
Chronic Pain, 90-day	NA	0	<11	1
Chronic Pain, 1-year	3.03 [0.31, 29.34]	<11	<11	0.615
Wound Issues, 30-day	1.00 [0.25, 4.05]	<11	<11	1
Wound Issues, 90-day	0.59 [0.21, 1.65]	<11	<11	0.445
Wound Issues, 1-year	0.58 [0.25, 1.36]	15 (6.9%)	<11	0.294

DVT, 30-day	0.50 [0.09, 2.73]	<11	<11	0.681
DVT, 90-day	0.75 [0.17, 3.38]	<11	<11	1
DVT, 1-year	1.00 [0.29, 3.51]	<11	<11	1
PE, 30-day	NA	<11	0	1
PE, 90-day	NA	<11	0	1
PE, 1-year	NA	<11	0	1
Pneumonia, 30-day	0.28 [0.06, 1.36]	<11	<11	0.178
Pneumonia, 90-day	**1.19 [0.82, 1.71]**	**16 (7.4%)**	**<11**	**0.002**
Pneumonia, 1-year	**0.17 [0.06, 0.44]**	**27 (12.5%)**	**<11**	**<0.001**
ER Visit, 30-day	**0.38 [0.19, 0.75]**	**31 (14.4%)**	**13 (7.4%)**	**0.007**
ER Visit, 90-day	**0.41 [0.25, 0.67]**	**58 (26.9%)**	**28 (13.0%)**	**<0.001**
ER Visit, 1-year	**0.48 [0.32, 0.72]**	**91 (42.1%)**	**56 (25.9%)**	**0.001**

Impact of Bone Grafting on Outcomes in Infected and Non–Infected Nonunion Repair: A 1:1 Matched Analysis Using the PearlDiver National Database

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What was the question?
Does bone grafting affect postoperative outcomes in patients undergoing repair of infected and non–infected nonunion?

How did you answer the question?
We performed a retrospective cohort study using the 2016 to 2022 PearlDiver national database to identify patients undergoing nonunion repair with and without bone grafting. Patients were stratified into infected and non–infected cohorts. A 1:1 matched analysis was performed to balance baseline demographics and comorbidities between groups. Postoperative outcomes including reoperation, surgical site infection, wound complications, thromboembolic events, and emergency room utilization were assessed at multiple time points.

What are the results?
Among infected nonunion patients, 313 graft patients and 288 no–graft patients were identified, with 59 matched patients in each group. Bone grafting was not associated with significant differences in reoperation or most postoperative complications. However, emergency room visits at 30 and 90 days were significantly higher in the no–graft group.
Among non–infected nonunion patients, 5,265 graft patients and 7,092 no–graft patients were identified, with 4,202 matched patients in each group. In the matched analysis, the graft group had higher rates of reoperation at 1 year (9.4% vs 2.4%, $p < 0.001$) and 2 years (11.8% vs 2.7%, $p < 0.001$), higher rates of deep surgical site infection at 90 days (6.4% vs 5.6%, $p = 0.007$) and 1 year (11.5% vs 8.2%, $p < 0.001$), higher wound complication rates at 1 year (5.5% vs 4.4%, $p = 0.031$), and higher emergency room visit rates at 30 days (8.3% vs 7.0%, $p = 0.036$).

What are your conclusions?
This national database study demonstrates that in non–infected nonunions, patients receiving bone grafting had higher reoperation and complication rates, likely reflecting greater case complexity rather than graft–related harm. In infected nonunions, bone grafting showed comparable outcomes to non–grafted repairs. The clinical take–home message is that bone grafting outcomes in real–world practice are heavily influenced by patient selection, with grafting reserved for more challenging cases. These findings emphasize the limitations of administrative databases in evaluating surgical interventions where unmeasured clinical factors, such as nonunion type, defect size, and bone quality, drive both treatment selection and outcomes. Prospective studies with detailed clinical characterization are needed to identify which specific nonunion characteristics benefit most from bone grafting.

Factors Associated with "Surprise Positive" Cultures After Nonunion Surgery

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What was the question?
The purpose of this study is to evaluate potential risk factors associated with "surprise positive" intraoperative cultures during definitive surgery for nonunion to better identify and treat patients at risk for infection despite the absence of classic clinical and laboratory evidence.

How did you answer the question?
We conducted a retrospective analysis of all patients –18 years old who underwent surgical correction of nonunion at an urban, academic health system between November 2015 and June 2024. Patients were included if they had no prior fracture–related infection, no clinical or laboratory evidence of infection (e.g., draining sinus tract or markedly elevated inflammatory markers), no preoperative bone biopsy, and underwent intraoperative culture collection at the time of nonunion surgery. Patient–related variables considered included sex, age, Body Mass Index (BMI), and comorbidities such as hypertension (HTN), diabetes (DM), peripheral artery disease (PAD), chronic kidney disease (CKD), and smoking history. Inflammatory markers, including white blood count (WBC), erythrocyte sedimentation rate (ESR), and C–reactive protein (CRP), and fracture type (open vs. closed) were also collected and evaluated. Categorical variables were evaluated using Chi–square and Fisher–exact tests as appropriate, and non–parametric variables were evaluated using Mann–Whitney U–tests.

What are the results?
We identified 54 patients undergoing surgery for nonunion who were not presumed to have infection preoperatively but had intraoperative cultures obtained. Of these patients, 15 (38%) had a "surprise positive" culture result. Of the variables evaluated, male sex ($p = <0.001$), younger age ($p = 0.005$), and obesity ($p = 0.049$) were associated with a "surprise positive" culture result. Comorbidities, such as HTN, DM, PAD, CKD, and smoking, were not associated with surprise culture positivity. Likewise, inflammatory markers and fracture type were not associated with surprise culture positivity.

What are your conclusions?
Among patients without clinical or laboratory signs of infection, male sex, younger age, and obesity are associated with "surprise positive" intraoperative culture results after nonunion surgery. Infection should remain a consideration in patients who fall into these categories and are undergoing nonunion surgery despite a lack of clinical suspicion for infection. Further evaluation of pre– and peri–operative factors associated with surprise infection severity can help identify patient groups who may be at higher risk for more severe infection.

Session III:

Pediatrics Part 2

Moderator – Jill C. Flanagan, MD

Lessons from the Learning Curve: Hip Reconstruction for Congenital Femoral Deficiency

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What was the question?
The varying and complex proximal femoral deformities associated with congenital femoral deficiency (CFD) have been eloquently described and algorithms for treatment have been proposed. However, there is a paucity of literature reporting the outcomes of hip reconstruction The purpose of this study was to analyze the radiographic outcomes of an initial, consecutive series of hip reconstructions for CFD by a single surgeon.

How did you answer the question?
A clinical, surgical, and radiographic review was completed for all patients undergoing hip reconstruction for CFD between December 2018 and March 2025. CFD was classified on the immediate pre–operative radiograph based on the Paley classification. Neck–shaft angle (NSA) and acetabular index (AI) were measured on pre–op, immediate post–op and final follow–up (FFU) radiographs. The surgical procedure followed the SUPER hip technique described by Paley, including IT band release, hip flexor/psoas lengthening, abductor slide, piriformis release, proximal femoral valgus producing derotation osteotomy (goal to restore 130° NSA) with BMP–2 at the osteotomy site, and acetabuloplasty.

What are the results?
Sixteen patients (19 hips, 11 males), average age 5+11 years (range 3+8 to 11+3) at surgery, were followed for an average 34 months (range 17–73 months). There were 9 Paley 1A3, 1 1B1, 4 1B2, 2 1B3, 1 2A, 1 2C, and 1 3A. NSA averaged 90° (range 66°–116°) preoperatively, 129° (105°–150°) immediately postoperatively, and 124° (90°–150°) at FFU. A 130° NSA was achieved immediately post–operatively in 12/17 hips (71%). Those without a 130° NSA immediately post–operatively tended to be younger (average age 61 months vs. 80 months) at initial surgery. Paley classification did not seem to affect ability to achieve 130° NSA. 6/17 hips (35%) had a decreased NSA ‰¥ 5° at FFU, with an average age 66 months at initial surgery (vs. avg age 81 months in those with no decrease). Paley classification did not seem to affect ability to maintain a130° NSA. AI averaged 31° (9°–57°) preoperatively, 17° (2°–32°) immediately postoperatively, and 15° (7°–24°) at FFU. There were 4 complications in 3 patients, including a hip dislocation, non–union (2), and a delayed infection.

What are your conclusions?
Hip reconstruction for CFD achieves acceptable radiographic results, but reconstruction at a younger age may affect the ability to achieve and maintain deformity correction. Paley classification did not seem to affect the ability to achieve and maintain a 130° NSA. Surgeons should counsel families regarding the potential need for additional procedures related to recurrence of deformity and/or non–union.

Patellar Instability in Fibular Hemimelia: High Prevalence with Surgical Consequences

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What was the question?
Patients with fibular hemimelia (FH) commonly exhibit anatomical features associated with an increased risk of patellar instability, including genu valgum and lateral femoral condyle hypoplasia. However, the existing literature on knee instability in FH has largely focused on femorotibial instability, particularly anterior cruciate ligament deficiency, with limited attention to the patellofemoral joint. Accordingly, the primary aim of this study was to determine the prevalence of clinically diagnosed patellar instability (PI) in a cohort of patients with FH. Secondary objectives included characterizing the clinical features of patients with PI, identifying potential risk factors, describing nonoperative and operative management strategies, and evaluating clinical outcomes, including recurrent instability and return to activity.

How did you answer the question?
Following institutional IRB approval, we performed a retrospective cohort study of patients with a confirmed diagnosis of fibular hemimelia treated at our institution between 2000 and 2023. A total of 55 patients (62 affected limbs) met inclusion criteria. Patients with insufficient clinical or radiographic data were excluded. Collected variables included demographic characteristics, laterality, deformity severity based on the Achterman–Kalamchi and Paley classifications, presence of associated femoral deficiency, femorotibial instability, and detailed surgical history including prior amputations, deformity correction, and limb lengthening procedures. The primary outcome was patellar instability (PI), defined as documented patellar dislocation. In patients who developed PI, additional radiographic parameters including mechanical alignment and trochlear morphology were evaluated. Among patients with PI, treatment strategies including nonoperative and surgical management, clinical outcomes, recurrence of instability, and return to activity were assessed. Associations between clinical and radiographic variables and the development of PI were analyzed using Fisher's exact test, with statistical significance set at $p < 0.05$.

What are the results?
Fifty–five patients (62 limbs) were included, with an age range of 5 to 24 years at last follow–up. Thirty–eight patients (70.9%) were male. The overall prevalence of patellar instability (PI) was 17.7% (11 limbs), with a mean age of 13.0 ± 2.9 years at diagnosis. Among the 11 limbs with PI, 10 experienced initial dislocation at age 11 or later; a single case occurred at 6 years of age. Among patients aged ≥11 years at the time of analysis, the prevalence of PI was 29%, with a mean age at diagnosis of 15.6 ± 3.3 years. No significant associations were identified between PI and demographic factors, including sex and race ($p \geq 0.05$). Clinical characteristics, including laterality, Achterman–Kalamchi classification, Paley classification, and the presence of associated femoral deficiency, were not significantly associated with PI ($p \geq 0.05$). Similarly, clinical evidence of femorotibial instability, defined as cruciate deficiency on drawer testing, was not associated with the development of PI ($p \geq 0.05$). Regarding surgical history, 19.4% of limbs had undergone limb lengthening, 37.1% had prior amputation (most commonly Syme amputation), 25.8% had undergone acute deformity correction, and 48.4% had undergone growth guidance procedures; however, none of these factors were associated with PI. Among the 11 limbs with patellar instability (PI), valgus alignment was present in 63.6%. Mechanical alignment was distributed as follows: valgus zone 1 in 36.4% of limbs, valgus zone 2 in 27.3%, valgus zone 3 in 9.1%, and neutral alignment in 27.3%. Trochlear dysplasia was identified in 80% of limbs with adequate imaging. One limb, belonging to the youngest patient (6 years old), was excluded from analysis due to skeletal immaturity, as incomplete ossification of the knee precluded reliable assessment of trochlear morphology. Of the 11 limbs with PI, 6 (54.5%) underwent surgical stabilization. Among these, the most commonly performed procedures

Patellar Instability in Fibular Hemimelia: High Prevalence with Surgical Consequences
continued

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What are the results? continued
were medial patellofemoral ligament (MPFL) or medial quadriceps tendon femoral ligament (MQTFL) reconstructions combined with lateral release, accounting for 66.7% of cases. One patient underwent quadriceps lengthening with medial imbrication, and the youngest patient underwent patellar tendon transfer with medial plication. Within the surgical group, 83.3% of limbs experienced no further instability, while one limb sustained a recurrent dislocation. No postoperative complications were observed. Return–to–activity data were available for three patients, all of whom returned to sports or exceeded their preoperative activity level; data were unavailable for the remaining three. Five of the 11 limbs were managed nonoperatively with physical therapy and bracing, and 60% (3/5) experienced recurrent instability.

What are your conclusions?
Patellar instability is a relatively common yet underrecognized condition in patients with fibular hemimelia, affecting nearly one in five affected limbs in this cohort and approximately one in three patients over the age of 11. Trochlear dysplasia and genu valgum were frequently observed among patients who developed patellar instability, suggesting these may be important contributing factors. In patients with symptomatic instability, surgical stabilization demonstrated favorable outcomes, with 83.3% (5/6) of limbs experiencing no recurrent instability and no postoperative complications. In contrast, nonoperative management resulted in higher rates of recurrence, with 60% (3/5) of limbs experiencing recurrent instability. These findings highlight the importance of routine evaluation of the patellofemoral joint in patients with fibular hemimelia, particularly in older children and adolescents, to enable early diagnosis and guide appropriate management aimed at improving functional outcomes.

Ulnarization for Radial Aplasia: A Retrospective Radiographic and Clinical Analysis

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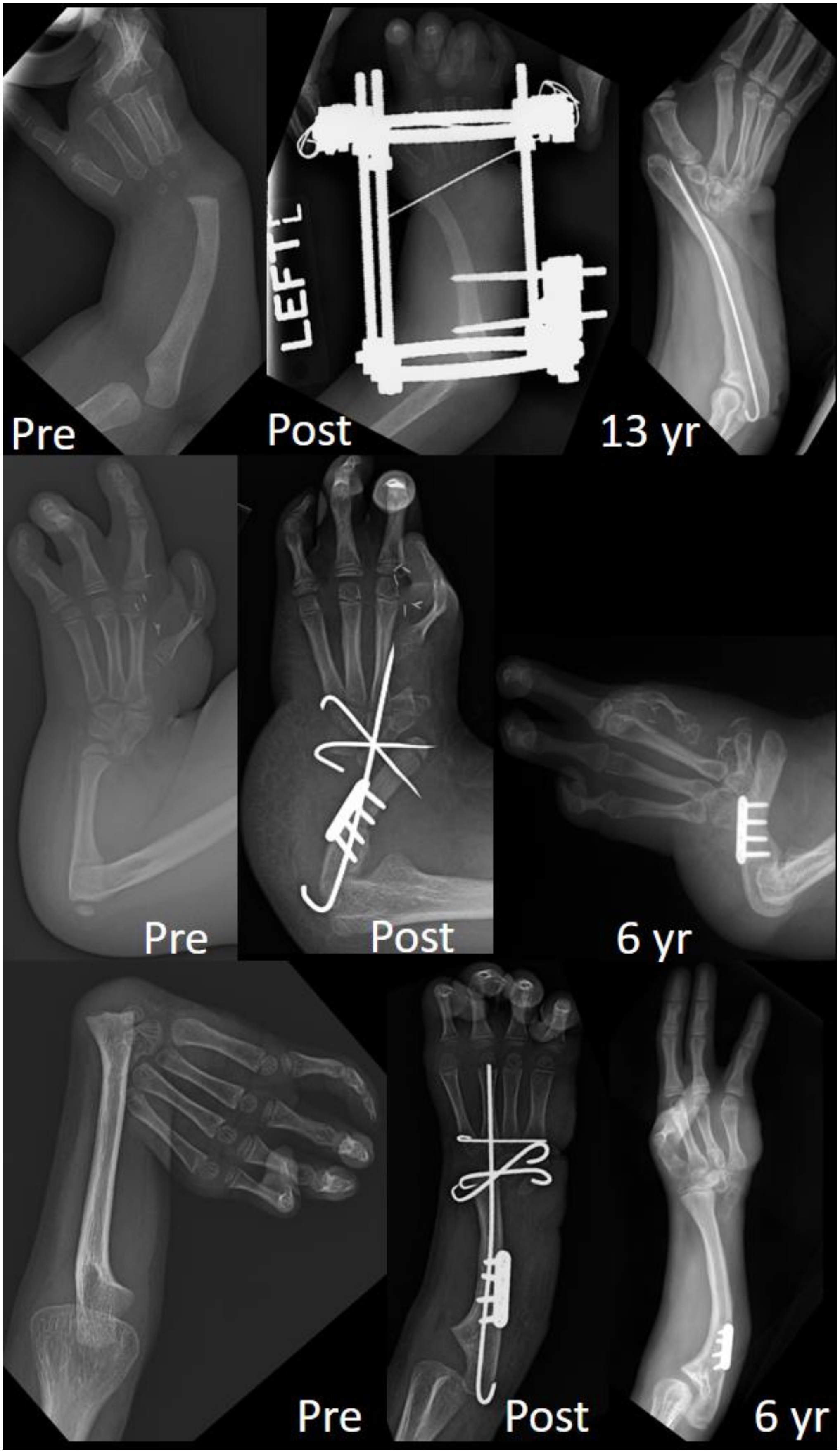
What was the question?
Ulnarization has been established as a reliable approach to treat radial aplasia. Over 2 decades, treatment have evolved from using external fixator (generation 1), to acute shortening of the ulnar diaphysis with internal fixation (generation 2), until involving the release of scapholunate ligament and hinging the scaphoid, if any, distally to create space for the ulnar head – similar to centralization (generation 3). We hypothesized that the latest method would yield better outcomes to previous treatment, both clinically and radiographically

How did you answer the question?
We reviewed patients with radial aplasia at a tertiary pediatric facility over a 15–year period. All surgeries was performed by the same team. Standard radiographic deformity markers, total amount of lengthening and complication rate, as well as demographic data were collected. Fisher–Freeman–Halton tests were used to evaluate categorical data. Kolmogorov–Smirnov tests were used to evaluate normal distribution. Paired t–tests were used to compare preoperative and latest follow–up values, while analysis of variance assessed differences across groups.

What are the results?
Out of 80 limbs, 40 (25 patients) met the inclusion and exclusion criteria with minimum follow up of 2 years. Twelve patients had thrombocytopenia–absent radius (TAR) syndrome, 7 had associated VACTERL, and 1 had Holt Oram syndrome. On average, patients had their ulnarizations at 3.3 ± 2.2 years old. With average follow up of 5.9 years, there was no statistically significant association between treatment type and complication rate (p=0.773), although a trend toward lower complications in the latest method (generation 3) was observed. 24 limbs (60%) underwent subsequent lengthening surgery, with average distraction achieved of 43±15 mm. No patients had deformity recurrence, growth arrest, or necrosis of the ulnar epiphysis at their latest follow up. In average, the hand–to–forearm angle improved from 73±25° of radial deviation to 28±20° of ulnar deviation (p<0.001) without significant differences at the latest follow up across the 3 methods (p=0.270). Functional ulnar length improved from an average of 72±20 mm to 121±45 mm at their latest follow up (p<0.001), with generation 1 showing larger values compared to newer methods (p= 0.0002, Î·^{2} = 0.38).

What are your conclusions?
Ulnarizations demonstrate comparable mid–term outcomes across all methods. Although did not reach statistical significance, there is a trend toward lower complications in the latest method of ulnarization, which mostly are prominent bump or pin site infection. Satisfactory functional outcomes are achievable, but it is difficult to reliably compare across patients given the clinical complexity and wide range of associated anomalies in radial aplasia, such as absent carpus, deficient musculature, vestigial humerus, or absence of the thumb. Majority of patients required subsequent lengthening procedure as ulnarization is often part of a staged reconstructive approach rather than a definitive single intervention. Most importantly, there were no cases of deformity recurrence, growth arrest, or ulnar epiphyseal necrosis, supporting the long–term reliability of ulnarization.



	Gen 1	Gen 2	Gen 3
Complication (+)	4	6	8
Complication (-)	4	7	13
	50.0%	46.2%	38.1%

Pubic Rami Distraction Osteogenesis and Staged Innominate Rotational Osteotomies for Salvage of Failed Cloacal Exstrophy Reconstruction

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What was the question?
Cloacal exstrophy is the most severe presentation of exstrophy–epispadias complex that presents at birth and is associated with a variety of severe pelvic deformities and abdominal anomalies, including an omphalocele, severe pubic diastasis and absence of the abdominal wall. Anterior and posterior pelvic osteotomies followed by staged primary closure have increased the primary closure rates, but do not address the underlying pelvic deformity. Unfortunately, failure of primary closure results in complex pelvic deformity that requires correction to close the abdominal wall and support urologic reconstruction. The purpose of this study was to describe our unique treatment protocol for pelvic deformity correction and review the clinical and radiographic results of 3 patients treated with this protocol.

How did you answer the question?
We retrospectively analyzed 3 patients with cloacal exstrophy and failed primary reconstruction treated with a novel 2–stage pelvic salvage protocol intended to facilitate abdominal wall closure while preserving pelvic cavity volume for bladder reconstruction, abdominal wall closure, and urogenital reconstruction. Stage 1 consisted of pubic rami and ischial osteotomies followed by gradual distraction osteogenesis using custom external fixation constructs spanning the supra–acetabular ilium to the pubis bilaterally to lengthen and approximate the anterior pelvis. Stage 2 consisted of supra–acetabular innominate osteotomies with rotational correction of both hemipelves to bring the lengthened pubic rami into apposition without compromising pelvic volume. The urology team subsequently reconstructed the bladder and closed the abdominal wall using the reconstructed pubis as an anchor. Clinical and radiographic outcomes were reviewed.

What are the results?
Patient 1: 4+11–year female, 7 cm preoperative diastasis, 2 cm bilateral pubic rami lengthening, 14 weeks in external fixator. Now with 3–year follow–up. Complicated by wound revision 2 weeks post op and an ischial pressure wound secondary to the lengthening, delaying second stage. Pelvis rotational osteotomies and abdominal closure performed 6 months later with second external fixator in place for 6 weeks. Abdominal closure successful but has developed a fistula and lost the Monti channel with impending urologic plans for fistula repair and creation of a CIC channel. Recently, at almost 3 years post–op, she underwent bilateral femoral derotational osteotomies for correction of femoral retroversion.

Patient 2: 5+7–year male, 7.5 cm pre–operative diastasis: 2.5 cm bilateral pubic rami lengthening with pelvic external fixator. 3 months after index procedure, he underwent pelvic rotational osteotomies and revision of external fixator 4 days prior to bladder closure abdominal wall repair. External fixator removed 6 weeks later at time of cystoscopy. No post–operative complications, in the context of a highly functioning, well–resourced family. Working clean intermittent catharerization (CIC) channel at 18 months follow–up.

Patient 3: 10+7 year male , 7 cm preoperative diastasis: 2 cm bilateral pubic rami lengthening complicated by premature consolidation and need for revision rami osteotomies. 3 months after index procedure, he underwent pelvic derotational osteotomies 4 days prior bladder closure abdominal wall repair. Postoperative care complicated by sciatic neuropraxia and an ileus requiring TPN. External fixator removed 6 weeks after derotational osteotomies. He had an extended (~6–month) inpatient stay for psychosocial reasons. Currently, at 1 year follow–up, doing well with a working CIC channel, ongoing PT, AFO use, and participation in summer camp.

Pubic Rami Distraction Osteogenesis and Staged Innominate Rotational Osteotomies for Salvage of Failed Cloacal Exstrophy Reconstruction *continued*

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What are your conclusions?
Pubic rami distraction osteogenesis combined with staged rotational innominate osteotomies aided the abdominal wall closure in a small cohort of severely involved cloacal exstrophy patients who previously failed classic reconstruction techniques. The pubic rami lengthening, when combined with rotational osteotomies, allows closure of the pubic symphysis, facilitates closure of the pubic symphysis, allows closure of the abdominal wall, and reestablishes a foundation for urologic reconstruction. This is a complex process that requires close collaboration with the urologic service and a dedicated multidisciplinary team to address pre–, peri–, and post–operative clinical, surgical, and psychological challenges and complications.

Rigid Intramedullary Fixation for Pediatric Tibia Fractures in Low– and Middle–Income Countries

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What was the question?
Pediatric tibial shaft fractures are one of the most common long bone fractures in children. Although a majority of these fractures can be managed conservatively, operative options include external fixation, plate osteosynthesis, and intramedullary nails (IMN). We sought to evaluate the rate of union and painless weight–bearing after rigid IMN fixation of pediatric tibial shaft fractures in patients with open proximal tibial physes.

How did you answer the question?
We queried the SIGN (Surgical Implant Generation Network) Fracture Care International online database to identify patients with tibial shaft fractures treated by rigid intramedullary nailing in the setting of an open proximal tibial physis. Patients without a minimum of 6–months follow–up were excluded. We evaluated the most recent follow–up radiograph to determine a modified Radiographic Union Scale in Tibial fractures (mRUST) score. A mRUST score of >11 was associated with radiographic union. Furthermore, the posterior proximal tibial angle (PPTA) was measured on preoperative and postoperative radiographs. We also recorded the percentage of patients that achieved painless full–weight bearing as determined by the treating surgeon.

What are the results?
There were 66 patients with pediatric tibial fractures, including 47 males (71%) and 19 females (29%) from X countries. The average age at the time of surgery was 11.2 +/– 2.7 years (range, 2 to 15 years). The average duration of follow–up was 1.6 years (range, 6 months to 9.7 years). Road traffic accident was the most common mechanism of injury affecting 32 patients (48%). There were 12 patients (18%) with open fractures. All patients were treated with reamed intramedullary nailing. At final follow–up, 61 patients (92%) had a mRUST score of >11 and 64 patients (97%) had painless full–weight bearing. The average preoperative and postoperative PPTA was 74.1 +/– 4.8 degrees and 79.6 +/– 2.9 degrees, respectively ($p<0.001$). Review of radiographs by the senior author did not demonstrate any partial growth arrest. There were five patients (8%) with non–union at final follow–up and two patients (3%) that developed an infection postoperatively.

What are your conclusions?
Pediatric tibial shaft fractures treated with rigid IMN fixation achieve high rates of radiographic union and painless weight–bearing with a relatively low complication profile, making it a viable option in resource–limited environments. The potential risk of growth arrest warrants careful patient selection and long–term monitoring.

Session IV:

Limb Reconstruction Part 1

Moderator – Mani D. Kahn, MD

How Much Acute Correction Can Be Done Safely When Performing a Distal Femoral Osteotomy in Pediatric Patients with Genu Valgum?

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What was the question?
Correction of distal femoral valgus deformity in adolescents is a common procedure for pediatric orthopedic surgeons. However, there is no consensus regarding how much acute correction can be performed safely without causing a potential neurovascular stretch injury during the angular correction. Consequently, the purpose of this multicenter study was to retrospectively review the range of correction magnitude obtained in patients undergoing acute correction of distal femoral valgus deformity and determine if there were any associated neurovascular complications. The goal would be to identify a safe zone for acute corrections when performing a distal femoral osteotomy for pediatric genu valgum.

How did you answer the question?
After institutional review board approval, we retrospectively reviewed pediatric patients who underwent distal femoral osteotomy with acute correction of genu valgum between January 1, 2016 and June 30, 2024, with ≥1–year follow–up at two large limb reconstruction centers. Femoral genu valgum was defined as a mechanical lateral distal femoral angle (mLDFA) less than 85°. Patients over 18 years or with mLDFA greater than or equal to 85° were excluded. Demographics, deformity characteristics, operative details, and follow–up data including any and all complications were collected. Pre– and postoperative mLDFA were measured on calibrated standing radiographs to quantify correction magnitude. All cases used a modified reverse–planning technique to determine osteotomy level and achieve acute realignment, followed by internal fixation. Pre– and postoperative mLDFA were compared using the Wilcoxon signed–rank test ($p<0.05$).

What are the results?
Twenty–eight patients (32 limbs; 18 female, 10 male) met inclusion criteria. Mean age at surgery was 14.9 ± 1.9 years. Mean mLDFA improved from 79.8 ± 4.0° to 89.6 ± 3.7° (mean change ‰ˆ10°; range 1.8€“18.5°; $p<0.0001$). Fixation included retrograde trauma nails (26 limbs), fixator–assisted plate–and–screw constructs (4 limbs), and retrograde lengthening nails (2 limbs). Patients progressed to full weight–bearing at a mean of 7 weeks. The mean follow–up was 16 months. No postoperative neurovascular complications were observed in any of the acute corrections.

What are your conclusions?
Acute distal femoral osteotomy and internal fixation in pediatric genu valgum was achieved without neurovascular complications in all 32 limbs. Based on the results of this series, it appears that corrections of 10 to 15 degrees can be performed safely and potentially as much as 18.5 degrees can be tolerated by the limb. Therefore, we suggest that a magnitude of correction safe zone from 0–15 degrees should be tolerated when planning valgus distal femur corrections if meticulous planning and stable fixation are used. Larger, multi–surgeon cohorts are needed to refine an evidence–based upper threshold and identify factors associated with risk at higher correction magnitudes.

Is Limb Lengthening Safe in Ollier Disease? A Multicenter Retrospective Study

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What was the question?
Ollier disease carries malignant potential, which makes surgeons hesitant to lengthen affected bone. We asked whether distraction osteogenesis in Ollier disease is associated with malignant transformation, prolonged fixation time, or excess complications.

How did you answer the question?
We performed a retrospective multicenter review of 16 patients with Ollier disease treated with limb lengthening at four centers. Clinical follow–up and serial radiographs were reviewed for pain, lesion enlargement, cortical destruction, periosteal reaction, or other signs suspicious for malignant transformation. We recorded the segment treated, construct type, length gained, fixation time, bone healing index (BHI), external fixation index (EFI), complications, limb–length discrepancy (LLD) correction, and ASAMI outcome.

What are the results?
Sixteen patients (11 female, 5 male) were included. Median follow–up was 83.4 months (range, 45–242). Femoral and tibial lengthenings were nearly balanced, with slight femoral predominance. The tibia was usually treated with circular external fixation, whereas the femur was treated mainly with a monolateral rail system and, in selected adults, a magnetically controlled intramedullary lengthening nail. Mean length gained was 9.0 cm, and mean absolute LLD improved from 9.6 cm to less than 1 cm at final follow–up. Median BHI and EFI were 26.3 and 25.3 days/cm, respectively. ASAMI outcome was excellent or good in 15 of 16 patients (94%). No patient developed clinical or radiographic findings suspicious for malignant transformation, and there was no excess pin–tract infection or other complications.

What are your conclusions?
Limb lengthening in Ollier disease was safe and effective in this multicenter series. No oncologic signal emerged, correction was substantial, and healing indices compared favorably with conventional external–fixator limb–lengthening series in the general population, suggesting shorter fixation times without increased complications.

Table 1: Summary of key findings.

Measure	Finding
Cohort	16 patients from 4 centers; 11 female and 5 male; median follow-up 83.4 months (range, 45–242)
Segments and constructs	Femoral and tibial lengthenings were nearly balanced, with slight femoral predominance. Tibial lengthening was usually performed with a circular external fixator; femoral lengthening was performed mainly with a monolateral rail system, with occasional use of a magnetically controlled intramedullary lengthening nail
Correction	Mean length gained was 9.0 cm; mean limb-length discrepancy improved from 9.6 cm preoperatively to less than 1 cm at final follow-up
Healing	Median bone healing index was 26.3 days/cm; median external fixation index was 25.3 days/cm
Outcome	ASAMI outcome was excellent or good in 15 of 16 patients (94%); malignant transformation was observed in 0 of 16 patients; no excess pin-tract infection or other complications were observed

ASAMI, Association for the Study and Application of the Methods of Ilizarov.

Safety Profile of Trochanteric Entry Intramedullary Lengthening Nails in Skeletally Immature Patients

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What was the question?
There are historical concerns with trochanteric entry intramedullary femoral nailing in skeletally immature patients due to possible osteonecrosis and growth disturbance of the proximal femur, including coxa valga. While more contemporary studies suggest improved safety with modern nail designs, data specific to femoral lengthening nails in patients with substantial growth remaining are limited. The purpose of this study was to evaluate the safety profile and proximal femoral morphology following trochanteric entry intramedullary lengthening in skeletally immature patients.

How did you answer the question?
A retrospective institutional review board–approved case series was performed of skeletally immature patients who underwent antegrade femoral lengthening with a nail between 2017 and 2024. Inclusion criteria required >2 years of growth remaining at surgery and a minimum of 1 year of radiographic follow–up. Radiographic parameters – including neck–shaft angle (NSA), mechanical lateral proximal femoral angle (mLPFA), and articulotrochanteric distance (ATD) – were measured pre–operatively and at latest follow–up. Clinically meaningful coxa valga was defined as a ≥2 standard deviation increase in NSA from baseline. Linear regression analyses were performed to assess the effect of time remaining until skeletal maturity on proximal femoral morphology.

What are the results?
Twenty–four femoral lengthenings in 22 patients (mean age 12.2 ± 2.3 years) were included with a mean radiographic follow–up of 23.4 ± 18.8 months. The mean age at nail insertion was 12.2 ± 2.3 years and mean lengthening was 46.4 ± 19.5 mm. There were no cases of infection, implant failure, or osteonecrosis. For the series, no significant differences were observed between pre– and postoperative NSA (p=0.068), mLPFA (p=0.615), or ATD (p=0.132). One patient (4.2%), treated at age 8.6 years, developed progressive coxa valga at long–term follow–up. Linear regression analysis demonstrated that greater time remaining until skeletal maturity was significantly associated with valgus–directed post–operative changes in NSA, mLPFA, and ATD (p≤0.01 for all).

What are your conclusions?
Trochanteric entry intramedullary femoral lengthening using the nail demonstrates a favorable safety profile in skeletally immature patients with & >2 years of growth remaining, with a low risk of clinically significant proximal femoral deformity and no observed osteonecrosis. Younger patients with substantial growth remaining may be at higher risk for valgus proximal femoral changes, warranting routine radiographic surveillance until skeletal maturity.

Figure 1. Measurement technique for radiographic parameters. Neck-shaft angle (A), mechanical lateral proximal femoral angle (mLPFA), and articulotrochanteric distance (ATD) were assessed.

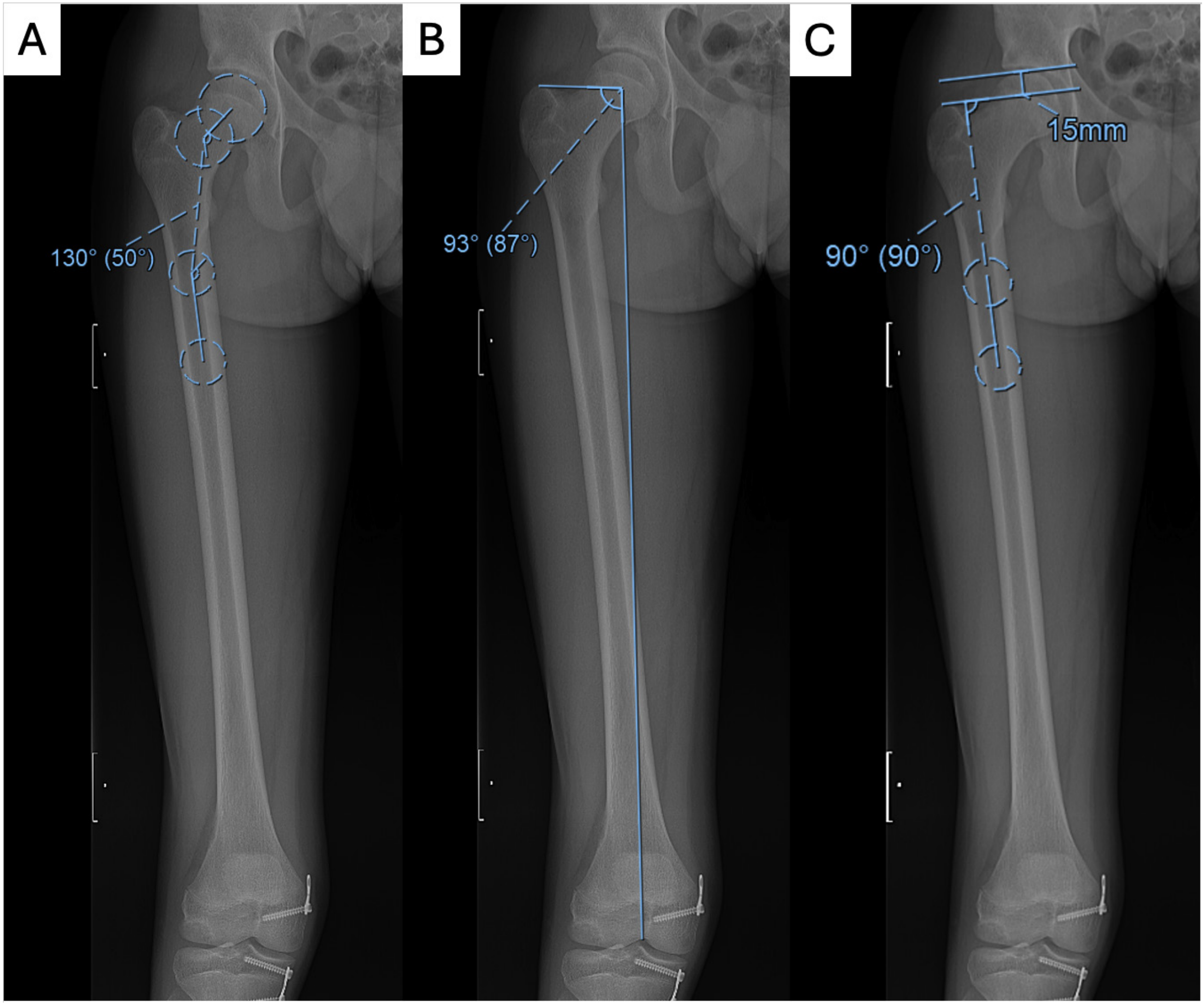
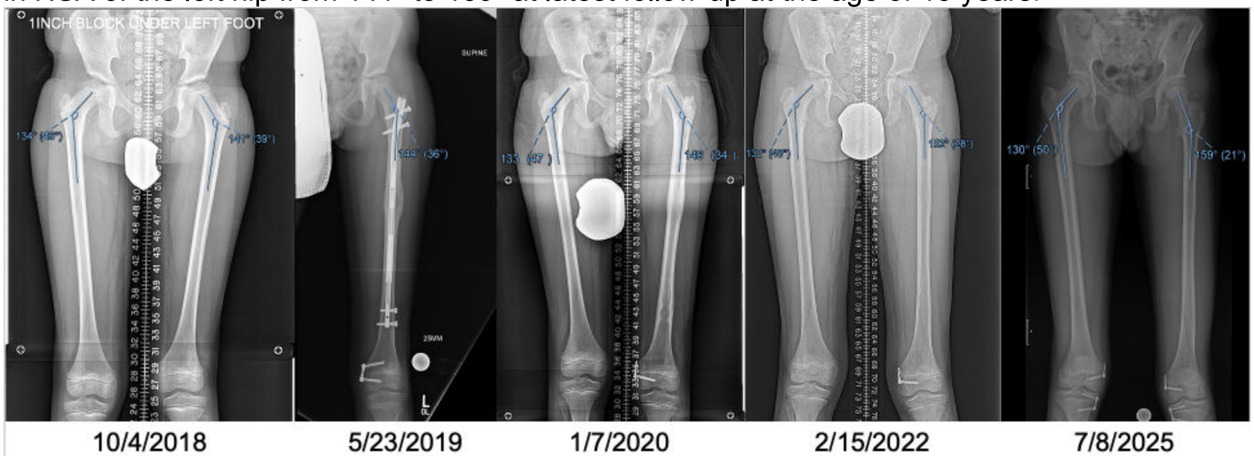


Figure 2. Radiographic changes for one patient who developed coxa valga after insertion of intramedullary lengthening nail. From pre-operative (10/4/2018), there is a progressive increase in NSA of the left hip from 141˚ to 159˚ at latest follow-up at the age of 15 years.



Linear regression analysis revealed that there was significant relationship between time until skeletal maturity and delta NSA (beta = 1.5, 95% CI 0.4 to 2.6, $p=0.010$, $r^2=0.267$), delta mLPFA (beta = -2.5, 95% CI -3.8 to -1.1, $p=0.001$, $r^2=0.395$), and delta ATD (beta = 1.9, 95% CI 1.0 to 2.8, $p<0.001$, $r^2=0.493$). For NSA, this indicates that for each additional year until estimated skeletal maturity, there is a positive 1.5˚ increase in the change in NSA. Similarly, each additional year was associated with a 2.5˚ decrease in the change in mLPFA and 1.9mm increase in the change in ATD. Taken together, this reflects that nail placement in patients with greater growth remaining is associated with more valgus changes that decrease as skeletal maturity is reached.

Table 1. Demographics of the 24 femora in 22 patients

Variable	**Mean ± SD (range) or Number (%)**
Age at surgery (years)	12.2 ± 2.3 (8.4-14.9)
Sex	
Male	17 (70.8)
Female	7 (29.2)
BMI (kg/m^2)	20.8 ± 4.0 (15.8-32.5)
Laterality	
Right	14 (58.3)
Left	10 (41.7)
Clinical follow-up (months)	26.4 ± 20.2 (12.0-81.5)
Radiographic follow-up (months)	23.4 ± 18.8 (12.0-79.9)
Reason for lengthening	
Amniotic band syndrome	1 (4.2)
Contralateral hemihypertrophy	2 (8.3)

CFD	5 (20.8)
CFD, Fibular hemimelia	1 (4.2)
Fibular hemimelia	1 (4.2)
Fibular hemimelia, spina bifida	1 (4.2)
Neonatal multifocal osteomyelitis	2 (8.3)
Ollier's disease	1 (4.2)
Russell-Silver syndrome	3 (12.5)
Short stature	4 (16.7)
Tibia fracture c/b segmental bone loss	1 (4.2)

Table 2. Surgical and post-operative characteristics

Variable	Mean ± SD (range) or Number (%)
Nail diameter (mm)	
8.5	13 (54.2)
10.7	11 (45.8)
Nail length (mm)	285.0 ± 30.2 (215.0-335.0)
Lengthening time (days)	47.2 ± 18.5 (21.0-78.0)
Concomitant procedures	
Distal femur, proximal tibia ROH	1 (4.2)
Medial distal femur HE	1 (4.2)
Medial proximal tibia HE	1 (4.2)
Medial distal femur, proximal tibia HE	1 (4.2)
Removal of hardware	22 (91.7)
Time to ROH (months)	15.2 ± 6.1 (8.9-33.8)
Complications	
Infection	0 (0)
Hardware failure	0 (0)
Osteonecrosis	0 (0)
Development of coxa valga	1 (4.2)

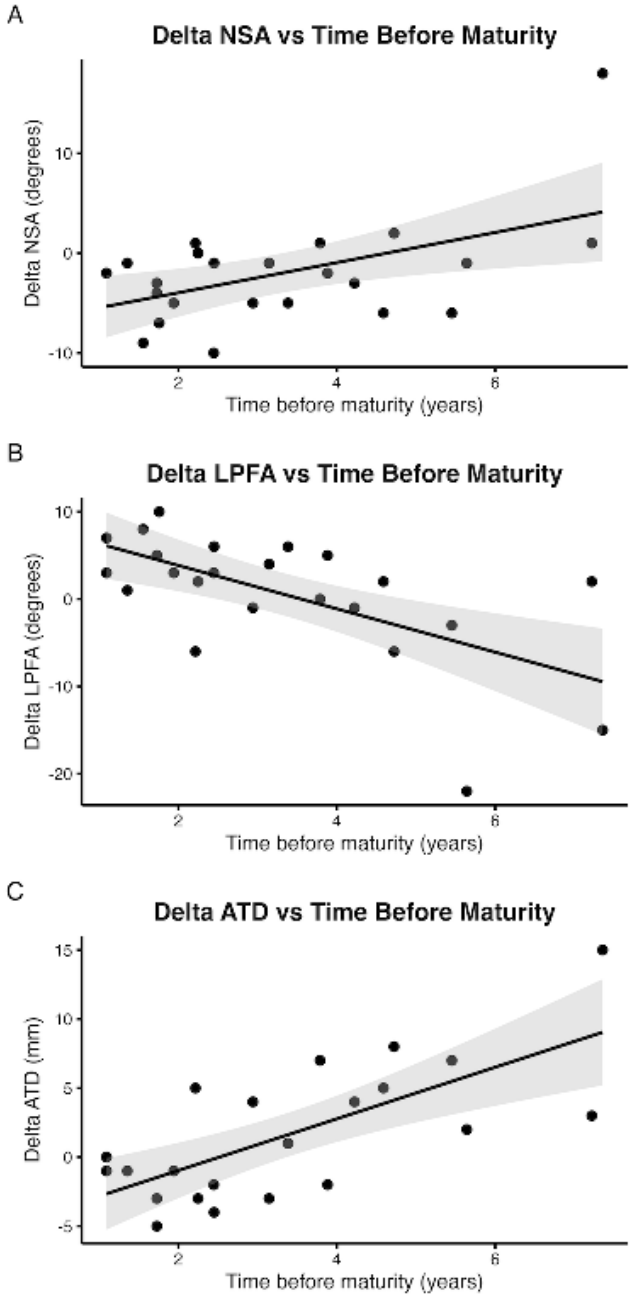
HE = hemi-epiphysiodesis, ROH = removal of hardware

Table 3. Radiographic parameters

Variable	Pre-operative	Post-operative	P-value
Neck-shaft angle (˚)	136.6 ± 6.7 (126.0-152.0)	134.5 ± 8.8 (123.0-159.0)	0.068
Mechanical LPFA (˚)	83.3 ± 8.1 (72.0-110.0)	84.0 ± 8.5 (64.0-96.0)	0.615
ATD (mm)	19.8 ± 3.7 (12.0-26.0)	21.2 ± 6.3 (13.0-35.0)	0.132

Mean ± SD (range). LPFA = lateral proximal femoral angle.

Figure 3. Changes in radiographic parameters versus estimated time to skeletal maturity. Each dot represents a single patient and the change (delta) from pre- to post-operative. The solid line represents the linear regression fit, and the shaded region represents the 95% confidence interval for the mean fitted line.



The Use of Circular External Fixation for Gradual Correction of Ankle and Hindfoot Contractures

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What was the question?
What are the clinical and radiographic outcomes of gradual correction of ankle/ hindfoot soft tissue contractures using a circular external fixator? Are there patient factors that affect the outcome?

How did you answer the question?
A retrospective chart review was conducted from prospectively collected registry data at the investigators' institution over 15 consecutive years. Consecutive patients that underwent gradual correction of an ankle with or without additional hindfoot contracture using a circular or hexapod external fixator were identified. Charts and radiographs were reviewed to determine the contracture type, etiology, degree of severity, duration of deformity, correction achieved, concomitant procedures, complications and if recurrence occurred. Clinical and radiographic outcomes with a minimum of one year follow up were assessed.

What are the results?
Thirty–eight consecutive patients, 42 ankles, that underwent gradual correction of an ankle contracture with a circular or hexapod external fixator were eligible for inclusion. Twenty–nine cases had complete charts available for review and were included. There were 12 patients with equinovarus deformity and 17 patients with pure equinus deformities. Clinically there was significant improvement in all equinus contractures from a mean of 33.9 degrees (10.0 to 70.0) preoperatively to 1.4 degrees (0.0 to 15.0) post fixator removal ($p<0.05$) and all varus contractures from a mean of 20.0 degrees (range 10.0–30.0) preoperatively to 0.0 post fixator removal ($p<0.05$). Radiographically there was significant improvement in all equinus contractures from a mean of 32.8 degrees (2.9 to 69.1) preoperatively to 0.5 degrees (–13.8 to 23.2) post fixator removal ($p<0.05$). There was recurrence of equinus in 3 patients. All patients with recurrence had a post–traumatic etiology with prior fracture fixation. However, there was no association between etiology, patient age, severity of deformity or duration of deformity and recurrence or incomplete correction of deformity.

What are your conclusions?
Gradual correction of ankle soft tissue contractures with a circular external fixator is effective at correcting deformity in a safe manner. Neither patient factors nor deformity factors had an impact on outcome. This technique should be considered in patients with severe deformities, concern for nerve injury poor soft tissues that are not amenable to acute correction.

Corticotomy Location Increases Biomechanical Failure Risk During Transverse Tibial Transport

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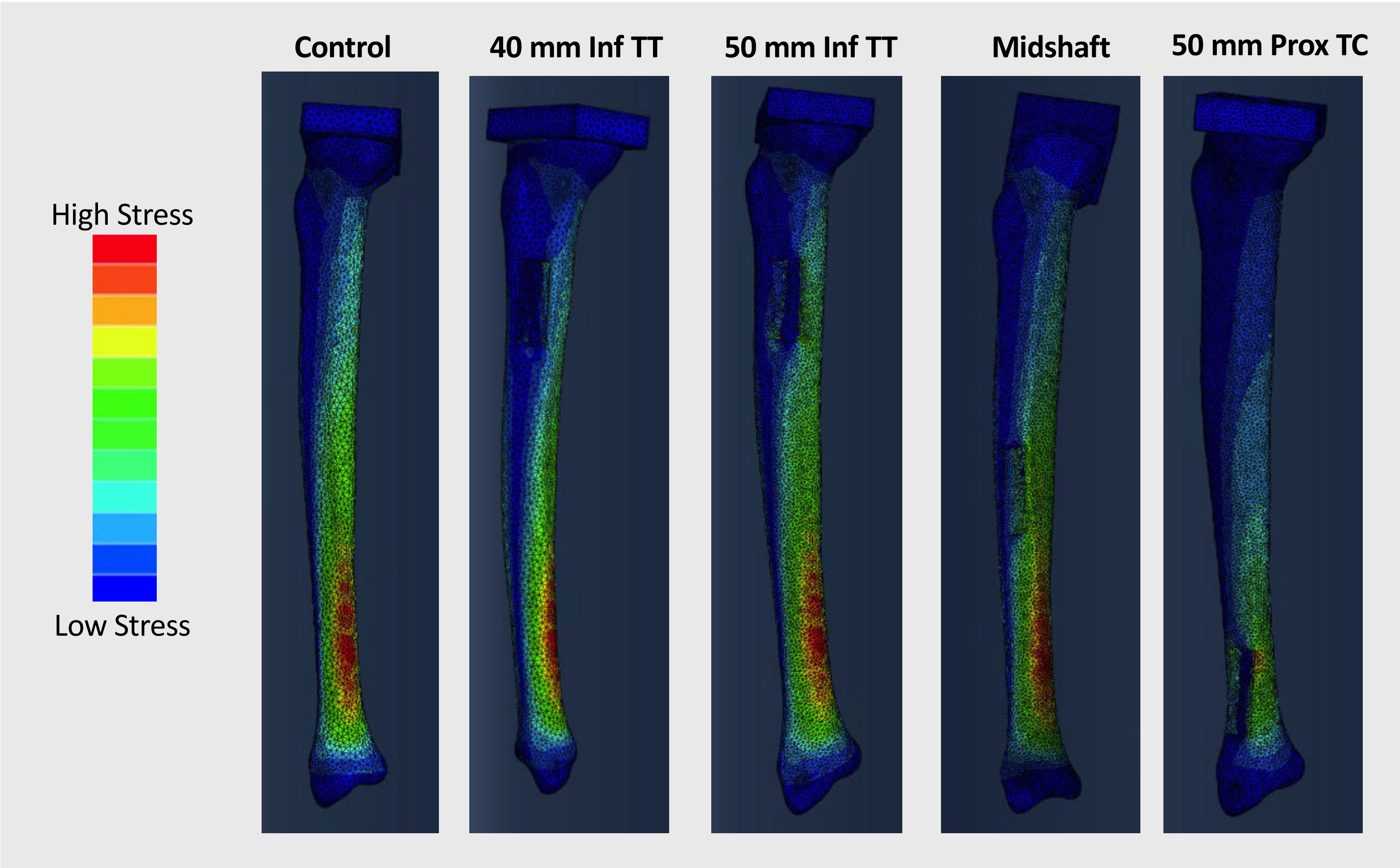
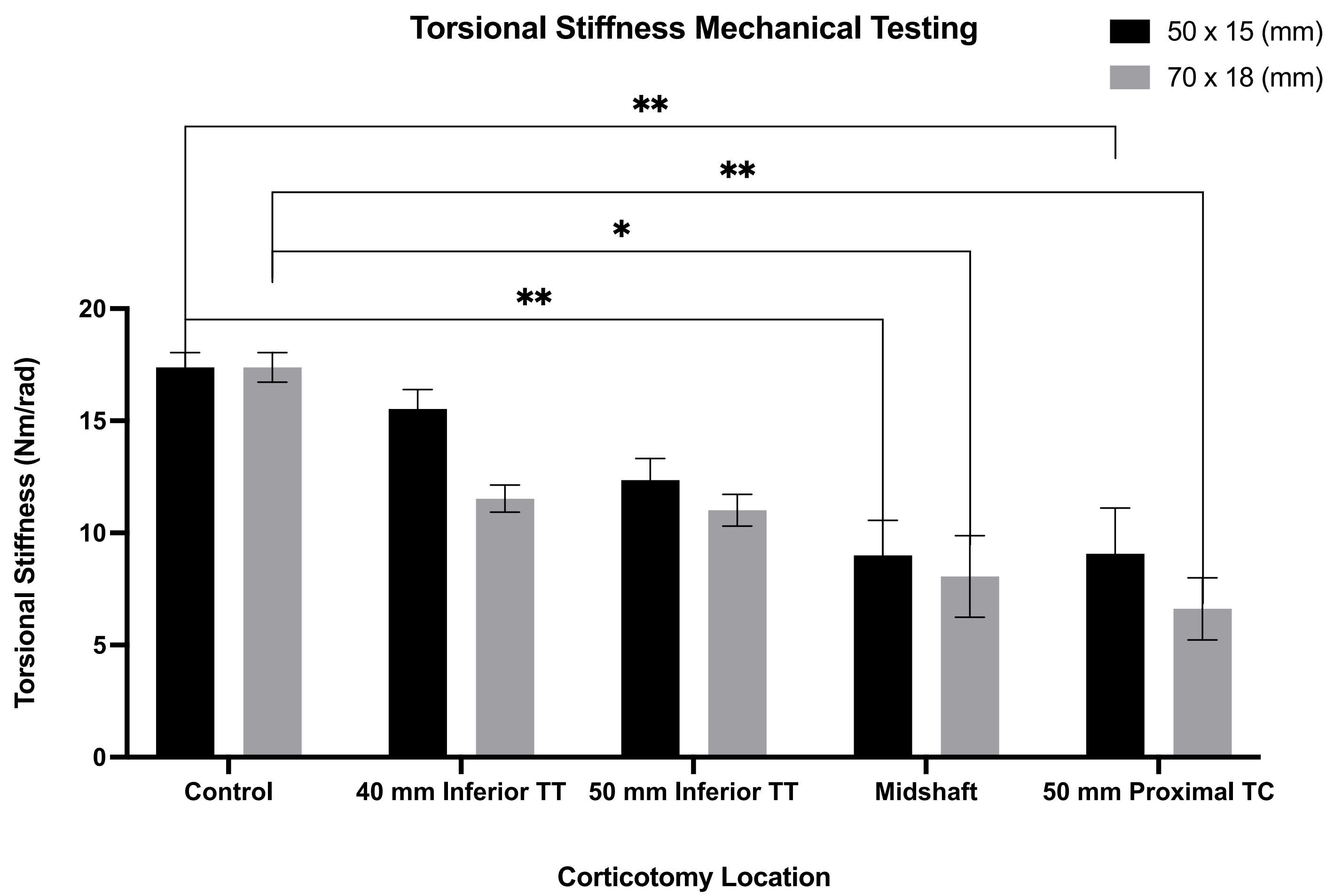
What was the question?
Transverse Tibial Transport (TTT) is an established surgical procedure that promotes angiogenesis and healing by harnessing distraction osteogenesis. The procedure involves creating a corticotomy on the tibia, which may increase fracture risk due to potential compromise of structural integrity. Clinically, the location and size of the cortical window differ between surgeons, and the biomechanical implications of these variations on tibial integrity remain poorly understood. This study evaluated how the location and size of the cortical window influence tibial mechanical stability and fracture risk during TTT using both mechanical testing and finite element analysis (FEA).

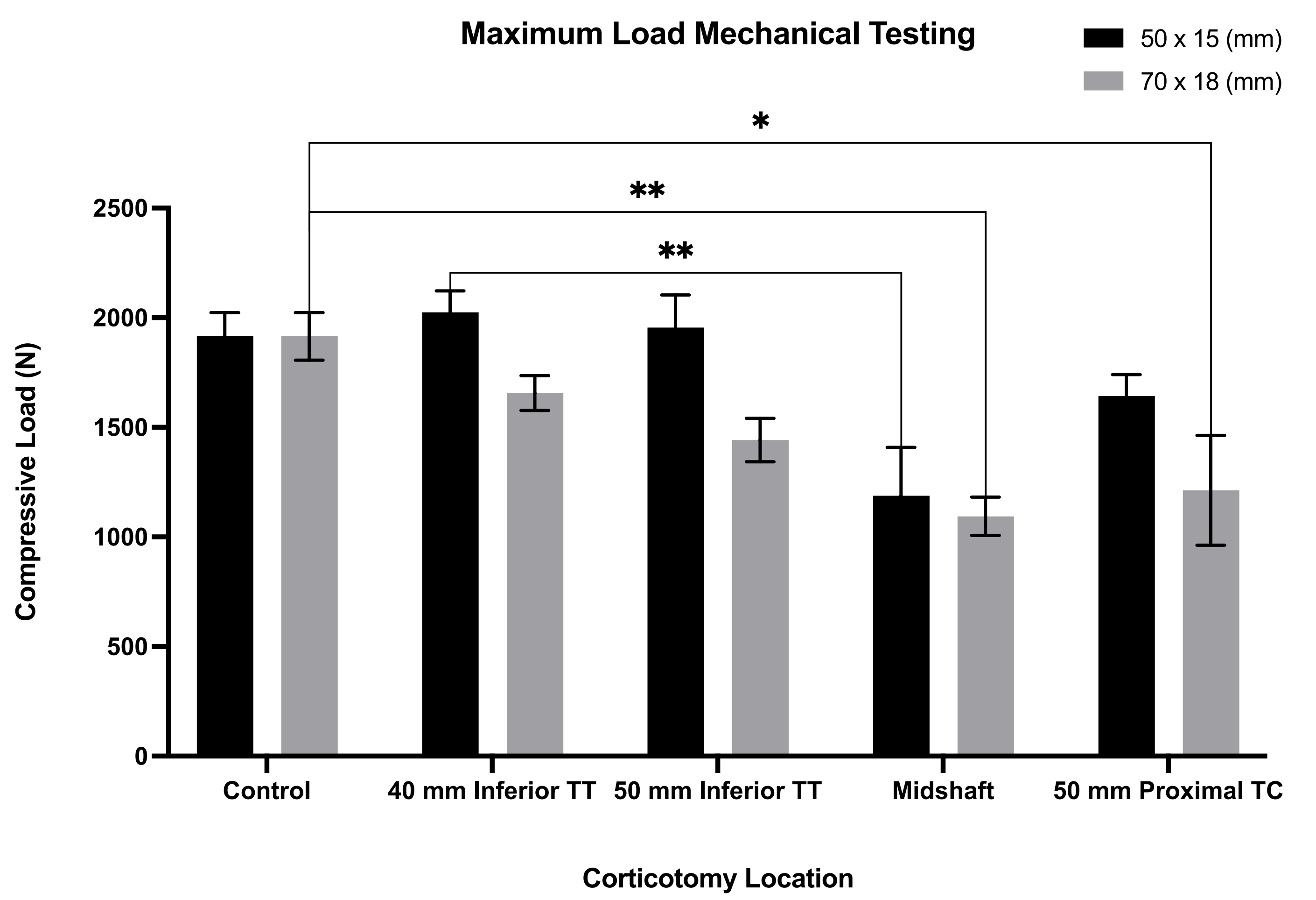
How did you answer the question?
Synthetic tibiae (Sawbones, Vashon Island, WA) were used for biomechanical testing. Two cortical window sizes (50x15 mm and 70x18 mm) were created at four anatomical locations: 40 mm inferior to the tibial tuberosity (TT), 50 mm inferior to the tibial tuberosity (TT), midshaft, and 50 mm proximal to the tibiotalar joint (TC). 3–D printed cutting templates were used to guide the oscillating saw while making the cut. Intact tibiae served as the control group ($n = 4$). Samples underwent axial compressive loading to failure and torsional loading using an Instron Universal Testing Machine. Torsional loading was applied at a maximum torque of 5 Nm at a rate of 0.5 Nm/s. Stiffness and maximum compressive load values were derived from the force vs. displacement curve. For FEA, tibial anatomy was segmented from a de–identified CT scan using Simpleware ScanIP. FEA models were then simulated in Abaqus under an axial compressive load of 784.8N. Von Mises stress and maximum principal stress were noted for each condition. Statistical analysis was conducted using the Kruskal–Wallis test with Dunn's post hoc pairwise comparisons and the Mann–Whitney U test ($p<0.05$).

What are the results?
Corticotomy location significantly affected all mechanical and FEA outcome variables for both size groups (all $p < 0.05$). Specifically, corticotomies placed at the midshaft and 50 mm proximal to the TC joint resulted in the highest mechanical compromise. For example, for the 70 x 18 mm cortical size, the midshaft cut demonstrated a 42.9% decrease in the compressive maximum load and a 34.8% decrease in stiffness compared to the control. Additionally, 50 mm inferior to the TC joint location showed a 36.7% reduction of compressive maximum load and 29.9% reduction in stiffness compared to the control. Similarly, torsional stiffness significantly decreased at the midshaft and distal locations for both corticotomy sizes. FEA validated these findings, showing significant increases in Von Mises and maximum principal stress concentrations at the midshaft and distal regions under both compressive and torsional loading. In contrast, corticotomies 40 mm and 50 mm inferior to the tibial tuberosity demonstrated mechanical properties similar to those of the control, with no statistically significant reduction in either size group. Corticotomy size did not significantly influence mechanical properties or stress concentrations at most locations. The exception was for Von Mises stresses during compression at the midshaft and torsion at 50 mm inferior to the TT. Here, the 70x 18 mm corticotomy produced significantly greater stress concentrations than the 50 x 15 mm corticotomy (both $p = 0.029$).

What are your conclusions?
Corticotomy location is a determinant of biomechanical compromise of the tibia during TTT. The midshaft and distal placements presented the greatest fracture risk for both compressive and torsional loading. Corticotomies placed at 40 mm inferior to the tibial tuberosity preserved mechanical properties most effectively across both sizes and loading conditions. Corticotomy size did not have a significant effect on mechanical outcomes. This suggests that surgeons have flexibility in cortical window sizing within the 50 x 15 mm to 17 x 18 mm range. This quantitative biomechanical guidance for corticotomy placement allows surgeons to minimize fracture risk and improve TTT outcomes for patients.


Control
40 mm Inf TT
50 mm Inf TT
Midshaft
50 mm Prox TC
High Stress
Low Stress


Torsional Stiffness Mechanical Testing
50 x 15 (mm)
70 x 18 (mm)
**
**
*
**
Torsional Stiffness (Nm/rad)
20
15
10
5
0
Control
40 mm Inferior TT
50 mm Inferior TT
Midshaft
50 mm Proximal TC
Corticotomy Location


Maximum Load Mechanical Testing
50 x 15 (mm)
70 x 18 (mm)
*
**
**
Compressive Load (N)
2500
2000
1500
1000
500
0
Control
40 mm Inferior TT
50 mm Inferior TT
Midshaft
50 mm Proximal TC
Corticotomy Location

Session V:

Patient Reported Outcomes

Moderator – Elizabeth Hubbard, MD

Prevalence of Psychological Morbidity in a Limb Reconstruction Practice and the Impact of an Embedded Psychiatrist–Led Liaison Clinic

Asanka Wijendra; Eva Broeckelmann; Ewa Okon–Rocha; Suzanne Swaine; Deborah Bond; Aaron Saini; Om Lahoti; Graeme Groom; Sarah Phillips
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What was the question?
Limb reconstruction surgery often involves prolonged treatment, repeated procedures, and disruption to function, work, and social roles, yet data on the prevalence of depression, anxiety, and post–traumatic stress symptoms in this population remain limited. Since 2012, our practice has routinely screened all patients and embedded a psychiatrist–led liaison clinic for those identified as needing additional support. We sought to quantify the prevalence of psychological morbidity in this population and to examine the effect of the embedded liaison clinic on symptom burden in patients referred for specialist evaluation.

How did you answer the question?
We retrospectively analyzed prospectively collected screening data from August 2012 to September 2023 using self–report measures for depression (PHQ–9), anxiety (GAD–7), and post–traumatic stress symptoms (PCL–4). In October 2023, a system–wide electronic health record change led to TSQ replacing PCL–4. For patients referred to the embedded psychiatrist–led liaison clinic between October 2023 and December 2025, we compared PHQ–9, GAD–7, and TSQ scores recorded at referral and after psychiatric review.

What are the results?
A total of 2,458 patients were screened between August 2012 and September 2023 (mean age, 47.2 years; 68.4% male). Probable anxiety was identified in 478 patients (19.6%; 95% CI, 18.0–21.2), probable major depression in 459 (18.8%; 95% CI, 17.3–20.5), and post–traumatic stress symptoms in 158 (7.4%; 95% CI, 6.3–8.5). Between October 2023 and December 2025, 58 patients were referred to the liaison psychiatry clinic and 50 completed evaluation; 33 had paired pre– and post–review questionnaire data. Mean PHQ–9, GAD–7, and TSQ scores decreased by 5.7, 5.4, and 2.4 points, respectively (all $p<0.001$). The mean interval between paired scores was approximately 8 months, during which patients attended an average of 2.7 psychiatry appointments.

What are your conclusions?
Psychological morbidity is common among patients undergoing limb reconstruction. An embedded liaison psychiatry model may reduce symptom burden in patients identified as needing specialist support. These findings quantify demand and support the development of integrated psychological care pathways within limb reconstruction practice.

RECONS: An International, Multi–Stage Consensus Study Establishing a Core Outcome Domain Set for Lower–Limb Lengthening Surgery

Ali Yalcinkaya; Ole Rahbek; Christopher A. Iobst, MD; Søren Kold; Michael Skovdal Rathleff; Lili Worre Høpfner Jensen; Pernille Damborg Clasen
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What was the question?
Lower–limb lengthening surgery spans a broad range of indications–including congenital limb–length discrepancy, post–traumatic deformity, skeletal dysplasias, and elective cosmetic lengthening–and involves prolonged, high–burden treatment pathways with a meaningful risk of serious complications. Despite decades of clinical research, outcome reporting in this field has remained deeply heterogeneous: a prior RECONS scoping review identified 2,939 verbatim outcomes distributed across 110 headings and subheadings in the published literature. This fragmentation prevents meaningful evidence synthesis, impairs cross–study comparability, and risks systematic under–representation of outcomes considered most important by patients and caregivers. Prior to this work, no international, multi–stakeholder consensus existed on which outcomes should be measured and reported in lower–limb lengthening surgery. The RECONS Network was therefore established to answer the following question: What is the minimum set of outcome domains that should be measured and reported in all clinical effectiveness studies of lower–limb lengthening surgery, as agreed upon by an international group of patients, caregivers, and healthcare professionals?

How did you answer the question?
This international, multi–stage consensus study was designed and conducted in accordance with COMET Initiative guidance and Core Outcome Set Standards for Development (COS–STAD) recommendations, and is reported following Core Outcome Set Standards for Reporting (COS–STAR).
The study comprised five stages:

* Stage 1 – Scoping Review (previously published): Systematic identification of 2,939 verbatim outcomes from the published literature, mapped to 110 outcome headings/subheadings.
* Stage 2 – Healthcare Professional (HCP) Stakeholder Discussion Group: An international group of surgeons, nurses, physiotherapists, psychologists, and researchers critically reviewed the candidate outcome list, proposing mergers and removals to create a manageable Delphi candidate set. This stage included an in–person discussion with a preceding survey, involving 18 HCPs/researchers from 7 countries, conducted at the EORS 2024 Conference in Aalborg, Denmark.
* Stage 3 – Lived–Experience Review: Proposed mergers and removals from Stage 2 were reviewed with adults, children/adolescents, and caregivers with lived experience of lower–limb lengthening, ensuring patient–centred language and domain framing.
* Stage 4 – Two–Round Modified International Delphi Survey: Following stakeholder refinement, 27 candidate outcome domains entered a two–round online Delphi survey conducted simultaneously with two independent stakeholder panels–patients/caregivers and HCPs/researchers–recruited from 28 and 20 countries respectively. Participants rated the importance of each domain on a 1–9 Likert scale. Free–text feedback after Round 1 was reviewed by the study management team, which also introduced one new appearance/cosmetic satisfaction domain for Round 2. Consensus–in was pre–specified as ≥70% of respondents in both stakeholder groups rating the domain 7–9 and <15% in both groups rating it 1–3. Consensus–out required ≥70% rating 1–3 and <15% rating 7–9 in both groups.
* Stage 5 – Post–Delphi Stakeholder Meeting: HCPs/researchers and patient and caregiver representatives participated directly, reviewing all Delphi results and confirming the outcome domain set.

Recruitment was facilitated through international professional societies including LLRS–North America, EPOS, and LLRS–Nordic, as well as 28 recruiting centres globally. Patient participants were identified and followed up locally by their clinical teams to maximise retention of this specialised population.

RECONS: An International, Multi–Stage Consensus Study Establishing a Core Outcome Domain Set for Lower–Limb Lengthening Surgery *continued*

Ali Yalcinkaya; Ole Rahbek; Christopher A. Iobst, MD; Søren Kold; Michael Skovdal Rathleff; Lili Worre Høpfner Jensen; Pernille Damborg Clasen
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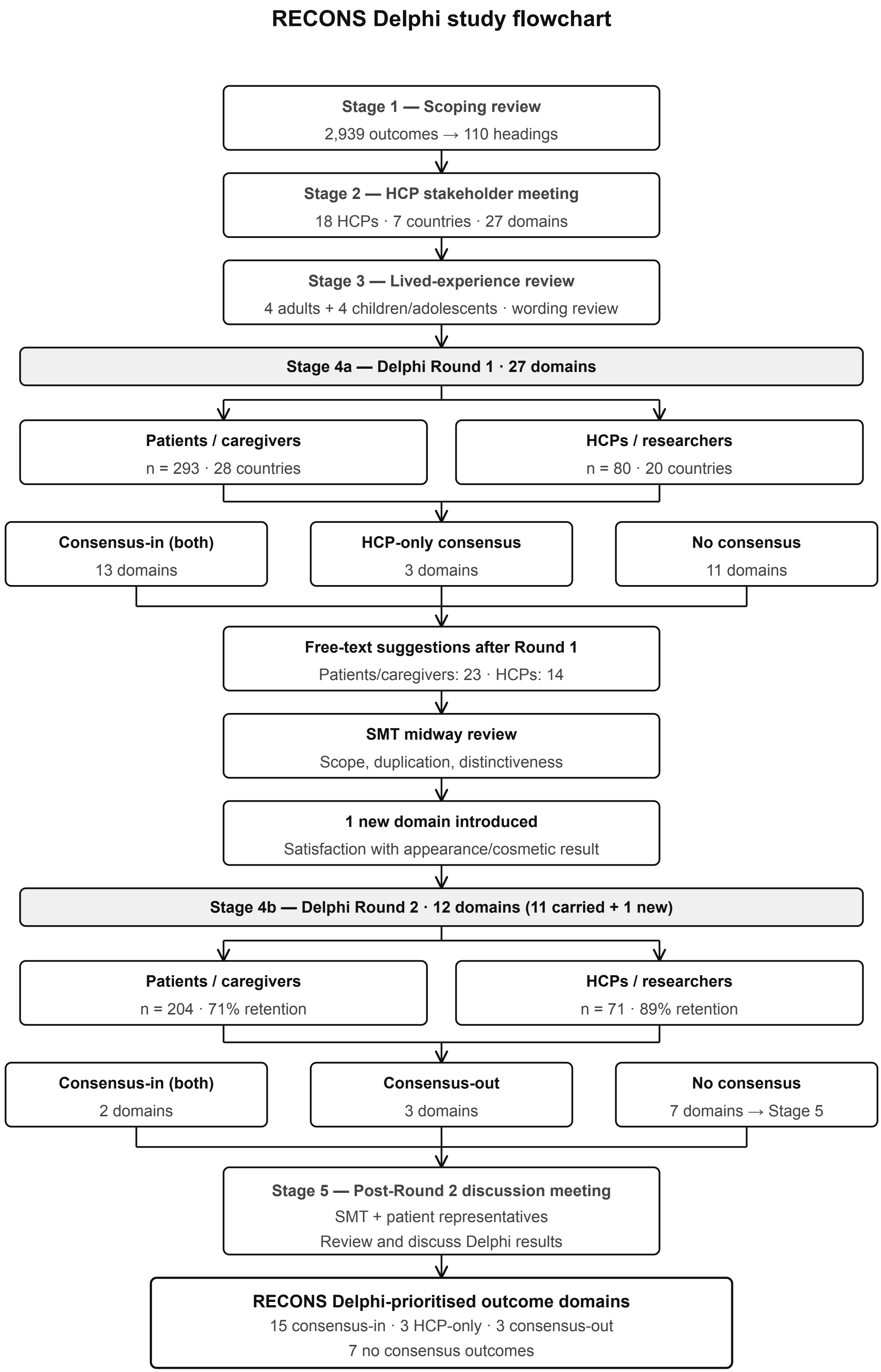
What are the results?
A total of 293 patients/caregivers (from 28 countries) and 80 HCPs/researchers (from 20 countries) completed Round 1; retention to Round 2 was 71% (n = 204) and 89% (n = 71), respectively. Patient respondents had a median age of 19 years (IQR 13–30), and represented diverse surgical indications including congenital conditions (54%), trauma (14%), and cosmetic lengthening (12%).
After Round 1, 13 outcome domains achieved consensus–in across both stakeholder groups, and an additional 3 domains achieved HCP–only consensus–in (≥90% rating 7–9). Eleven domains were advanced to Round 2. One new domain–satisfaction with appearance/cosmetic result–was introduced for Round 2 based on free–text feedback, yielding 28 unique domains considered across the full Delphi process.
After Round 2, two further domains achieved consensus–in across both groups (external fixation time; satisfaction with appearance/cosmetic result), three domains reached consensus–out (length of hospital stay, outpatient visits, readmission), and seven domains remained without consensus (total number of surgeries, total treatment duration, carrying out daily routine, cost of treatment, reoperation, reliance on others, superficial infection).

In total, 15 outcome domains achieved consensus–in across both stakeholder groups, spanning six conceptual categories:
* Life Impact – Quality of life; Psychological well–being; Pain or discomfort
* Participation &aRole Functioning – Work, employment, and education; Social functioning; Self–care
* Physical Function – Lower limb function; Range of motion; Muscle strength; Full weight bearing
* Biological / Technical Effectiveness – Bone healing; Lengthening achieved; Lower limb alignment and joint orientation; External fixation time
* Satisfaction – Satisfaction with treatment outcome; Satisfaction with appearance/cosmetic result
* Adverse events – Complications; Deep infection

What are your conclusions?
This multi–stage international consensus study–engaging over 370 unique stakeholders across 34 countries, including a substantial patient and caregiver panel–has produced a stakeholder–informed RECONS outcome domain set for lower–limb lengthening surgery. The 15 consensus–in domains span the full breadth of relevant constructs, from biological and technical success through functional recovery, participation, quality of life, psychological well–being, and patient satisfaction, reflecting the priorities of both clinicians and those living with the consequences of this treatment. Importantly, three additional domains–complications, pain or discomfort, and deep infection–achieved consensus–in among HCPs only and are recommended as essential components of clinical reporting.

The RECONS outcome domain set will be presented and further elaborated as RECONS 1.0 at an international consensus meeting in Stellenbosch, South Africa (December 2026), where standardized outcome definitions and timing across the treatment pathway will be established. Adoption of this domain set in future clinical research will reduce outcome heterogeneity, facilitate evidence synthesis, and ensure that the outcomes most valued by patients, caregivers, and clinicians are consistently captured. These findings have direct implications for trial design, systematic review methodology, and the development of clinical practice guidelines for lower–limb lengthening surgery globally.


RECONS Delphi study flowchart
Stage 1 — Scoping review
2,939 outcomes → 110 headings
Stage 2 — HCP stakeholder meeting
18 HCPs · 7 countries · 27 domains
Stage 3 — Lived-experience review
4 adults + 4 children/adolescents · wording review
Stage 4a — Delphi Round 1 · 27 domains
Patients / caregivers
n = 293 · 28 countries
HCPs / researchers
n = 80 · 20 countries
Consensus-in (both)
13 domains
HCP-only consensus
3 domains
No consensus
11 domains
Free-text suggestions after Round 1
Patients/caregivers: 23 · HCPs: 14
SMT midway review
Scope, duplication, distinctiveness
1 new domain introduced
Satisfaction with appearance/cosmetic result
Stage 4b — Delphi Round 2 · 12 domains (11 carried + 1 new)
Patients / caregivers
n = 204 · 71% retention
HCPs / researchers
n = 71 · 89% retention
Consensus-in (both)
2 domains
Consensus-out
3 domains
No consensus
7 domains → Stage 5
Stage 5 — Post-Round 2 discussion meeting
SMT + patient representatives
Review and discuss Delphi results
RECONS Delphi-prioritised outcome domains
15 consensus-in · 3 HCP-only · 3 consensus-out
7 no consensus outcomes

The International Osteogenesis Imperfecta Registry: A Collaborative Platform to Advance Orthopaedic Outcomes Research in Osteogenesis Imperfecta

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What was the question?
The development of this registry is in its nature not a hypothesis–driven study, however, it is designed in such a way that it can be used as a platform to facilitate the execution of a prioiri hypothesis driven trials. Osteogenesis Imperfecta (OI) is a rare genetic disorder characterized by bone fragility, recurrent fractures, and progressive deformities. Despite the clinical heterogeneity and lifelong impact of musculoskeletal manifestations due to OI, there is a paucity of longitudinal, standardized data capturing the nature and evolution of limb differences across the lifespan. To address this gap, under the International Limb Differences Registry (ILDR), we have established a dedicated longitudinal observational registry for OI. The objective is to collect long–term, standardized, patient–centered data on children and adolescents with OI to support orthopaedic outcomes research, improve clinical care, and inform shared decision–making.

How did you answer the question?
The ILDR–OI registry was developed by an international group of orthopaedic surgeons and researchers with expertise in treating OI. Core data elements include demographics, socio–economic status, OI type, fracture history, surgical interventions (e.g., intramedullary rodding, osteotomies), radiological assessments, bone density, adverse events, and patient–reported outcomes. Numeric pain rating scale, PROMIS Global Health Scale, and LIMB–Q Kids are used to collect patient–reported outcomes at baseline and every six months from baseline. The registry design allows for prospective longitudinal data collection and entry of any prior treatment for OI before joining the registry. Data are securely collected using REDCap, a web–based electronic data capture system.

What are the results?
Since the launch of the OI registry in 2024, 5 sites from Canada and the USA have recruited 129 patients (Table 1). 30 patients have been followed prospectively for at least 3 months since recruitment and 38 surgeries, 16 fractures, 8 bone density scans, and 5 adverse events have been reported. At the time of abstract submission, 13 sites in total (Germany, the Netherlands, India, Canada, Nigeria, and the United States) have all necessary approvals for recruitment for ILDR. Three sites (Denmark, India, and the United Kingdom) are currently obtaining the required approvals.
Early findings confirm that standardized, harmonized data collection across international sites is feasible through the OI registry.

What are your conclusions?
This comprehensive OI registry represents a significant advancement in the global effort to improve understanding of OI. With a dedicated international scientific advisory committee, research team and data management infrastructure, this platform is well–positioned to generate high–quality, clinically meaningful data. The registry data will support studies aimed at addressing existing gaps in the treatment and long–term management of individuals with OI. Ongoing international expansion of this registry will further enhance its capacity to inform best practices and improve quality of life for patients living with OI.

Table 1: Demographic and clinical data at the time of recruitment into the registry by OI severity

	Mild	**Moderate**	**Severe**	**Total**
Total Recruits	**39**	**31**	**45**	**129** **14 OI severity not reported*
Age at recruitment (years)	**8.0** (Max = 15.8, Min = 1.7)	**8.3** (Max = 18.2, Min = 1.9)	**6.0** (Max = 17.9, Min = 0.7)	**7.8** (Max = 18.2, Min = 0.7)
Sex	Female = **15**, Male = **24**	Female = **16**, Male = **15**	Female = **20**, Male = **25**	Female = **55**, Male = **74**
Type of OI	Type 1=37, Type 4=2	Type 1=6, Type 3=3, Type 4=18, Others=4	Type 1=3, Type 3=35, Type 4=1, Others=6	Type 1=48, Type 3=39, Type 4=24, Others=13 **5 type not reported*
Median Number of Previous *Surgeries* Per Patient Reported at Recruitment	**2** (IQR 2, 1, n=20)	**3** (IQR 4, 2, n=16)	**4** (IQR 6, 2, n=25)	**2** (IQR 4, 2, n=66)
Median Number of Previous *Fractures* Per Patient Reported at Recruitment	**5** (IQR 7, 3, n=29)	**7** (IQR 11, 3.5, n=19)	**11** (IQR 20, 4, n=29)	**7** (IQR 11, 3, n=87)
Median *PROMIS Pediatric Global Health* Score Reported at Recruitment **(max 100, 100 reflect a better score)**	Parent = **51.8** (IQR 55.9, 48.7, n=15) Self = **53.3** (IQR 57.0, 45.7, n=11)	Parent = **51.8** (IQR 60.1, 48.1, n=11) Self = **37.2** (IQR 41.45, 34, n=3)	Parent = **48.3** (IQR 53.8, 45.4, n=18) Self = **48.3** (IQR 51.5, 44.5, n=4)	Parent = **50.6** (IQR 54.5, 47.3, n=46) Self = **47.5** (IQR 55.1, 41.7, n=18)
Median *LIMB-Q Kids* Scores Reported at Recruitment **(Self-report only, max 100, 100 reflects a better score)**	Leg Appearance = **70** (IQR 82, 64, n=4) Physical Function = **100** (IQR 100, 90, n=5)	Leg Appearance = **63** (IQR 79.8, 49.5, n=5) Physical Function = **83** (IQR 87.3, 69, n=5)	Leg Appearance = **73** (IQR 93.3, 54.3, n=3) Physical Function = **69** (IQR 72, 43.5, n=3)	Leg Appearance = **70** (IQR 75.3, 53, n=15) Physical Function = **73** (IQR 100, 66.8, n=14)
Median *Numeric Pain Rating* Score Reported at Recruitment **(max 10, 0 reflects a better score)**	**1** (IQR 1.3, 0, n=25)	**1** (IQR 4.3, 0, n=13)	**1** (IQR 2.5, 0, n=15)	**1** (IQR 2.3, 0, n=56)

**Data as of 2026-Apr-02*

Patient–Reported Outcomes and Mobility in Young Adults Treated by Amputation for Severe Congenital Fibular Deficiency

John G. Birch, MD FRCS(C); Kelly Jeans; J. Anthony Herring, MD; Charles E Johnston, MD; Kirsten Tulchin–Francis; Chan–Hee Jo, PhD
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What was the question?
We previously reported the functional status at age 8–10 of 20 patients treated in early childhood by Syme/Boyd amputation for severe unilateral congenital fibular deficiency. The purpose of this study was to evaluate subsequent treatment and functional status of this cohort at skeletal maturity.

How did you answer the question?
We reviewed the medical records and radiographs of the 20 amputee subjects in the original cohort. We also designed a call–back study of prosthetic evaluation, clinical assessment, radiographs of the lower extremity, movement science evaluation, and patient–reported outcome measures (PROs). Movement science evaluation included a 6–minute walk test, oxygen consumption during overground walking and submaximal VO2 max test on an inclined treadmill. PRO's included the numeric pain scale, UCLA Pedi–Activity Score, IKDC, I–HOT, appearance satisfaction, and Coopersmith Self–Esteem Assessment. Subjects were recruited over a 6–year period by mail, phone calls, and e–mail.

What are the results?
All 20 amputee subjects had been followed at a single institution until skeletal maturity. Six had undergone growth modulation for distal femoral/proximal tibial valgus deformity, and one of these had also undergone ACL reconstruction. 14/20 had no further surgery after the initial amputation. 13 subjects (8 males and 5 females; average age 25.5, range 19.4–30.4) returned for full study assessment. 2 further subjects completed on–line PRO's, while 5 subjects declined to participate or did not respond to multiple contact efforts. One of the 13 subjects returning for full assessment required refitting of a prosthesis before movement science evaluation could be conducted. All others had a functional prosthesis on presentation. Movement science parameters were collected and compared to an intra–institutional database of 31 age–, sex–, and BMI–matched healthy controls. While the amputee subjects were unrestricted in their mobility and performed well, most standard measurements (such as overground walking velocity (m/min) and VO2 cost (ml/kg/m); and submaximal VO2 max test VO2 rate (ml/kg/min), speed (mph), and incline (% grade)) were inferior to the matched able–bodied cohort (Table 1). Timed 6–minute walk test averaged 65% ± 11% of matched able–bodied controls. No PRO instrument or score correlated to movement science functional measurements. All subjects were satisfied with the treatment path that had been chosen for them as infants.

What are your conclusions?
70% of the patients in this cohort had no subsequent surgery after their amputation in infancy. PRO scores were generally satisfactory. Movement science documented somewhat below average–to–average mobility compared to able–bodied peers. PRO scores were not predictive of objective movement science mobility function. These results can be used to counsel families considering early amputation or staged reconstruction for severe fibular deficiency. Movement science documentation of amputee function after Syme amputation should be compared to those in a comparable staged–reconstruction cohort in the future.

Supported in part by a POSNA research grant 2019. (POSNA 678401)

Table 1. Functional Outcomes at Skeletal Maturity following Amputation for Fibular Hemimelia

		Amputees (n=13)		Controls (n=31)		
Variables	**units**	**Mean**	**SD**	**Mean**	**SD**	**P**
6MWT	m	412.63	70.30			
6MWT%	%	65%	11%			
Overground Walking						
HR	bpm	108.02	10.48	102.49	16.89	0.137
Velocity	m/min	69.28	11.93	82.58	11.54	0.002
VO2Cost	ml/kg/m	0.16	0.04	0.20	0.03	0.003
Submax VO2 Max Test- final stage						
HR	bpm	165.32	18.73	175.80	17.62	0.071
VO2Rate	ml/kg/min	23.17	8.20	37.44	7.24	< 0.001
Speed	mph	3.02	0.50	4.01	0.39	< 0.001
Incline	% grade	9%	3%	13%	3%	< 0.001
Predicted Max		29.14	9.69	44.23	7.40	< 0.001

Measuring What Matters Beyond Function: Implementing LIMB-Q Kids for Longitudinal Outcome Assessment in Patients with Lower Limb Differences

Harpreet Chhina, PhD; Annie Wang; Carrie Kollias; Anthony Cooper
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What was the question?
Can implementation of LIMB-Q Kids provide meaningful longitudinal patient reported outcomes (PROs) data beyond traditional functional measures in pediatric patients with lower limb differences?

How did you answer the question?
We conducted a descriptive analysis of LIMB Q Kids questionnaires collected between January 2025 and March 2026 from pediatric patients treated at a tertiary care hospital. PROs were completed every six months as part of routine research practice and clinical care allowing for longitudinal outcome assessment.

What are the results?
A total of 177 LIMB-Q Kids were completed by 105 patients (median age 13 years at the time of LIMB-Q Kids completion) representing a wide range of congenital, developmental, and acquired lower limb conditions (Table 1). Overall, physical function and individual symptom domains demonstrated consistently high median scores (greater than 70 out of 100, higher scores mean better outcomes) given that majority of the patients had some treatment done at the time of completion of LIMB-Q Kids. In contrast, leg appearance, leg related distress, and social function domains showed greater variability. Appearance scores were consistently lower across various sub-groups including idiopathic leg length difference (LLD), LLD secondary to other diagnosis, Hemi-hypertrophy and Fibular Hemimelia (FH) and Congenital Femoral Deficiency (CFD) with idiopathic LLD group having the lowest scores (Table 2). Very low scores (less than 30 out of 100) were uncommon and primarily confined to physical function, leg appearance, leg-related distress, psychological function and social function scales. It is worth noting that the lower scores on appearance scale and the psychological function scales were more common in females as opposed to males. Lower scores on the physical function scale were seen in males with osteogenesis imperfecta. None of the individual symptom scales (Hip, knee, leg, foot and ankle) had scores below 30 out of 100.

What are your conclusions?
Early experience with LIMB Q Kids demonstrates its feasibility and value for longitudinal patient reported outcome assessment in pediatric limb reconstruction. Appearance related concerns seem to persist in this population irrespective of their physical function and symptoms as measured by LIMB-Q Kids. However, small size at the time of abstract submission limited any statistical analyses and these results are to be taken with a grain of salt. By capturing outcomes beyond function alone, LIMB Q Kids enables more comprehensive outcome benchmarking and supports patient centered evaluation of limb lengthening and deformity correction care.

Table 1

Participant Demographics	
Female	46
Male	49
Total	**105**
Treatment Status at the time of LIMB-Q Kids completion	
Post-op	131
Pre-op	22
No surgery	24

Table 2

	Idiopathic LLD N =6 Median LLD: 2.7 cm (IQR=2.0-3.9 cm	**LLD Secondary to other diagnosis N=48** Median LLD: 2.5 cm (IQR=2.15-2.7 cm	**Hemi-hypertrophy N= 13** Median LLD: 2.8 cm (IQR=2.2-3.7 cm)	**FH and CFD N=14** Median LLD: 2.7 cm (IQR=1.4-4.9cm)
Scale	**Median Score (IQR)**			
Leg Appearance	35 (31.5-54)	55 (43-70)	45 (41-70.25)	58 (43-70)
Physical Function	100 (91.5-100)	90 (70-100)	100 (95.75-100)	90 (73-100)
Hip Symptoms	100	100 (89-100)	100 (75-100)	100 (89-100)
Leg Symptoms	83 (61-90)	76 (64.75-90)	83 (71-100)	83 (71-90)
Knee Symptoms	94.5 (89-100)	89 (75-100)	81 (75-100)	89 (81-100)
Foot and Ankle Symptoms	90 (53-90)	90 (63-100)	100 (90-100)	100 (63-100)
Leg-related Distress	89 (80.5-94.5)	72 (55-89)	89 (64-100)	72 (64-89)
Psychological Function	82 (67-100)	75 (65-100)	74 (65-100)	92 (71.5-100)
Social Function	84 (55-90)	76 (59 – 95)	73 (63-100)	90 (70-100)

Session VI:

Limb Reconstruction Part 2

Moderator – Stephen M. Quinnan, MD

Does Patient Age Affect Outcomes of Osseointegration Limb Replacement Surgery?

S. Robert Rozbruch, MD; Ethan Nguyen; Taylor J. Reif, MD; Jason S. Hoellwarth, MD
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What was the question?
Transcutaneous osseointegration for amputees (TOFA) enables direct attachment of a prosthesis to the skeleton through an implant placed in the residual limb. This approach eliminates the need for a socket interface and has expanded the pool of patients eligible for prosthetic rehabilitation. As education about and incorporation of lower extremity osseointegration has grown, it has been applied to a broader patient population, including elderly individuals. These patients have historically been considered at higher risk because of concerns related to bone quality, wound healing, and comorbidity burden. Despite these concerns, the influence of age, particularly at older extremes, on postoperative complications and functional recovery remains incompletely understood. Are the clinical, functional, and patient–reported outcomes between younger patients aged 20 to 40 years and older patients aged 65 years and above undergoing lower–extremity osseointegration different?

How did you answer the question?
A retrospective cohort study was conducted of all patients who underwent lower–extremity press–fit osseointegration at LLCRS since 2018 Patients aged 20 to 40 years and â‰¥65 years at the time of surgery were included. All patients had a minimum of one year of clinical follow–up. The primary outcome was reoperation within one year following osseointegration. Secondary outcomes included postoperative complications, functional measures (6–minute walk test, Timed Up and Go), and patient–reported outcome measures (PROMIS Global Physical Health and Global Mental Health). Baseline demographic and clinical variables, including sex, body mass index (BMI), tobacco use, amputation level, etiology, and time from amputation to osseointegration, were collected. Categorical variables were compared using chi–square or Fisher's exact tests as appropriate, and continuous variables were analyzed using unpaired t–tests or nonparametric equivalents based on distributional assumptions.

What are the results?
The 1–year reoperation rate was comparable between patients aged 20–40 and ≥65 years (9/59=15.3% vs 5/21=23.8%, p=0.5039). Similarly, postoperative infection rates were not significantly different across groups (28/59=47.5% vs 9/21=42.9%, p=0.8016). Patients aged â‰¥65 demonstrated a greater improvement in Timed Up and Go (TUG) performance compared to those aged 20–40, (3.673 ± 5.080 vs 1.499 ± 2.733, p=0.4631). PROMIS, 6–minute walk test, and implant failure outcomes were not different between the groups.

What are your conclusions?
TOFA in patients aged ≥65 years demonstrates a safety profile comparable to that of a younger, healthy reference cohort, with no significant differences in reoperation or infection rates. Functional improvement, as measured by TUG, was also similar, with a trend toward greater gains in older patients. While careful patient selection remains important, advanced age appears to not on its own be a contraindication to osseointegration.

Stoma Creation for Osseointegration Patients Based on Seventeen Years of Experience

Prof. Munjed Al Muderis; Atiya Oomatia; William Lu
atiya@osseointegrationaustralia.com.au

What was the question?

Osseointegration has transformed limb reconstruction by enabling direct skeletal attachment of prosthetic limbs. A critical yet underreported component of this procedure is the creation and long–term management of the transcutaneous stoma. Early approaches often involved complex soft tissue handling and postoperative care strategies. Based on evolving clinical experience, we hypothesized that simplifying both stoma creation and postoperative management would lead to improved outcomes. Over 17 years, surgical techniques have been progressively refined alongside the transition to single–stage osseointegration, fundamentally altering soft tissue management principles. However, the optimal approach to stoma creation and postoperative management in osseointegration remains unclear. This study aims to evaluate how progressive simplification of surgical and postoperative techniques influences stoma stability, complication rates, and overall clinical outcomes.

How did you answer the question?

This study presents a retrospective review of stoma creation techniques developed over 17 years in patients undergoing osseointegration. With the transition to single–stage surgery, a more aggressive approach to soft tissue management was adopted, including excision of redundant skin and subcutaneous tissue to minimize the distance between bone and skin. Bone preparation involved resection to healthy cortical margins, removal of exostoses, and shaping of the distal femur to optimize implant contact. Nerve management included targeted muscle reinnervation of major nerves. A structured myodesis technique was performed, anchoring deep and superficial muscle layers circumferentially around the implant collar. Skin closure was tailored to residual limb characteristics, using either flap–based techniques with secondary coring or direct closure around the implant in cases with limited soft tissue. Outcomes were assessed based on stoma stability, soft tissue complications, and need for revision.

What are the results?

The evolution towards simplified and more aggressive soft tissue reduction resulted in improved stoma stability and reduced soft tissue redundancy. Minimizing movement at the skin-implant interface decreased local irritation and complications. Tailored closure techniques allowed successful management across a wide range of cases, including those with compromised soft tissue. The simplified stoma management approach was clinically demonstrated to be effective, with reduced need for complex postoperative care and improved functional integration. Additionally, these refinements supported early loading rehabilitation facilitated by stable implant fixation.

What are your conclusions?

Stoma creation is a key determinant of success in osseointegration surgery and should be approached with a focus on simplicity, stability, and individualization. The shift to single–stage surgery and aggressive soft tissue optimization has enabled more reliable outcomes by reducing redundancy and interface motion. This 17–year experience supports a simplified surgical and postoperative management strategy, demonstrating that less complex approaches can yield superior clinical outcomes across both standard and complex cases.

Deep Learning-Based Classification of Femoral Rotational Abnormalities from Standing AP X-rays

Tanush Soni; Michael J. Mosca, PhD; Jason S. Hoellwarth, MD; Taylor J. Reif, MD;
S. Robert Rozbruch, MD; Austin T. Fragomen, MD
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What was the question?
Femoral rotational abnormalities are under-recognized contributors to hip/knee pain, gait disturbance, patellofemoral instability, and are common indicators for femoral derotational osteotomy. Currently, computed tomography (CT) is widely regarded as the reference standard for assessing femoral rotation because it allows direct axial-plane visualization and reproducible angular measurements. However, CT-based workflows increase radiation exposure, cost, and diagnostic burden. Standing anteroposterior (AP) long leg radiographs are obtained routinely in orthopedic deformity evaluation, yet their role in screening has been limited by the indirect nature of projection cues and the difficulty of interpreting them on visual inspection alone. Could a machine learning model be used to predict femoral rotation using the standing AP radiograph?

How did you answer the question?
A deep-learning (DL) pipeline was developed to classify femoral version from routinely obtained standing anteroposterior radiographs into three clinically relevant categories - normal (10-20), anteversion (>20), and retroversion (<10) - using CT-confirmed measurements as the reference standard. The system consists of three stages: (1) YOLOv8-small for femoral region of interest detection, (2) U-Net with ResNet-18 backbone for femoral segmentation, and (3) ResNet-18 for version classification. The dataset comprised 122 legs from 79 patients, divided into training (86 legs), validation (16 legs), and test (20 legs) sets.

What are the results?
On the test set, the pipeline achieved a balanced accuracy of 0.84 and macro-averaged F1-score of 0.85 across all three categories, with highest performance for retroversion (F1-score 0.89). Representative misclassified cases demonstrated that all errors occurred within 1 of a diagnostic threshold, with the predicted probabilities reflecting true radiographic ambiguity at borderline angles. These are cases where CT-confirmed versions measured 19 (1 below the anteversion threshold of 20) or 9 (1 above the retroversion threshold of 10). The DL model's reliance on lesser trochanter projection geometry as a landmark mirrors the known clinical challenge of interpreting femoral version on AP radiographs.

What are your conclusions?
This study demonstrates the feasibility of deep learning-based classification of femoral rotational abnormalities from routinely acquired standing AP radiographs. Errors are confined to cases that challenge expert human interpretation, indicating a path towards a decision support system that can be trusted in future practice. While not replacing CT-based measurement, the DL model is effective in identifying patients with abnormal femoral versions.

Evaluation of the LLRS Traveling Fellowship: A Survey-Based Analysis of Adult and Pediatric Fellows

Stephen Wallace, MD
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What was the question?
What is the perceived value, structure, and impact of the LLRS Traveling Fellowship among recent adult and pediatric participants, and how can the program be optimized for future fellows?

How did you answer the question?
A structured survey was administered to recent adult and pediatric LLRS Traveling Fellowship participants, including fellows and early-career surgeons (≤5 years in practice). Survey domains included program awareness, site-specific feedback, clinical engagement (case discussions during and after fellowship), perceived value, logistical considerations (travel, cost, institutional support), and recommendations for improvement. Responses were analyzed descriptively and compared between adult and pediatric cohorts.

What are the results?
Most participants learned of the fellowship through word of mouth. Both adult and pediatric host sites were highly rated, with several identified as "must keep." Pediatric fellows demonstrated higher engagement, with all presenting cases during the fellowship and continuing mentorship afterward, whereas adult fellows had more variable participation. The most valued components were interaction with leaders in the field, operating room observation, and informal mentorship. Travel logistics were adequate for all participants. Financial support was generally sufficient but often supplemented by institutions. All participants would recommend the fellowship.

What are your conclusions?
The LLRS Traveling Fellowship provides high-value educational and mentorship experiences with consistent positive feedback across participants. Early-career participation appears optimal. Opportunities for improvement include increasing structured case engagement in the adult fellowship and refining site sequencing. Overall, the program has a meaningful and lasting impact on clinical development and professional growth.

Presidential Guest Lecture

Introduction by Mitchell Bernstein, MD

The Privileges of Being a Limb Reconstruction Surgeon –

To Reach What You Cannot and Be a Sparking Plug

Reggie C. Hamdy, MBBS

Traveling Fellowship Presentation

Introduction by Jaclyn F. Hill, MD

2025 Adult Fellows

Elizabeth Wellings, MD, PhD

Asanka Wijendra, MD

2026 Pediatric Fellows

Erin Honcharuk, MD

Daniela Alessia Marletta, MD

Session VII:

Torsion

Moderator – S. Robert Rozbruch, MD

The Acetabulum Doesn't Matter: Relationship Between Clinical Examination and Radiographic Measurements for Planning Torsional Corrections in the Lower Extremity

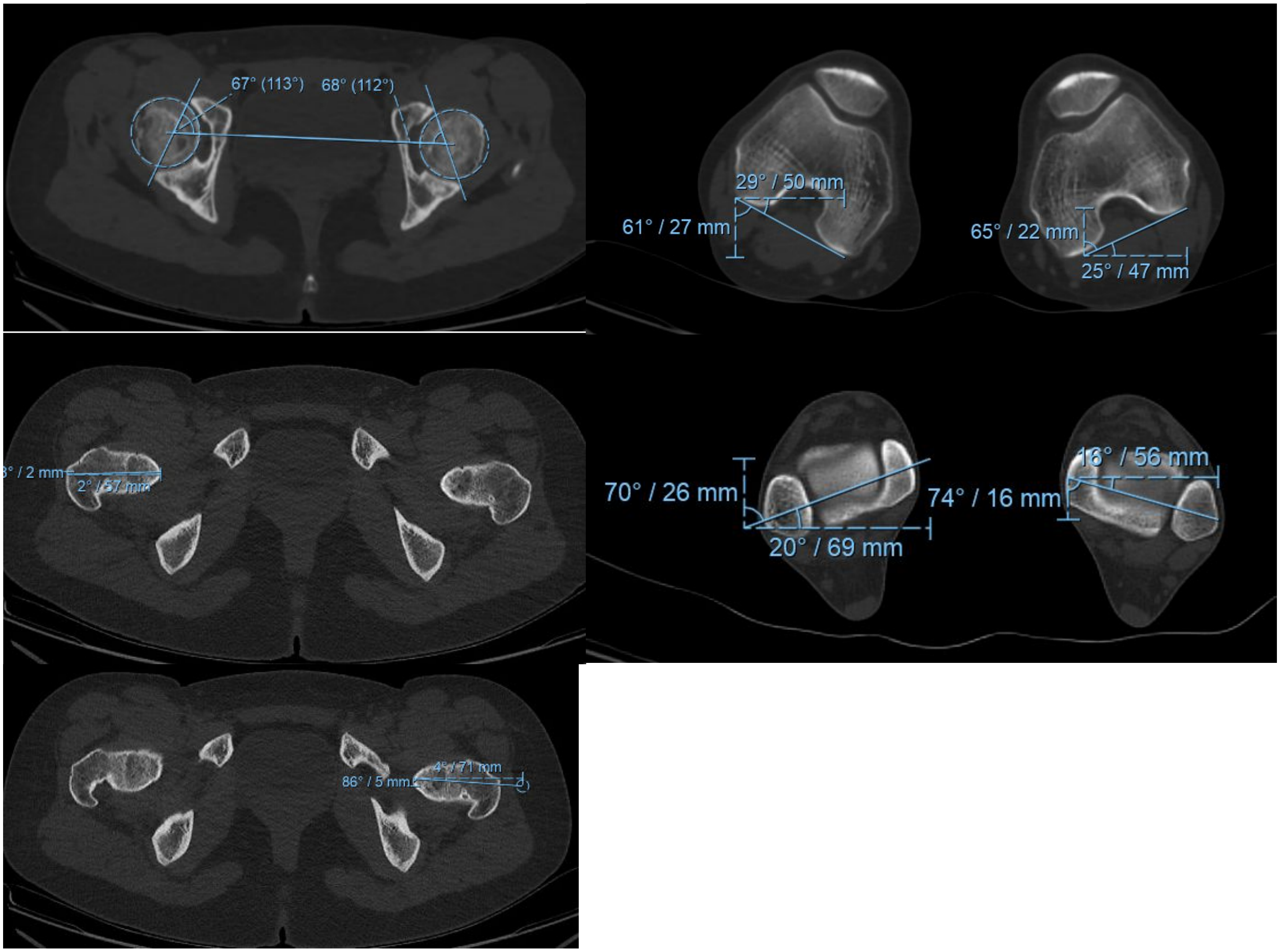
David Burns, MD, PhD; Drew LoPolito; Zachary Glassband; Jidapa Wongcharoenwatana, MD; Jason Hoellwarth, MD; Taylor J. Reif, MD; Austin T. Fragomen, MD; S. Robert Rozbruch, MD
david.mo.burns@gmail.com

What was the question?
Torsional malalignment in the lower extremities can occur from a diverse group of etiologies and lead to disordered gait with hip, knee and ankle pain. The platonic ideal is that the hip is in a neutral rotation during midstance of gait with the knee and foot oriented forward. Correlation of clinical and functional parameters with radiographic measurements is essential to understanding and planning torsional deformity correction. In the absence of soft tissue constraint, joint ankylosis, and foot deformity, we hypothesize the clinical rotational profile of the lower extremity is derived as a function of acetabular, femoral, and tibial torsion which together dictate the orientation of the knee and foot when the hip is extended in neutral rotation.

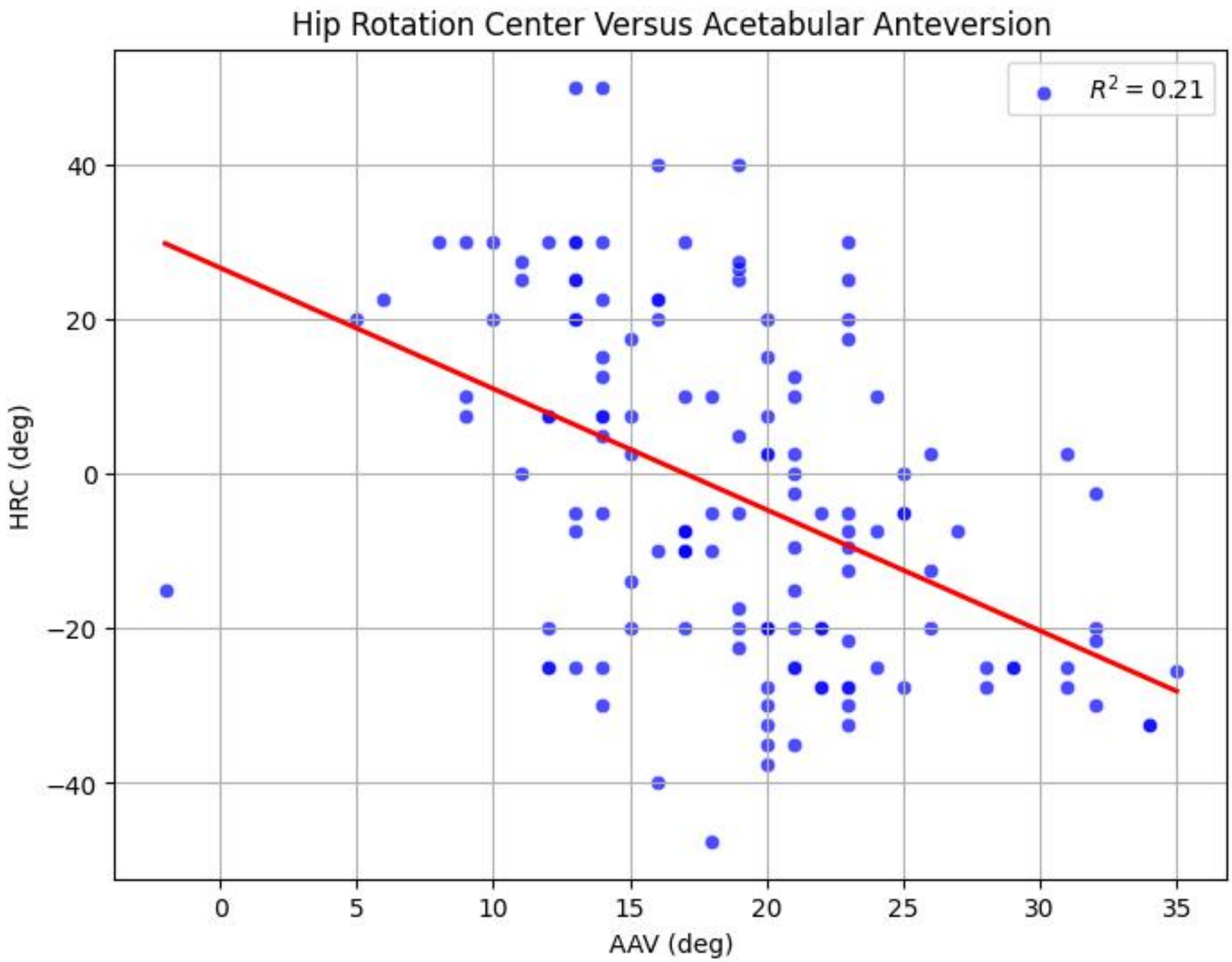
How did you answer the question?
We retrospectively reviewed all patients at our institution who underwent rotational deformity correction between April 2016 and June 2022, including both isolated rotations and multiplanar deformity. Patients with significant deformity within the foot bones were excluded. We measured the pre-operative clinical rotation profile including prone hip internal rotation (HIR), prone hip external rotation (HER), thigh foot axis (TFA), and gait foot progression angle (FPA) using a goniometer. The hip rotation center (HRC) is calculated as HER - HIR. We measured the radiographic pre-operative rotational profile including acetabular anteversion at the 3 o'clock position (AAV), femoral anteversion (FAV), and external tibial torsion (ETT) using axial CT multiplane reformats. We perform and report a linear regression analysis to determine the relationship between the clinical rotational parameters (HRC, TFA, FPA) and radiographic rotational parameters (AAV, FAV, and ETT).

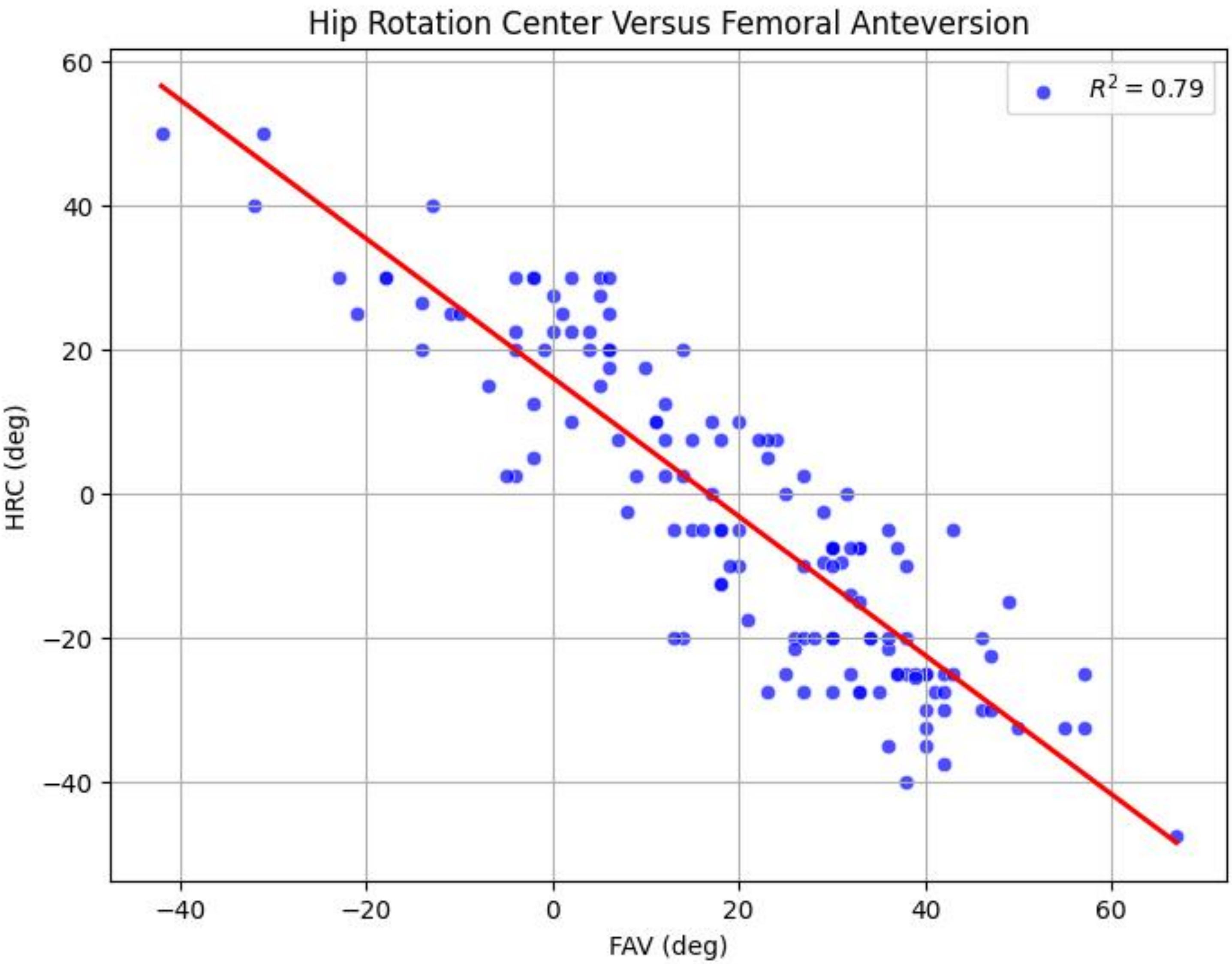
What are the results?
154 limbs in 77 patients were included in this cohort. There is a strong 1:1 linear relationship between hip rotation center and femoral anteversion ($R2=0.79$, slope=0.97). There is no significant improvement when modeling hip rotation center from either the Mckkibon index (sum of femoral and acetabular anteversion, $R2=0.80$) or as a bivariate model of femoral and acetabular anteversion ($R2=0.81$). There is a moderate linear relationship between thigh foot axis and external tibial torsion ($R2=0.47$, slope=0.63). There is a moderate-poor linear relationship between foot progression angle and combined femoral and tibial torsions ($R2=0.39$).

What are your conclusions?
Acetabular anteversion measured at the 3 o'clock position has minimal impact on the clinical prone hip rotation center and can be ignored when planning rotational corrections in the lower extremity. The hip rotation center is dictated by the femoral anteversion alone, which forms a solid basis for planning isolated femoral corrections. Thigh foot axis and gait foot progression angle have only moderate and moderate-weak relationships to the radiographic rotational measurements and caution should be used when planning rotational corrections based on them.



67° (113°)
68° (112°)
29° / 50 mm
61° / 27 mm
65° / 22 mm
25° / 47 mm
70° / 26 mm
74° / 16 mm
20° / 69 mm
86° / 5 mm
4° / 71 mm


Hip Rotation Center Versus Acetabular Anteversion
$R^2 = 0.21$
HRC (deg)
40
20
0
−20
−40
AAV (deg)
0
5
10
15
20
25
30
35



Hip Rotation Center Versus Femoral Anteversion
$R^2 = 0.79$
HRC (deg)
FAV (deg)
60
40
20
0
−20
−40
−40
−20
0
20
40
60

For Rotational Guided Growth Surgery the Sagittal Plane Angle Between the Constructs is Representative of Rotational Correction

Elizabeth A. Simmons, DO; Anjelyna Siamphone; Raymond W. Liu, MD
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What was the question?
Rotational guided growth is a potential lower morbidity alternative to osteotomy for pathologic femoral version and tibial torsion. It can be achieved by placing screw and cable tether constructs spanning the medial and lateral aspects of the physis oriented 90 degrees between the two on the lateral view. This study investigated whether change in the angle between the constructs on the lateral view is representative of rotational correction clinically.

How did you answer the question?
All rotational guided growth operations included in this study were performed by a single surgeon. At follow up, lateral radiographs of the knee were obtained, and construct angles were measured. Photographs of hip internal rotation and thigh foot angle were obtained at each follow up and measured digitally. Mean values were reported if initial post operative and at least one additional measurement was available at each respective data point.

What are the results?
A total of 13 constructs were assessed (7 patients total, 6 bilateral, 4 femurs, 9 tibias). Mean surgical age was 10.5±2.1 years. Six patients were male and one was female. Femur constructs had mean construct angulation change from baseline of 7 degrees, 21 degrees and 36 degrees at 3, 6 and 9 months ($r = 0.851$, $p<0.001$, $n = 12$). Tibia constructs had mean construct angulation change from baseline of 8 degrees, 13 degrees, 12 degrees, 21 degrees, and 27 degrees at 3, 6, 9, 12, and 15 months ($r = 0.738$, $p<0.001$, $n = 27$). Clinical images of hip internal rotation angle demonstrated a change from baseline of 6 degrees, 9 degrees, and 14 degrees at 6, 9, and 12 months ($r=0.922$ versus change in femur construct angle). Clinical images of thigh foot angle demonstrated a change from baseline of 6 degrees, 8 degrees, 9 degrees, 9 degrees and 12 degrees at 3, 6, 9, 12, and 15 months ($r=0.608$ versus change in tibia construct angle).

What are your conclusions?
Rotational guided growth is a new but valuable tool to treat rotational deformity in skeletally immature patients. Rotational guided growth appears to correct rotational deformity in both the femur and tibia, and radiographic angle between the constructs correlates fairly well with rotational correction in this small cohort. Surgeons using this technique should consider measuring construct angle on the lateral view at each visit, as construct angulation change reaffirms correction of rotational deformity.

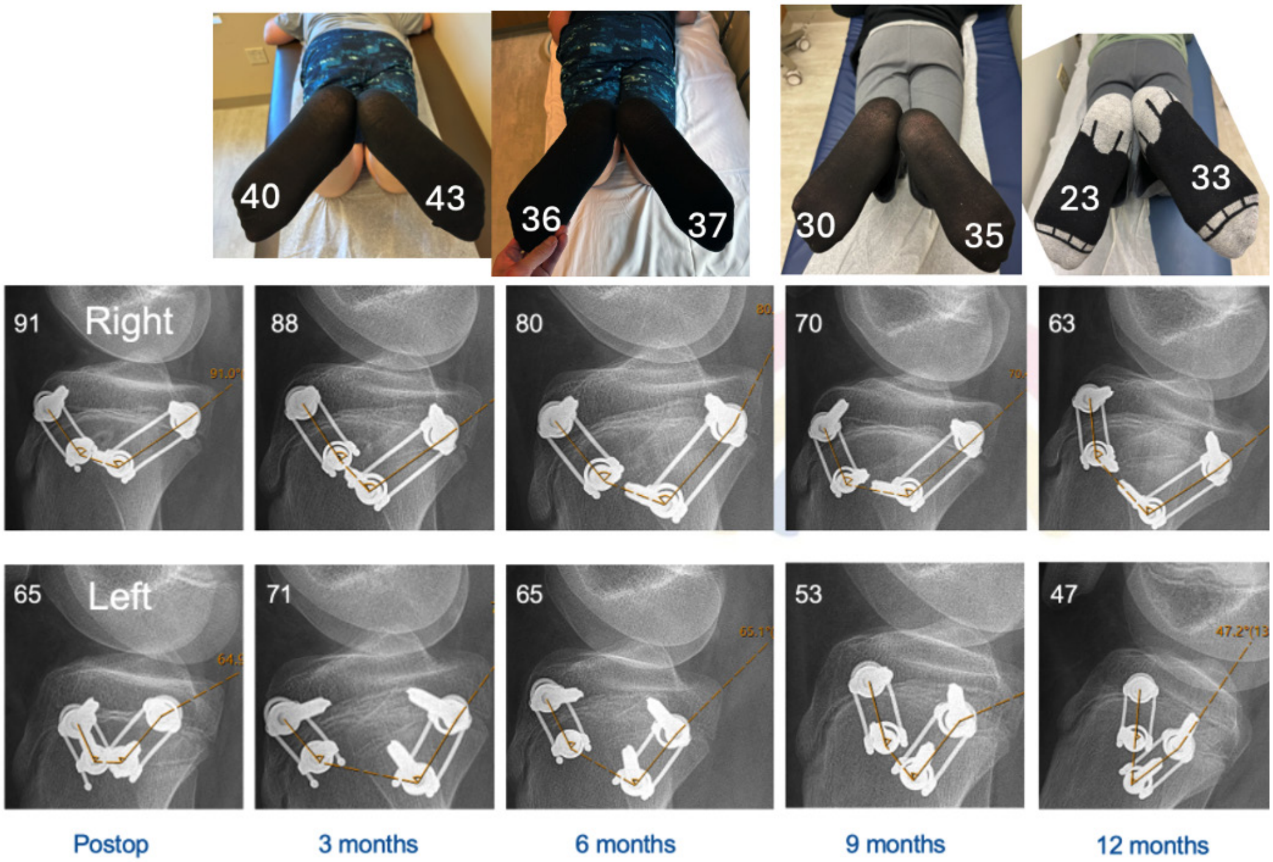

Figure: Photographs and radiographs of a 12-year-old male with bilateral external tibial torsion demonstrates progressive decrease in construct angle and decrease in thigh foot angle at each visit. Degrees of measurement are labeled on each image.

Effects of Femoral De–Rotation on Lower Limb Alignment Using Patient–Specific Guides with Reliance on EOS Scan, A Retrospective Study

Prof. Munjed Al Muderis; Muhammad Taqi; Jidapa Wongcharoenwatana; Mustafa Alttahir;
Kevin Tetsworth, MD
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What was the question?
Lower limb rotational alignment plays a critical role in gait mechanics, joint loading, and overall functional mobility. Abnormal femoral version, including excessive anteversion or retroversion, alters hip biomechanics and is associated with pain, instability, and compensatory gait adaptations. These changes can propagate throughout the kinetic chain, affecting knee alignment, pelvic posture, and potentially contributing to long–term degenerative conditions. Femoral de–rotation osteotomy is an established surgical intervention to restore physiological alignment and improve symptoms. However, concerns remain regarding its potential impact on coronal and sagittal plane alignment, as well as pelvic parameters, particularly given the complex interplay between axial correction and overall limb mechanics. Advances in three–dimensional (3D) imaging and patient–specific instrumentation (PSI) have enabled more precise correction of femoral torsion, yet the downstream effects of these techniques on global lower limb alignment remain incompletely understood. The aim of this study is to (1) evaluate the effects of midshaft femoral de–rotation surgery on the alignment of the lower limbs in the coronal and sagittal planes, (2) as well as its impact on pelvic parameters in patients with significant femoral anteversion or retroversion.

How did you answer the question?
A retrospective review was conducted on patients who underwent femoral de–rotation procedures using a minimally invasive patient–specific external guide system from January 2014 to January 2022 at Macquarie University Hospital. The surgery was done using preoperative 3D modelling and patient–specific external guides. Inclusion criteria comprised patients presenting with hip, knee, or patellofemoral symptoms due to high femoral anteversion who had complete EOS scans performed preoperatively and postoperatively. The EOS imaging system was utilized for accurate assessment and comparative analysis of alignment changes following the femoral de–rotation.

What are the results?
There were 22 limbs from 15 patients with an average age at operation of 30.41 ± 10.14 years (range 16.77–47.50). The average preoperative 3D EOS measurement of the femoral version in anteversion and retroversion groups were 32.84 ± 7.53 and -22.67 ± 13.32, respectively. The postoperative femoral version in anteversion and retroversion groups were 13.39 ± 12.90 and 3.67 ± 9.29 having $p<0.001$ and $p<0.014$, respectively. Paired t–test was employed to calculate statistical values. Other parameters, including Hip–knee–shaft (HKS) angle, knee angle, pelvic tilt, pelvic incidence, mechanical lateral distal femoral angle (mLDFA), and coronal plane alignment of the knee, were not statistically significant differences.

What are your conclusions?
This study provides evidence that femoral midshaft de–rotation surgery using patient–specific instrumentation (PSI) guides is an effective approach for correcting femoral anteversion and retroversion with no significant impact on coronal and sagittal lower limb alignment except femoral neck offset.

Rotational Guided Growth: Biomechanical Analysis of Asymmetrical Construct Length, Angle, and Fixation Tensioning

Anjelyna L Siamphone; Alexander Chang; Raymond W Liu, MD
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What was the question?
Femur and tibia rotational deformities are traditionally treated with osteotomy, which has significant surgical morbidity. Rotational guided growth (RGG), a relatively new lower morbidity alternative, uses obliquely oriented tension band constructs across the physis to gradually correct rotation during growth. Early experimental and clinical studies have shown rotational correction using symmetrically placed constructs. However, real clinical application may involve variations in construct length, insertional angle, or construct tensioning that could influence rotational correction. The biomechanical effects of these asymmetric constructs remain poorly understood. We aimed to evaluate how construct asymmetry affects rotational correction.

How did you answer the question?
A mathematical expression relating rotational correction to femoral diameter, construct length, construct angle, and distraction when symmetrical surgery is performed was used to generate theoretical correction curves. A custom biomechanical model using a sawbone femur was created to simulate progressive physeal distraction. Three experimental conditions were evaluated: (1) construct length mismatch placed at 45º angles (16+22mm, 16+28mm, 22+28mm), (2) angular mismatch using 22mm constructs (30º+45º, 30º+60º, 45º+60º), and (3) simulated fixation looseness using one construct 2mm oversized to the drillholes and placed at 45º angles (16+18mm, 22+24mm, 28+30mm). Incremental rotational correction with distraction was measured digitally on axial photographs and compared to theoretical values. Each experimental conditions was repeated three times and values averaged.

What are the results?
Rotational correction increased with distraction across all conditions, however, deviations from theoretical values were observed. (1) Construct length mismatch demonstrated rotational correction patterns closely matching theoretical predictions. (2) Angular mismatch produced correction approximating the average of predicted until the shorter-angle construct became vertical and prevented distraction. (3) Construct loosening followed theoretical but demonstrated delayed rotational response.

What are your conclusions?
RGG remains a promising technique for rotational deformities. These findings demonstrate that rotational guided growth with asymmetrical constructs remain close to theoretical predictions, suggesting that asymmetry in construct placement is relatively well tolerated. With angular mismatch, however, correction is limited once one construct becomes vertical and halts distraction on that side. The tolerance of construct asymmetries observed in this study suggest that minor placement inaccuracies due to anatomical constraints or surgical technique are acceptable.

Figure 1. Construct length mismatch at 45º. Green plot shows model results which match with theoretical values well.

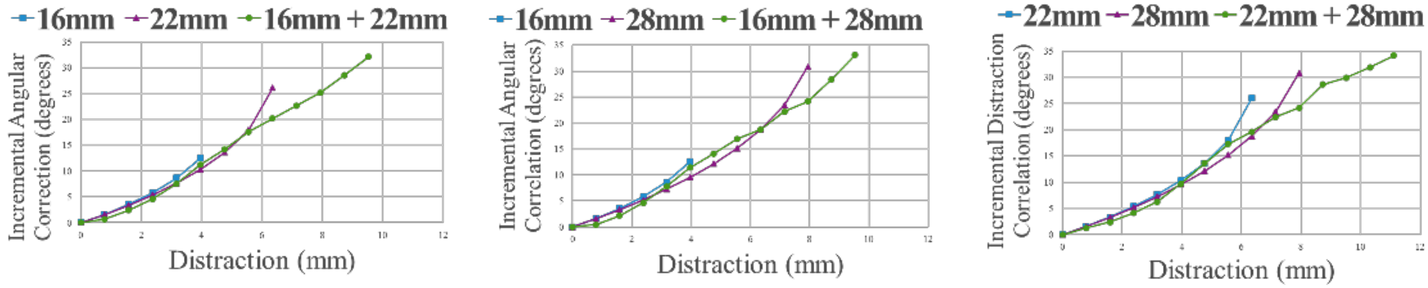


Figure 2. Angular mismatch using 22 mm constructs. Green plot shows model results which performs in between theoretical values but with a changes in slope when one construct becomes vertical (arrows).

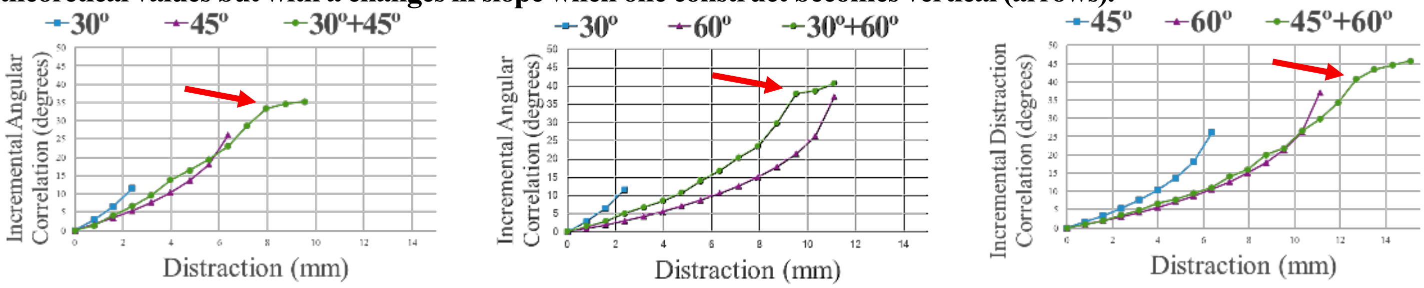
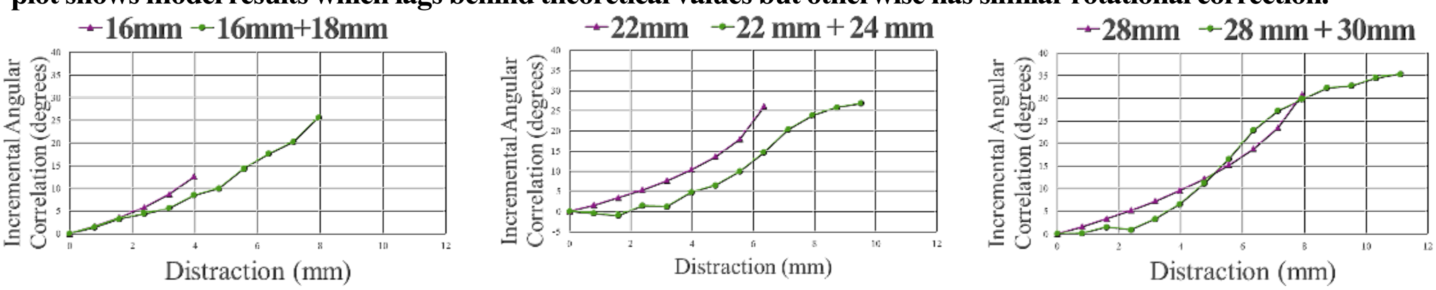


Figure 3. Construct tensioning purposely decreased on one side simulated by using a construct 2mm too large. Green plot shows model results which lags behind theoretical values but otherwise has similar rotational correction.



Deborah F. Stanitski Diversity Presentation

Confidence, Imposter Syndrome, and Perfectionism in Surgery

Julie B. Samora, MD, PhD, MPH

Deborah F. Stanitski, MD

Dr. Debbie Stanitski is a retired pediatric orthopedic surgeon and former event rider who sustained a traumatic brain injury in 1999. Today she competes in Para Dressage with her Danish mare Skovlunds de Nice ("Jolie"). Debbie lives in Charleston, South Carolina with her husband Carl.

• Born Chicago, Illinois June 12,1953. One brother November 2,1954
• AFS student in Penang. Malaysia 1970
• BA Smith College 1975-microbiology and Asian Studies. Sigma Xi honor society
• Rockefeller University-tumor virology 1975-6
• 1976-80 M.D. University of Cincinnati
• 1981-1985 Harvard University resident in orthopedic surgery
• January-July 1986trauma fellowship University of Toronto
• July-December 1986 Pediatric Orthopedic fellowship University of Toronto
• 1986-91 Lecturer and Assistant Professor University of Toronto
• 1991-October 1998. Associate Professor and assistant department chief Children's Hospital of Michigan
• October, 1998- December 2005 Full Professor Medical University of South Carolina, Charleston
• March 14, 1999 closed head injury. January, 2000- retirement in December, 2005 nonoperative orthopedics
• Currently need walker for balance; wheelchair for long distance.
• Currently spend much time playing croquet (have advanced to tournament level from beginner). 4-5 x/week
• Paraequestrian dressage on newish (June, 2024) 6 year old calm bay gelding- 4-5x/week
• Gym 6x/week

Dr. Deborah Stanitski - Life After a Traumatic Brain Injury

Session VIII:

Limb Reconstruction Part 3

Moderator – Aaron J. Huser, DO

Intraoperative Neuromonitoring in Setting of Peripheral Nerve Blocks for Lower Extremity Deformity Corrections

Rajiv Siddhartha Vasudevan; Kevin Pirruccio; David B. Frumberg, MD
rajiv.vasudevan@yale.edu

What was the question?
Peripheral nerve blocks (PNBs) are widely used in orthopaedic surgery to improve perioperative analgesia and reduce opioid consumption. However, their use in procedures requiring intraoperative neuromonitoring (IONM) has historically been limited due to concerns that regional anesthesia may attenuate neural conduction and degrade somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs). While prior studies have explored the interaction between regional anesthesia and neuromonitoring in spinal deformity surgery, the impact of distal PNBs on IONM signal quality during lower extremity deformity correction has not been well characterized. The purpose of this study was to evaluate the quality and interpretability of neuromonitoring data in patients undergoing lower extremity deformity correction who received preoperative PNBs.

How did you answer the question?
As part of a pilot feasibility assessment, we conducted a retrospective observational study of patients undergoing lower extremity deformity correction procedures performed by a single surgeon between September 2022 and December 2025. All patients received a PNB in the preoperative holding area and IONM. IONM signals were categorized as Good, Fair, or Poor based on established neurophysiologic criteria. Descriptive statistics were used to summarize patient characteristics, block types, anesthetic variables, and neuromonitoring signal quality.

What are the results?
13 patients undergoing 14 surgical cases were included. The most common blocks were sciatic (85.7%), femoral (57.1%), and adductor canal (35.7%). At the start of surgery, 71.4% of cases demonstrated Good IONM signal quality and 28.6% demonstrated Fair signal quality, with no cases classified as Poor. All cases with Good baseline signals maintained Good signal quality throughout surgery. One case demonstrated signal deterioration from Fair to Poor quality by the end of the procedure. Neuromonitoring changes were documented in 21.4% of cases. No postoperative neurologic deficits were observed.

What are your conclusions?
In this pilot cohort, clinically interpretable neuromonitoring signals were obtained in all patients undergoing lower extremity deformity correction despite the use of preoperative PNBs. These findings suggest that distal peripheral nerve blocks do not uniformly preclude reliable neuromonitoring and may be compatible with intraoperative neurologic surveillance while preserving the analgesic benefits of regional anesthesia.

Exploring Perceptions of Body Image and Eating Behaviour in Adolescents with Lower Limb Differences

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What was the question?
What is the prevalence of body image concerns in adolescents with lower limb differences, and how do these concerns intersect with disordered eating, psychological well-being, and limb-specific measures?

How did you answer the question?
Participants were recruited from a Limb Reconstruction Clinic situated within a tertiary care hospital. Body image concerns and disordered eating behaviours were assessed using the Youth Eating Disorder Examination Questionnaire (YEDE-Q8). Psychological well-being and limb-specific outcomes, including limb appearance, physical function, and leg-related distress, were assessed using LIMB-Q Kids, a condition-specific patient-reported outcome measure. Linear regression analyses were conducted to examine associations between body image concerns and both disordered eating and psychological well-being. Pearson correlations and Welch tests were used to assess relationships with limb-specific and clinical outcomes, as well as demographic variables.

What are the results?
At the time of abstract submission, 40 participants completed YEDE-Q8 (Table 1). More than half of participants reported at least some level of body image concern (52.5%) and disordered-eating behaviour (57.5%). Greater body image concerns were significantly associated with increased disordered eating behaviour and poorer psychological well-being, but not with limb-specific measures or the severity of limb length difference. Additionally, body image concerns did not differ by gender or age (Table 2).

What are your conclusions?
Based on the available data, body image concerns seem to be strongly associated with disordered eating behaviours and psychological well-being in adolescents with lower limb differences, but do not appear to be related to limb-specific outcomes or length discrepancy or demographic factors. These findings suggest that body image concerns in this population may be more reflective of a broader psychosocial construct than of specific limb-related concerns. Psychological interventions targeting body image may improve psychosocial outcomes and reduce the risk of disordered eating in this population. However, a bigger sample size is required to perform a more robust analysis. Qualitative interviews are planned to further explore perceptions of body image and eating behaviour related concerns in this population.

Table 1. Participant Characteristics

Characteristic	Value
YEDE-Q8 sample size, n	40
Age, median (IQR)	12 (10.5-14.5)
Female, n (%)	21 (52.5%)
Male, n (%)	19 (47.5%)

Note. The full sample (n = 40) was used for YEDE-Q8 analyses. LIMB-Q Kids analyses were conducted on a subset of participants (n = 36) due to incomplete LIMB-Q Kids data.

Table 2. Associations Between Body Image Concerns and Behavioural, Psychological, Limb-Specific, and Clinical Outcomes

Association	Result
Primary Outcomes	
Body image concerns and disordered eating behaviour	$\beta = 0.73$, $p < .001$, $R^2 = .62$
Body image concerns and psychological well-being	$\beta = -7.76$, $p = .006$, $R^2 = .20$
Limb-Specific Outcomes	
Body image concerns and limb appearance satisfaction	$r = .06$, $p = .70$
Body image concerns and leg-related distress	$r = -.04$, $p = .80$
Body image concerns and physical function	$r = .10$, $p = .50$
Demographic Variables	
Body image concerns and age	$r = .12$, $p = .50$
Body image concerns and gender	$p = .40$
Leg Length Discrepancy (LLD)	
Body image concerns and LLD severity	$r = -.30$, $p = .20$
Behavioural symptoms and LLD severity	$r = -.43$, $p = .03$
Psychological functioning and LLD severity	$r = .21$, $p = .30$

Defining Early Postoperative Weight Trends in Patients Undergoing Limb Reconstruction Surgery by Distraction Osteogenesis

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What was the question?
Distraction osteogenesis (DO) is central to treating limb length discrepancy, deformity, and segmental defects. During recovery, weight may change due to osteogenic metabolic demand, pain, reduced mobility, appetite variation, and disuse–related muscle loss. Because clinically meaningful weight change may influence wound healing, infection risk, and regenerate quality, defining the early postoperative trajectory in humans is important. We aimed to characterize early weight change after DO–based limb reconstruction and identify when deviations from baseline are greatest.

How did you answer the question?
We performed a single–center retrospective review of major limb reconstruction procedures (January 1, 2016–December 31, 2022) with ≥1 year follow–up. Demographics, treatment group, implant type, healing milestones, complications, and serial weights were collected. Percent change in body weight from baseline within 0–84 postoperative days was modeled using linear mixed–effects regression with a quadratic time term and patient–specific random intercepts and slopes. We estimated the timing and magnitude of the lowest point with 95% confidence intervals. Analyses were performed in Stata 18.

What are the results?
Across four treatment groups (external fixation for deformity correction alone, external fixation for limb length discrepancy equalization, extramedullary lengthening, and intramedullary lengthening), 175 patients contributed 1,066 postoperative weight measurements (mean 6.1 per patient). Over 12 weeks, intramedullary lengthening demonstrated the most distinct U–shaped trajectory, with early weight loss reaching its lowest point of about 2% below baseline around 6 weeks (about 45 days), followed by gradual recovery. (Figure 1) Across lengthening cohorts, early weight loss was associated with higher bone healing index or external fixator index (BHI,EFI) (suggesting slower healing), but differences were not statistically significant. (Figure 2)

What are your conclusions?
Early postoperative weight trajectories after DO vary by treatment group, with intramedullary lengthening showing the most pronounced early decline and subsequent recovery. Early weight loss showed a consistent, though non–significant, trend toward higher bone healing index and external fixator index. It appears the nutritional evaluation and potential supplementation may be beneficial, especially for intramedullary lengthening patients.

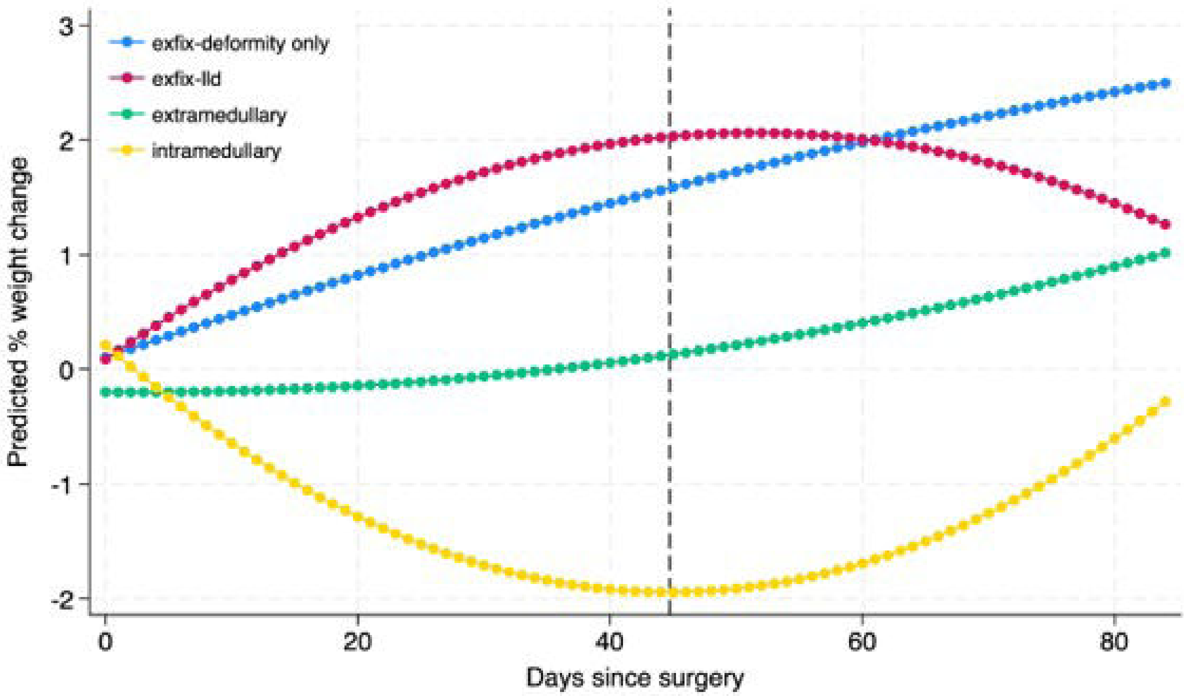

Figure 1. Model-based trajectories of percent weight change during postoperative days 0–84 by treatment group.

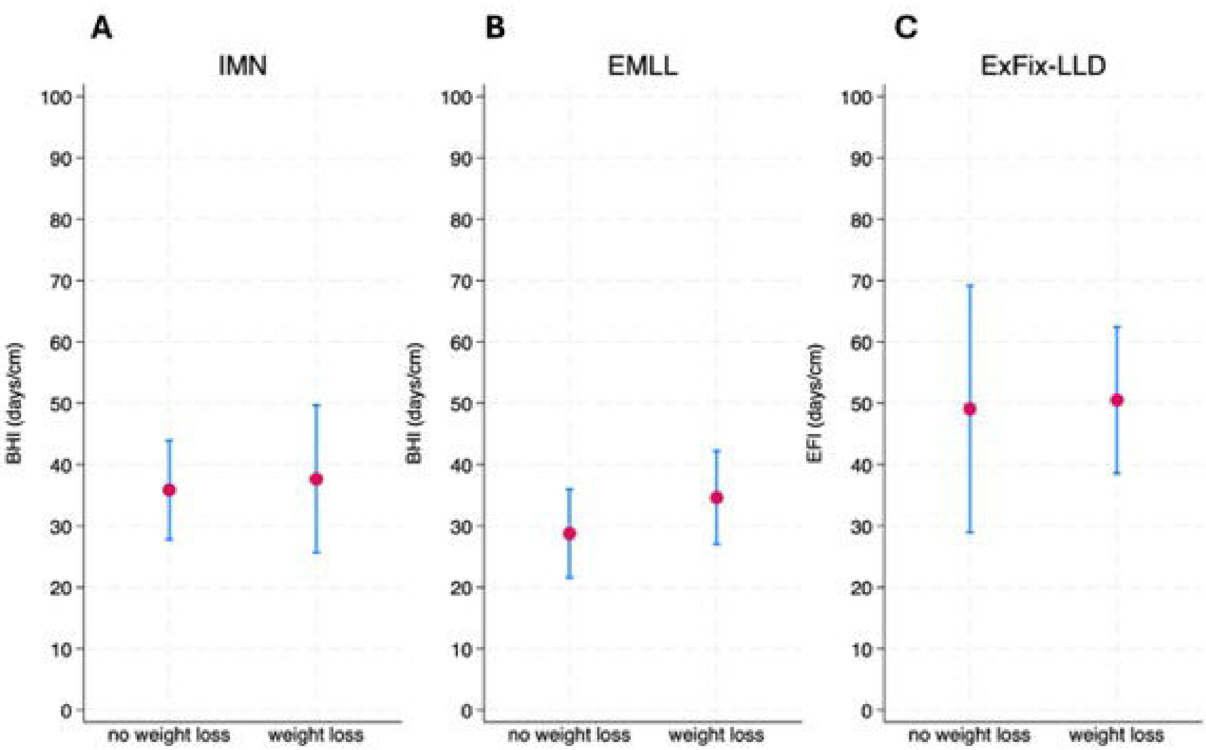

Figure 2: Bone healing indices and external fixator indices (BHI,EFI) by early postoperative weight change (weight loss vs no loss) across three limb lengthening cohorts. **A**. Intramedullary limb lengthening (IMLL). **B**. Extramedullary limb lengthening (EMLL). **C**. External fixator limb lengthening.

An Assessment of the Pre-Operative Vitamin D Levels in Patients Undergoing Limb Lengthening Surgery

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What was the question?
Vitamin D plays a crucial role in skeletal health. With distraction osteogenesis representing one of the most biologically demanding forms of bone regeneration, adequate nutritional and hormonal support are essential to sustain the cellular and molecular processes that drive bone formation during distraction and consolidation. Emerging evidence suggests that vitamin D deficiency is prevalent among patients undergoing limb reconstruction surgery. The potential impact of preoperative vitamin D status on bone healing efficiency and complication risk during distraction osteogenesis in children remains poorly understood. Our objective was to determine the prevalence of preoperative vitamin D deficiency among pediatric patients undergoing limb reconstruction for deformity correction or limb length discrepancy, and evaluate the association between preoperative vitamin D levels, bone healing parameters, and the incidence of postoperative complications.

How did you answer the question?
We conducted a retrospective chart review of pediatric patients treated at our institution between January 2017 and December 2021 for lower limb length discrepancy using an internal lengthening nail. We grouped patients into deficient, insufficient, and sufficient subgroups based on pre-operative vitamin D levels and compared vitamin D levels with the Bone Healing Index (BHI) as well as the incidence of complications.

What are the results?
A total of 75 pediatric patients undergoing limb reconstruction surgery were included in this study. Twenty-two patients (29.3%) were classified as vitamin D deficient (<20 ng/mL), 30 (40.0%) as insufficient (20-29 ng/mL), and 23 (30.7%) as sufficient (-30 ng/mL). No patients had vitamin D levels exceeding 120 ng/mL. Patient demographics were similar across the subgroups. Complications occurred in 13.6% of patients with deficient vitamin D levels, 6.7% with insufficient levels, and 8.7% with sufficient levels. There was no statistically significant difference in the incidence of complications across the three groups ($p = 0.791$). There was no significant correlation between preoperative vitamin D levels and the bone healing index.

What are your conclusions?
Preoperative serum vitamin D level was not a significant predictor of bone healing rate, as measured by the Bone Healing Index, in pediatric patients undergoing limb reconstruction. Within the physiologic range observed, variations in vitamin D concentration did not appear to meaningfully influence regenerate formation or maturation.

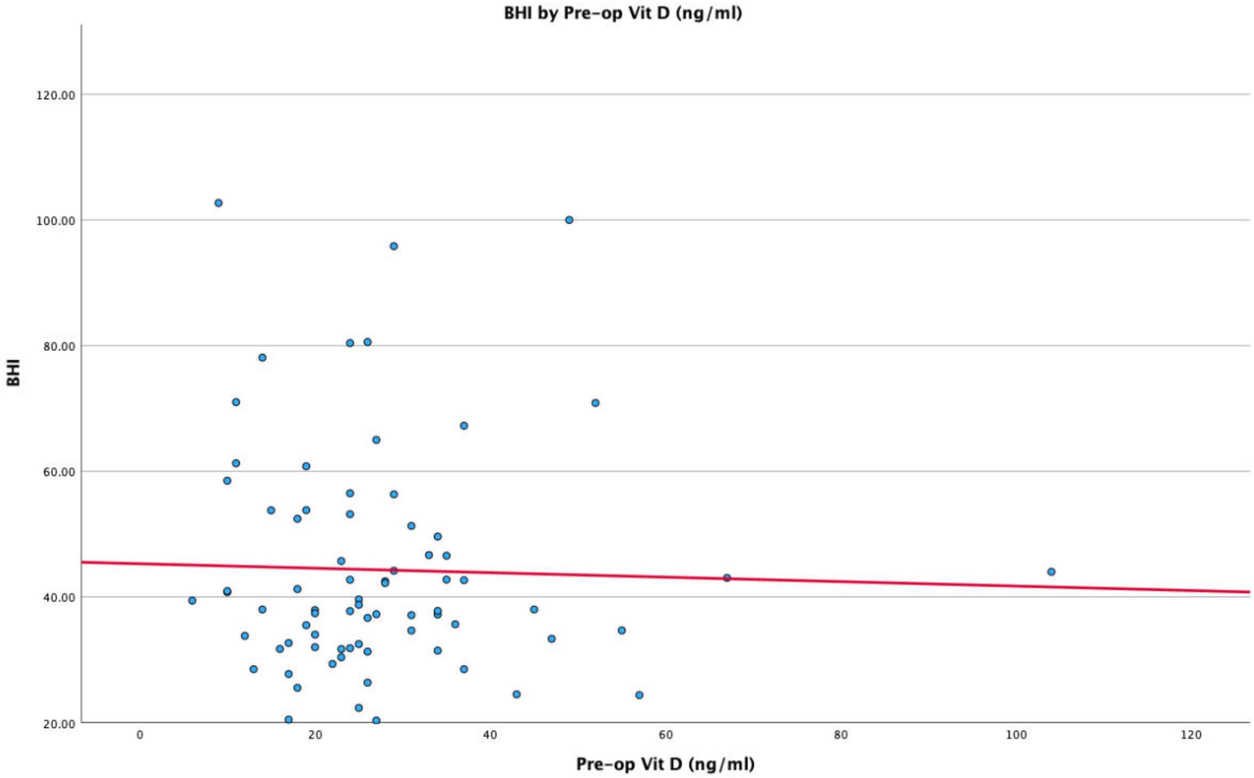

Figure. Scatterplot for preoperative vitamin D levels versus bone healing index (BHI) .

Table. Summary characteristics of patients by Vitamin D category

Variable	Deficient (<20 ng/mL)	Insufficient (20–29 ng/mL)	Sufficient (≥30 ng/mL)	p-value*
Age (years)	14.00 [12.00–18.00]	15.00 [11.00–15.00]	15.00 [12.00–16.00]	0.877
BMI (kg/m²)	22.58 [19.99–28.19]	19.94 [17.46–23.01]	19.86 [17.73–20.97]	0.144
Surgery duration (mins)	95.00 [75.00–137.50]	95.00 [84.00–131.00]	105.00 [89.00–126.00]	0.735
BHI (days/cm)	40.09 [32.20–59.65]	39.17 [31.84–53.18]	38.00 [34.65–46.56]	0.747
Lengthening index (days/cm)	13.43 [12.22–15.78]	12.71 [11.00–14.50]	13.26 [11.67–15.76]	0.229
Length gained (cm)	3.825 [2.5–4.85]	4.0 [3.0–4.9]	3.7 [3.0–4.3]	0.606
Days of lengthening	56.00 [35.00–71.00]	53.00 [42.00–57.00]	53.00 [41.00–57.00]	0.876
Hardware retention (days)	332.50 [283.00–385.00]	371.50 [275.00–446.00]	371.00 [273.00–441.00]	0.854
Healing duration (days)	136.50 [113.50–194.50]	153.50 [128.00–194.00]	142.00 [117.00–170.00]	0.721
Sex	Female 10 (45.5%) Male 12 (54.5%)	Female 7 (23.3%) Male 23 (76.7%)	Female 7 (30.4%) Male 16 (69.6%)	0.236 (χ^2)
Complications (Yes/No)	3 (13.6%) / 19 (86.4%)	2 (6.7%) / 28 (93.3%)	2 (8.7%) / 21 (91.3%)	0.791‡
Bone involved (Femur/Tibia)	19/3 (86.4/13.6%)	28/2 (93.3/6.7%)	19/4 (82.6/17.4%)	0.545 ‡

The International Limb Differences Registry: A Global Collaboration to Advance Limb Reconstruction Outcomes

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What was the question?
The development of this registry is in its nature not a hypothesis-driven study, however, it is designed in such a way that it can be used as a platform to facilitate the execution of a prioiri hypothesis driven trials. Children with limb differences undergo complex surgeries with lifelong physical, psychological, and social impact, yet clinical decisions largely rely on fragmented, retrospective or small-scale prospective data. The International Limb Differences Registry (ILDR) addresses this gap by collecting standardized, prospective, long-term data across the full spectrum of limb differences to advance evidence-based and patient-centered care.

How did you answer the question?
ILDR is a multicentre, prospective group of diagnosis-specific sub-registries with follow-up to atleast skeletal maturity. Data collection includes demographics, socio-economic variables, diagnosis, disease classification, clinical and radiographic outcomes, interventions, complications, and patient reported outcomes. Registry development involves collaboration with clinicians from various high-, middle-, and low-income countries to ensure feasibility, accessibility and scalability across healthcare settings.

What are the results?
Since 2024, ILDR has expanded to 6 actively recruiting sites from Canada and the USA. In total, 13 sites have complete training and approvals. Six additional sites from Denmark, India and the UK are engaged in obtaining approvals.
We have 129 patients from 5 sites recruited for the Osteogenesis Imperfecta-sub-registry and 14 patients from 3 sites recruited for the Musculoskeletal Infections sub-registry across Canada and the USA (Table 1). The Morquio-B sub-registry is also open for recruitment. Sub-registries in development include congenital pseudoarthrosis of tibia, fibular hemimelia, congenital femoral deficiency, Blount€™s disease, benign tumours, posteromedial bowing, tibial hemimelia and skeletal dysplasia.

What are your conclusions?
ILDR represents the first international effort capturing comprehensive, standardized, prospectively collected data on children with limb differences. Inclusion of clinicians from both high- and low-income countries ensures global relevance and feasibility. By fostering global collaboration, the registry aims to generate high-quality evidence to optimize care, benchmark outcomes, and amplify patient voices. As ILDR expands, this registry will further enhance its capacity to inform best practices and improve quality of life for patients with limb differences.

Table 1: Summary of recruited patients per sub-registry by country

Sub-Registry	**Canada**	**United States**	**Total**
Osteogenesis Imperfecta *(Since May 2024)*	20	109	129
Musculoskeletal Infections *(Since October 2025)*	10	4	14

**Data as of 2026-Apr-02*

Session IX:

Award Nominated Papers Part 1

Moderator – Jessica C. Rivera, MD, PhD

Effect of Tibiofibular Screw Angle on Distal Fibular Migration in Tibial Distraction Osteogenesis: A Finite Element Analysis

İsmail Tarık Atasoy; Oğuzhan Günbatar; Mert Ege; Dağhan Koyuncu; Aleyna Yeşilyurt;
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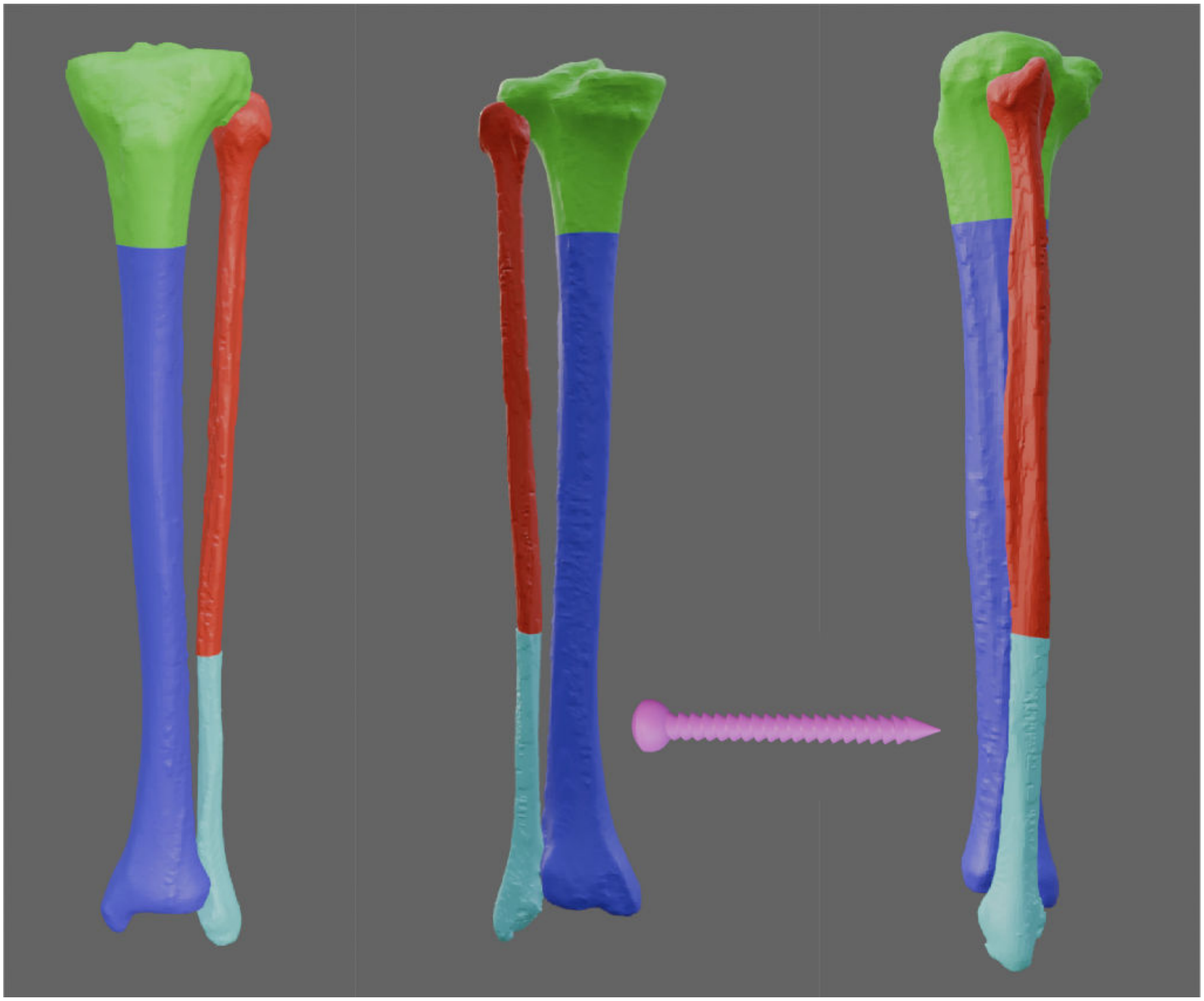
tarikatasoy96@gmail.com

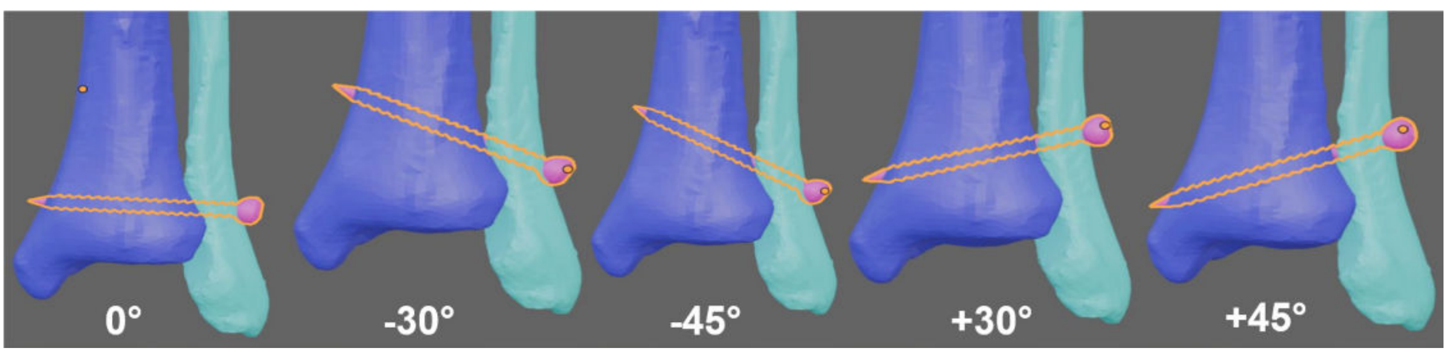
What was the question?
During tibial distraction osteogenesis, fibular migration can occur and may contribute to ankle and knee alignment problems. This study asked whether tibiofibular screw angle (relative to the ankle joint line) affects stepwise distal fibular migration and implant/bone stress distribution, and which screw orientation provides the most favorable biomechanical balance.

How did you answer the question?
A three-dimensional finite element model of the tibia, fibula, interosseous membrane, and a tibiofibular screw was developed. Osteotomies were simulated at the proximal one-third of the tibia and distal one-third of the fibula, and five screw orientations were tested: 0°, +30°, +45°, -30°, and -45° relative to the ankle joint line. Materials were modeled as isotropic, homogeneous, and linearly elastic using published properties, with standardized boundary conditions and a 300 N axial load representing the average resultant of muscle and ground reaction forces during a 1 mm lengthening step. Outcomes included distal fibular migration, screw/bone stresses (von Mises, shear, normal), and safety factors.

What are the results?
All finite element models converged and showed similar global deformation under a 300 N axial load during a single 1-mm distraction step. Distal fibular migration occurred in every configuration and ranged from 0.0096-0.015 mm. Migration was highest with the 0° (joint-parallel) screw (0.015 mm) and decreased slightly with positive obliquity (+30°: 0.014 mm; +45°: 0.0135 mm). Negative obliquity reduced migration further (-30°: 0.0096 mm; -45°: 0.013 mm). Screw loading patterns were angle-dependent: the 0° construct was predominantly shear-loaded (peak shear 1.74 MPa) with negligible normal stress. At +30°, peak shear fell to 0.85 MPa while normal stress increased to 1.47 MPa, indicating a shift toward combined loading. At +45°, shear and normal stresses were approximately balanced (~1.4 MPa each). Despite the lower migration, negative-angle constructs increased screw von Mises stress (2.04-2.18 MPa). Tibial and fibular stresses remained low overall, with stress concentrations primarily at the screw-cortex interface and around osteotomy regions. Minimum safety factors remained high across all models (~45 fibula, ~55 tibia, ~206 screw).

What are your conclusions?
Finite element analysis indicates that tibiofibular screw orientation meaningfully influences distal fibular migration and implant stress distribution during tibial lengthening. Although negative obliquity may reduce migration, it increases screw stress, whereas a +30° oblique screw provides a practical compromise-low migration with lower implant stresses and high safety margins. These findings support considering a moderately oblique (+30°) configuration when tibiofibular screw stabilization is used during tibial distraction osteogenesis.





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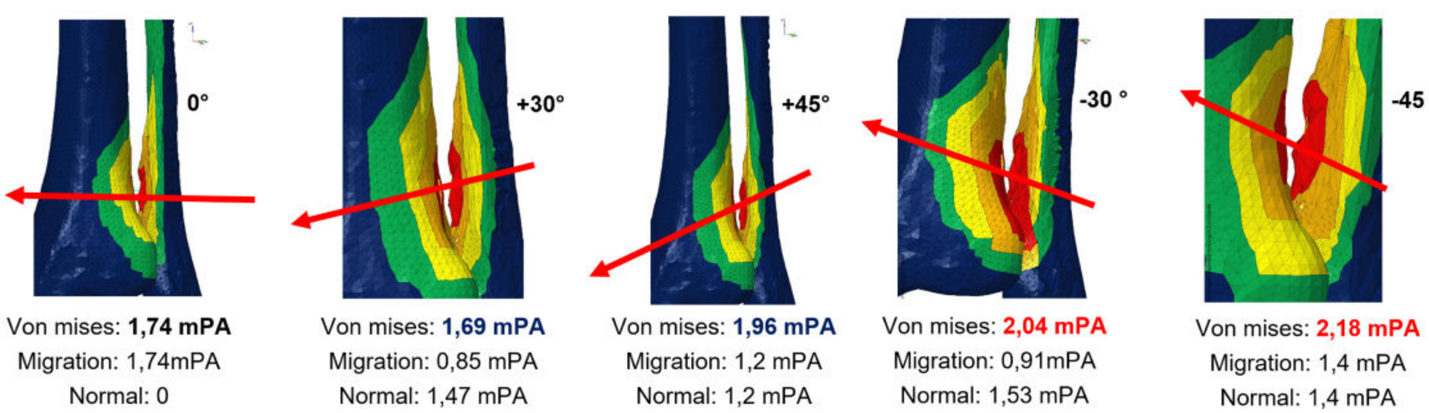

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Von mises: **2,04 mPA**
Migration: 0,91mPA
Normal: 1,53 mPA
Von mises: **2,18 mPA**
Migration: 1,4 mPA
Normal: 1,4 mPA

Does Calcium Sulfate affect Post–Injury Local Immune Environment?

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What was the question?
Common bone void fillers, such as calcium sulfate preparations, are often used as a means to deliver antibiotics to compromised injured tissue considered at risk for infection. However, elevated extracellular calcium has been shown to perpetuate pro–inflammatory immune cell phenotypes which could result in adverse effects on local tissue. The purpose of this study was to examine how a clinically available calcium sulfate bead product modulated macrophage polarization in vitro and in vivo.

How did you answer the question?
Following regulatory approvals (IBC #5142; IACUC #5072), RAW 264.7 murine macrophages were cultured under standard conditions (37°C, 5% CO_2; Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum and 1% penicillin–streptomycin) and exposed to sterile calcium sulfate beads secured in 3D–printed polylactic acid inserts within 35 mm diameter culture plates. Polylactic acid inserts without beads served as controls. After a 48–hour incubation, culture supernatant was collected for cytokine profiling using the LEGENDplex™ Mouse Macrophage Panel (13–plex), which measures both pro–inflammatory (CXCL1, IL–18, IL–23, IL–12p70, IL–6, TNF–α, IL–12p40, IL–1Î²) and anti–inflammatory (TGF–Î²1, CCL22, IL–10, IL–6, G–CSF, CCL17) cytokines. Cells were fixed in zinc–buffered formalin, stained with phalloidin/DAPI, and imaged via confocal microscopy to evaluate cell morphology and density. For in vivo study, 32 female CD–1 mice underwent a unilateral freeze burn injury to the vastus lateralis muscle and then were randomized to calcium sulfate bead placement (experimental) or no bead placement (control). Mice were euthanized and tissue samples (muscle, bone, marrow) were harvested at days 3 and 14 post–injury for RNA extraction and histologic analysis. Harvested muscles were stained with H&E, and immunofluorescence stains including DAPI to detect all nuclei present, IBA1 for pan macrophage, CD86 for M1 phenotype macrophages, and CD206 for M2 phenotype macrophages. MicroCT of the calcium sulfate bead dispersal was calculated to as a proxy for calcium exposure to the tissue.

What are the results?
Cytokine analysis indicated that calcium sulfate exposure was not associated with profile shifts to either pro– or anti–inflammatory cytokines typical for macrophage polarization. TNF– α and IL–10 levels were significantly elevated following calcium sulfate bead exposure compared to controls while remaining cytokines remained below detectable thresholds. Cell morphology was not qualitatively different between experimental and control cultured cells. The in vivo microCT analysis of the calcium sulfate bead revealed the mean intensity and maximum intensity of the bead–labeled voxels decreased at day 14 compared to day 3 and variability in bead dispersion was greater in the 14–day post–injury mice with a calcium sulfate dispersal volume ranging from 18.81 mm3 to 589.04 mm3, compared to 63.03 mm3 to 113.71 mm3 at day 3. All harvested muscles have been stained and qualitative analysis of the tissue macrophage populations is ongoing.

What are your conclusions?
Calcium sulfate bead exposure did not strongly bias RAW 264.7 macrophages toward either a pro–inflammatory or anti–inflammatory phenotype. These in vitro results are limited by the non–polarized state of our RAW macrophage model where injured tissues would involved polarized macrophages. Final quantification of the in vivo results is ongoing to confirm or dispute the in vitro results in the setting of an injury model. However, the limited observed effect of calcium sulfate to affect macrophage polarization is reassuring given the common application of calcium sulfate in wound environments.

Comparative Analysis of Hindfoot Arthrodesis Using Dynamic Compression Nails Versus Static Nails

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What was the question?
Hindfoot fusion benefits from compression of the fusion surfaces, typically delivered intra–operatively. A new generation of hindfoot nails provide ongoing “dynamic” compression after leaving the OR, either via nitinol or magnetically controlled compression, which in theory should speed fusion and improve fusion rates, even in difficult situations. So how does this new generation of nails compare with static compression nails, with regard to fusion time and rate, time to weight bearing, and patient reported outcomes?

How did you answer the question?
All hindfoot (tibiotalocalcaneal and tibiocalcaneal) arthrodeses performed with intramedullary implants from January 2016 to July 2025 were reviewed. A total of 90 ankle (TT or TC) joints and 72 subtalar joints were available for analysis. Bone grafting was performed in all cases except for 2 ankles in the dynamic group and 4 in the static group. Fusion was considered successful if there was at least 50% bone bridging across the joint surface on XR or CT. Clinic records identified when the patient confirmed the ability to weight bear as tolerated on the operative ankle. Self–reported patient outcome scores, PROMIS and LD–SRS, were collected preoperatively and postoperatively. Operative and patient variables were collected to evaluate the influence of comorbidities on surgical outcomes. For time to union, weightbearing, and PROMs, either a Student’s t–test or Wilcoxon Rank–Sum test was applied. Fusion rates were compared using X2 analysis. A univariate linear regression was used to evaluate the effect of each comorbidity on the log–transformed time to union for both joints. Comorbidities found to be significant in this analysis were then entered into a multivariate linear regression model. A p–value ‰¤ 0.05 was considered statistically significant for all analyses.

What are the results?
There were 44 ankle and 32 subtalar fusions in the dynamic group versus 46 ankle and 40 subtalar joints in the static group. For the ankle joint, time to union was significantly faster in the dynamic group by an average of 9 days (93 [IQR 45.75] vs 102 [IQR 65.5], p = 0.05). The subtalar joint also showed an improvement for dynamic nails by 6 days (90 [IQR 24.75] vs 96 [IQR 51.5], p=0.36) but this difference was not statistically significant (Figure 1). The fusion rate of the ankle joint was 10% higher in the dynamic group (42/44 [95%] vs 39/46 [85%], p=0.16) and the same in the subtalar joint (88%), neither of which was significantly different. The dynamic group had significantly faster time to weightbearing than the static group by an average of 15 days (80 [IQR 14.3] vs 95 [IQR 47], p = 0.0001, Figure 2). The overall reoperation rate was 12% in the dynamic group and 19% in the static group, not significantly different. Both groups demonstrated improvement across all five PROMIS domains, but these changes were all significant in the dynamic group, and only the Physical Health domain reached significance in the static group. Both groups had significant improvements in overall LDSRS scores. In the univariate analyses, peripheral neuropathy and Charcot were significantly associated with longer time to union for the ankle joint (p = 0.003 and p = 0.008 respectively). After multivariate analysis, dynamic compression remained statistically significant for a shorter time to union (p = 0.04), and peripheral neuropathy continued to demonstrate a significantly longer time to union (p = 0.02).

What are your conclusions?
Dynamic compression nails significantly decreased the ankle joint time to union and weightbearing versus static nails. Fusion rates were comparable between the two nail types. Dynamic compression may provide a modest benefit for hindfoot arthrodesis, particularly to support faster recovery.

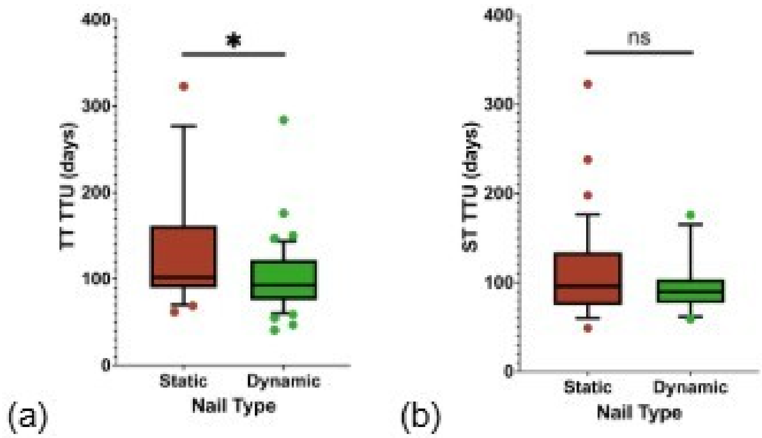

Figure 1. Time to radiographic union for the (a) tibiotalar/tibiocalcaneal joint and (b) subtalar joint.

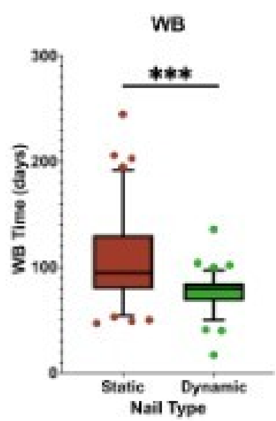

Figure 2. Time to weightbearing in days.

Comparison of Outcomes at Skeletal Maturity of Treatment for Severe Congenital Fibular Deficiency by Amputation vs. Staged Limb Reconstruction

John G. Birch MD FRCS(C); Dror Paley MD FRCS(C); J. Anthony Herring MD; Charles E Johnston MD; Kelly Jeans; Kirsten Tulchin-Francis; Philip McClure; John Herzenberg; Chan-Hee Jo; Darin Roberts; Nathaniel Helwig
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What was the question?
We previously reported functional outcomes at 8-12 years of age in 20 patients treated by amputation and 22 patients treated by staged reconstruction for severe unilateral congenital fibular deficiency. The purpose of this study was to compare treatment outcomes by these two methods in those cohorts at skeletal maturity.

How did you answer the question?
We designed a call-back study of the previous cohorts consisting of clinical assessment, radiographs of the lower extremity, movement science evaluation, and patient-reported outcome measures (PROs), including numeric pain scale, UCLA Pedi-Activity Score, IKDC, I-HOT, appearance satisfaction, and Coopersmith Self-Esteem Assessment. We endeavored to recruit subjects from three treating institutions over a 6-year period by mail, phone calls, and e-mail.

What are the results?
15/20 amputee subjects and 10/22 staged reconstruction patients consented to completing demographic and PRO questionnaires. 4/15 consenting amputee subjects had undergone growth modulation for distal femoral/proximal tibial valgus deformity, and one of these had also undergone ACL reconstruction. 11/15 had no further surgery after the initial amputation. The 10 staged reconstruction patients had undergone 1-7 lengthening procedures after index reconstruction. 9/10 had other reconstructive procedures as well including growth modulation (6), PAO (2), intraarticular knee reconstruction (2), and secondary foot surgery (4). Six had subsequent tibio-talar fusion. Four patients required surgery to manage complications (2 hip subluxations, knee subluxation, deep infection). None had undergone secondary amputation. PRO and satisfaction surveys were comparable between the cohorts, except that the staged reconstruction cohort reported to be more active, were more satisfied with the appearance of their affected extremity, and had higher Coopersmith self-esteem raw and categorical scores compared to the amputation group (Table). All subjects were satisfied with the treatment path that had been chosen for them as infants.

What are your conclusions?
In young adulthood, the amputation and staged reconstruction cohorts had essentially comparable satisfaction and PRO's, except for a reported higher level of activity and self-esteem in the staged reconstruction cohort. Parents and caregivers must weigh the advantages of substantially fewer surgical interventions after early amputation against the implications of a lifetime dependence on a prosthesis. This is the first study directly comparing outcome measures in prospectively identified cohorts after amputation or staged reconstruction in a young adult population.

Supported in part by a POSNA research grant 2019. (POSNA 678401)

Variable	Amputation (15)	Staged Reconstruction (10)	p-value
Sex (M:F)	10:5	4:6	0.241[1]
Age (range)	26.0 (19.4-30.8)	26.4 (23.4-30.2)	0.756[2]
Pain Score (range)	1.3 (0-5.8)	1.3 (0-4.5)	0.990[3]
Prosthetic/Limb satisfaction (range)	2.8 (1.0-4.0)	3.5 (2.5-4.0)	0.047[2]
UCLA Activity Score	5.7 (3.0-10.0)	7.8 (5.0-10.0)	0.033[3]
IKDC Knee Score	87.1 (71.3-98.9)	87.9 (70.1-97.7)	0.804[2]
I-HOT Hip Score	88.4 (60.9-100)	88.9 (68.8-100)	0.909[2]
Coopersmith Self-Esteem Score (Raw)	38.9 (16-46)	43.7 (21-49)	0.010[3]
Coopersmith Self-Esteem Score (Ordinal)	2.7 (1-5)	4.2 (1-5)	0.009[3]
Complications requiring surgical intervention (patients)	0	4	0.029[1]

[1]Fisher

[2]t-test

[3]Mann-Whitney

Alessandro Codivilla and Wellness Presentation

Introduction by Mitchell Bernstein, MD

The Surgeon Health Paradox: Performance vs. Health

Harley Pasternak

Hall of Fame

John G. Birch, MD

John G. Birch MD, FRCS(C) was born in Windsor Ontario Canada. The oldest of five children, he moved to Detroit Michigan at the age of two, returning to Windsor at the age of twelve. After completing a degree in Honours Biology at the University of Windsor, he attended medical school at the University of Western Ontario (now Western University) in London Ontario. A rotating internship at the Ottawa Civic Hospital was followed by four years of orthopedic surgical training in the University of Ottawa Division of Orthopedic Surgery. After successfully passing the written and oral examinations of the Royal College of Surgeons of Canada (granting the FRCS(C)) in the Fall of 1980, he completed six months of travelling fellowship (University of Florida Shands Hospital (Gainesville FL); Newington Children' Hospital (Newington CT), and the A.I. Dupont Institute (Wilmington DE)), followed by a one-year fellowship in pediatric orthopedic and scoliosis surgery at Texas Scottish Rite Hospital for Children (TSRH) in Dallas. He returned to Ottawa in 1982 to join the orthopedic staff at Children's Hospital of Eastern Ontario (CHEO). He was invited to join the full-time staff at TSRH, beginning in September 1984.

He practiced as a full-time general pediatric orthopedic surgeon at TSRH where he also served as Medical Director of Ambulatory Care and Assistant Chief of Staff until retiring from direct patient care January 1, 2015. Since then, he has remained active as volunteer consultant medical staff (TSRH) and Adjunct Professor of Orthopedics, University of Texas Southwestern Medical School (UTSW) teaching TSRH pediatric orthopedic fellows and UTSW orthopedic residents; participating in clinical research programs; and providing patient management advice. Mesmerized by Professor Ilizarov's presentations at the 1988 Tachdjian leg lengthening pre-course, he enrolled in a one-week introductory course to the Ilizarov Method conducted by the Orthopedic surgeons of the Oespedale Generale di Lecco, and returned one year later with his family to spend a further six weeks learning from those talented surgeons.

Expertise in the small patient-centered program Dr. Birch established at TSRH with the support of his colleagues and administrators was exponentially increased by the addition of Drs. Mikhail Samchukov, Marina Makarov, and Alex Cherkashin from the Ilizarov Institute in Kurgan between 1990-1993. With the additional talents of David Ross, Hong Lin, and Dr. Mauricio Delgado, the "TSRH Ilizarov team" developed an early (pre 6-strut) computerized deformity correction planning system; an intraoperative peripheral nerve monitoring program for both upper and lower extremities; a pneumatic wire tensioner; and modifications to traditional Ilizarov and hexapod circular external fixator systems. Professionally speaking, he is proudest of establishing an "Ilizarov clinic" supported by the nursing staff and psychologists at TSRH, which was dedicated to patient education, care, and support through the often-arduous journey of limb lengthening in a pediatric population. He was the first surgeon in North America to insert the Fitbone™ motorized intramedullary lengthening nail, under FDA Compassionate Use approval, with the support and guidance of TSRH, lifelong friend and colleague Mr. Bruce Foster, Wittenstein Intens™, and Professor Rainer Baumgart.

He served as member of the Board of ASAMI-NA (LLRS) for several years, culminating as President in 2003-4, and presided over the annual meeting in Toronto.
He was awarded the "Harold A. "Pete" Mattson Award for Outstanding Leadership", by the 2011 UTSW graduating orthopedic resident class; "Achievement Award in recognition of outstanding contributions to the profession of Orthopaedic Surgery" from the American Academy of Orthopaedic Surgeons in 2012; and "Award of Academic Excellence" by the TSRH Fellows and Staff in 2021-22. In 2021, he was inducted into the Pediatric Orthopedic Society of North America "Hall of Fame".

He is most proud and appreciative, however, of Eleanor, his wife of 42 years; their two children (Craig, pediatric orthopedic surgeon at Boston Children's Hospital, Boston MA; and Cailin, Global Economist for the Economist Intelligence Unit, London England); and their two (English!) grandchildren. He enjoys traveling with Eleanor, cycling, jogging, and playing old-man soccer.

Mark T. Dahl, MD

Director of Limb Length and Deformity Correction
Gillette Children's Hospital
St. Paul, Minnesota
Professor of Orthopedic Surgery
University of Minnesota
Minneapolis, Minnesota

Dr. Dahl graduated from Mayo Medical School and completed graduate studies in orthopedic surgery at the University of Minnesota. Trained by Dr. David Fischer in the Wagner limb lengthening method in the early 1980's, Dahl sought information on distraction osteogenesis upon his first knowledge in 1983. A visit to Professor DeBastianni was followed by meeting young North Americans including Chad Price, Jim Aronson, George Cierney, Dror Paley, and Stuart Green. He quickly returned to Italy for extended visits with Catagni, Cattaneo, and DeBastianni, and then Professor Ilizarov in Russia. A quest for more knowledge persists during in his 41-year career. Greater patient safety and less invasive techniques in lengthening and deformity correction surgery is a lasting goal for Dahl. He shares his experiences in workshops, lectures and OR's, continuously developing alternative techniques to be used in modern and austere locations around the world.

The immediate Dahl family includes wife Kathy, daughters Dana, Jenny, and Lindsay and six grandchildren. He now plans to diminish the urgent work of patient care and spend more time with family, reading, figurative sculpture in bronze, and fly-fishing as well as all-things outdoors.

Session X:

Award Nominated Papers Part 2

Moderator – David B. Frumberg, MD

Natural History of Leg Length Discrepancy in Posteromedial Bowing of the Tibia: A Multicenter Longitudinal Analysis

Sarah Nossov, MD; Ashley Startzman, DO; Richard Davidson, MD
snossov@shrinenet.org

What was the question?
Posterior medial bowing of the tibia (PMB) is a rare congenital deformity characterized by profound initial tibial angulation with expected spontaneous improvement over childhood and persistent leg length discrepancy (LLD). Current literature is limited to series of up to 44 patients. Treatment strategies range from conservative observation with deferred growth modulation or lengthening in adolescence, to early surgical intervention. To better inform surgical planning and patient counselling, we aimed to describe the natural history of angular correction and LLD progression over time in a large multicenter cohort, and to determine whether sex or initial deformity severity predict LLD accumulation rate.

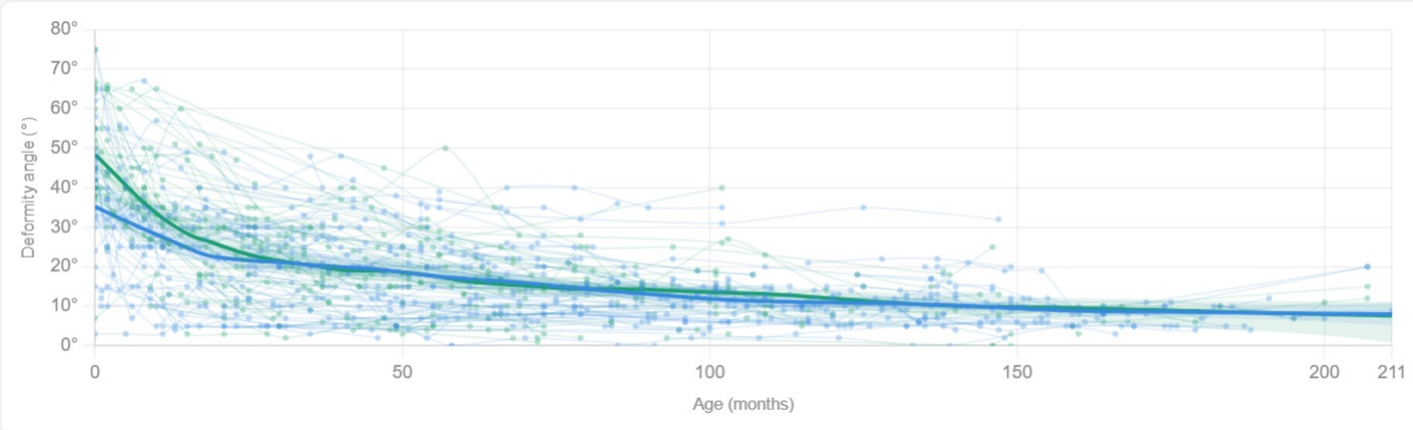
How did you answer the question?
Seven pediatric orthopaedic hospitals contributed to this IRB-approved retrospective multicenter study. Patients were identified within the electronic medical record with confirmed posterior medial tibial bowing and more than one radiographic evaluation. Data collected included demographic information, laterality, surgical interventions, and radiographic measurements of angular deformity and long bone length obtained by pediatric orthopaedic surgeons. Pre-intervention LLD slopes (cm/month) were calculated by linear regression restricted to measurements at or after 60 months of age to mitigate the geometric confound of active tibial bowing on straight-line length measurement. Sex differences in LLD slope were assessed by Mann-Whitney U test and further evaluated after normalization against age- and sex-specific expected limb growth velocities from Green-Anderson reference data. Spearman correlation assessed whether initial oblique plane deformity severity - quantified as the resultant angle ($\sqrt{AP^2+Lat^2}$) at first presentation within 12 months of birth - predicted LLD accumulation rate.

What are the results?
100 patients were included (57 female, 43 male); 99 were unilaterally affected and 1 bilaterally, with each side included for deformity analysis but excluded from LLD comparison. Radiographic evaluation spans birth to just under 18 years of age. 655 AP and 369 lateral deformity measurements were recorded, demonstrating consistent spontaneous angular improvement across the cohort. 206 LLD measurements were available for 30 patients. After restricting LLD analysis to measurements at or after 60 months, males and females accumulated LLD at median rates of 0.0272 and 0.0264 cm/month respectively (Mann-Whitney $p = 0.887$). After normalization for expected growth velocity, both sexes accumulated LLD at approximately 9% of their expected limb growth velocity ($p = 0.887$), indicating no sex-specific difference in growth inhibition fraction. Initial oblique plane deformity severity at presentation did not significantly predict LLD accumulation rate (Spearman $r = 0.393$, $p = 0.295$, $n = 9$).

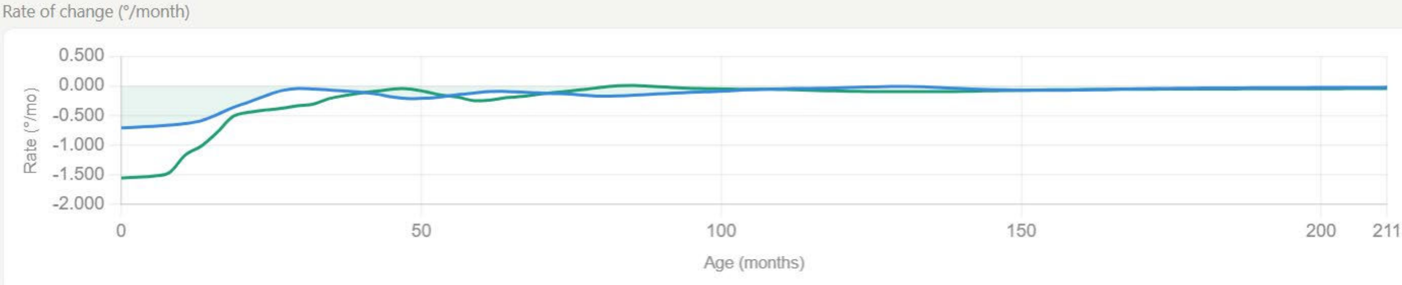
What are your conclusions?
Spontaneous angular correction and leg length discrepancy accumulation occur at varying rates over childhood in PMB. LLD accumulates at a consistent rate relative to normal growth velocity regardless of sex, suggesting standard growth models are applicable without sex-specific correction in this condition. Initial deformity severity at birth does not reliably predict LLD trajectory, limiting early radiographic counselling. This largest multicenter natural history dataset for PMB to date supports the need for prospective long-term follow-up to skeletal maturity to fully characterize LLD progression and better inform surgical timing decisions.

DEFORMITY ANGLES OVER AGE

AP (pooled) Lateral (pooled) *90% CI (cluster bootstrap, n=150)*



Rate of change (°/month)



AP (pooled) Lateral (pooled) *90% CI (cluster bootstrap, n=150)*

Biomimetic Hematoma-Mediated mRNA Delivery Restores Structure and Function in Volumetric Muscle Loss

Vaida Glatt, PhD; William Murphy; Joshua A. Choe; David Izquierdo; Enrique Blancarte-Hernandez
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What was the question?
Volumetric Muscle Loss (VML) leads to permanent disability following severe extremity trauma or surgical resection, with current treatments often resulting in impaired mobility or amputation. Despite extensive efforts using a variety of scaffolds, biologic molecules, and cell-based therapies, achieving consistent and functional muscle regeneration remains a significant challenge. Hematoma formation is a crucial early step in tissue repair, significantly influencing both muscle and bone regeneration. This understanding led to the development of the Biomimetic Hematoma (BH) scaffold, designed to replicate the native fracture hematoma and serve as a growth factor delivery system. Preclinical studies have demonstrated that BH delivering rhBMP-2 effectively regenerates large bone defects without complications. Recognizing the shared role of hematoma in muscle and bone repair, we investigated the potential of BH to deliver mRNA encoding RSPO-2, a myogenic growth factor, to enhance functional regeneration of VML in a rat tibialis anterior model.

How did you answer the question?
A 30% full-thickness, 8 mm tibialis anterior defect was created in male Fischer-344 rats. Animals were assigned to four groups (n=6/group): 1) Natural Healing (NH, 3 mm defect), 2) Empty Defect (ED), 3) Biomimetic Hematoma alone (BH), and 4) 25 µg RSPO-2 mRNA + BH (mRNA+BH). The uninjured limb served as a control. Autologous blood combined with calcium and thrombin was used to generate the BH scaffold, with or without RSPO-2 mRNA. Muscles were harvested at 5, 10, and 21 days, and 12 weeks post-injury to assess revascularization (microCT), tissue morphology (histology), and functional recovery (tetanic force).

What are the results?
At 5 days, the ED group showed no vessel formation, while NH demonstrated modest early recovery; in contrast, the BH and BH+mRNA groups exhibited early capillary formation. By 10 days, vascularization increased in all groups, with NH, BH, and BH+mRNA showing further gains in vessel volume and number. By 21 days, NH, BH, and BH+mRNA demonstrated substantial revascularization versus ED, with BH supporting consistent tissue formation and maturation, and BH+mRNA showing the greatest vessel volume and number. At 12 weeks, BH and BH+mRNA had significantly higher vessel number and thickness than ED, with BH+mRNA slightly exceeding BH and control. Histologically, all treatment groups showed disrupted muscle morphology at 5 days with presence of the BH scaffold, while the 3 mm defect showed limited repair versus control. By 10 days, BH scaffold resorption and early myofiber alignment were evident in BH-treated groups, more pronounced in BH+mRNA; ED remained poorly organized, and the 3 mm defect showed partial regeneration. At 21 days, BH+mRNA exhibited the most advanced regeneration with aligned myofibers approaching native morphology, BH showed substantial but less mature repair, the 3 mm defect was moderate and heterogeneous, and ED remained fibrotic. At 12 weeks, the ED group exhibited predominantly fibrotic and adipose tissue with minimal organized muscle compared to control. The BH group demonstrated muscle regeneration with aligned but heterogeneous myofibers, while the BH + mRNA group showed more organized and mature muscle architecture, more closely resembling control muscle morphology. Functional recovery as measured by tetanic force improved over time in all groups, with both BH and BH + mRNA demonstrating significantly greater functional recovery compared to the empty defect (~50%). The BH and mRNA+BH groups achieved the highest recovery approaching near-normal control limb levels by 12 weeks.

Biomimetic Hematoma-Mediated mRNA Delivery Restores Structure and Function in Volumetric Muscle Loss *continued*

Vaida Glatt, PhD; William Murphy; Joshua A. Choe; David Izquierdo; Enrique Blancarte-Hernandez
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What are your conclusions?
These findings demonstrate that replicating the native hematoma environment is a critical driver of muscle regeneration following VML. The BH scaffold alone supported consistent muscle formation, vascularization, and functional recovery, highlighting the importance of early provisional matrix cues by 12 weeks. Importantly, the addition of RSPO-2 mRNA further enhanced vascularization and improved the organization and maturity of regenerated muscle, resulting in tissue morphology more closely resembling native muscle. This enhanced vascular response likely contributed to the improved morphological and functional outcomes observed at later time points. In contrast, the empty defect group exhibited failed regeneration, with tissue dominated by fibrotic and adipose infiltration and poor functional recovery. BH-based delivery of mRNA represents a promising, biologically inspired strategy to achieve functional muscle regeneration in VML, with clear clinical relevance for improving limb salvage and restoring function in patients with severe muscle loss.

Lower Extremity Rotational and Coronal Plane Parameters Are Relatively Stable After Eight Years of Age Using CT Scanning in a Random Cohort

Moiz Nasir; Kallie Chen; Amrita Bonthu; Raymond W. Liu, MD
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What was the question?
While coronal lower-extremity alignment in children follows a predictable transition from physiologic genu varum to genu valgum, developmental patterns of rotational alignment remain less clearly defined despite growing clinical interest in rotational-guided growth. Normative data across the full pediatric age spectrum, particularly in younger age groups, are limited. Therefore, this study sought to establish year-by-year reference values to determine how coronal and rotational lower-extremity alignment parameters change from birth through adolescence and to identify the age at which these parameters stabilize using CT-based measurements.

How did you answer the question?
212 CT scans (ages 0-18; 115 males, 97 females) from the New Mexico Decedent Image Database were reconstructed into three-dimensional models. Femoral version was measured as the axial angle between a line between the posterior femoral condyles and a line from the femoral head to the neck, and tibial torsion as the axial angle between a line connecting the centers of the tibial plateaus and a line drawn from the lateral to medial anterior edge of the tibial plafond. Age-related differences were evaluated using one-way ANOVA ($\alpha=0.05$) with Tukey post hoc testing.

What are the results?
All measurements demonstrated excellent interrater reliability (ICC $\geq$ 0.75). mLDFA decreased significantly from birth through age 5 (101.4 to 85.8) and stabilized thereafter. MPTA remained stable during the first five years (91 to 92), then declined gradually with a significant decrease by age 8 (86.7). Femoral anteversion declined significantly from birth to age 8 (36.6 to 10.4), after which values stabilized. Tibial torsion showed no significant differences across the age range.

What are your conclusions?
Femoral version settled into mature values by approximately age 8, identifying this as a threshold beyond which further spontaneous improvement in rotational alignment is less likely. These findings help clarify how rotational and coronal plane alignment changes with growth, which can help guide timing recommendations for correcting rotational deformity.

Artificial Intelligence-Assisted Lower Extremity Deformity Analysis on Long-Leg Radiographs: Validation Across Experience Levels

Oğuzhan Günbatar; İsmail Tarık Atasoy; Cengiz Şen; Alper Şükrü Kendirci; Nurol Efe Alptekin; Halil İbrahim Balcı
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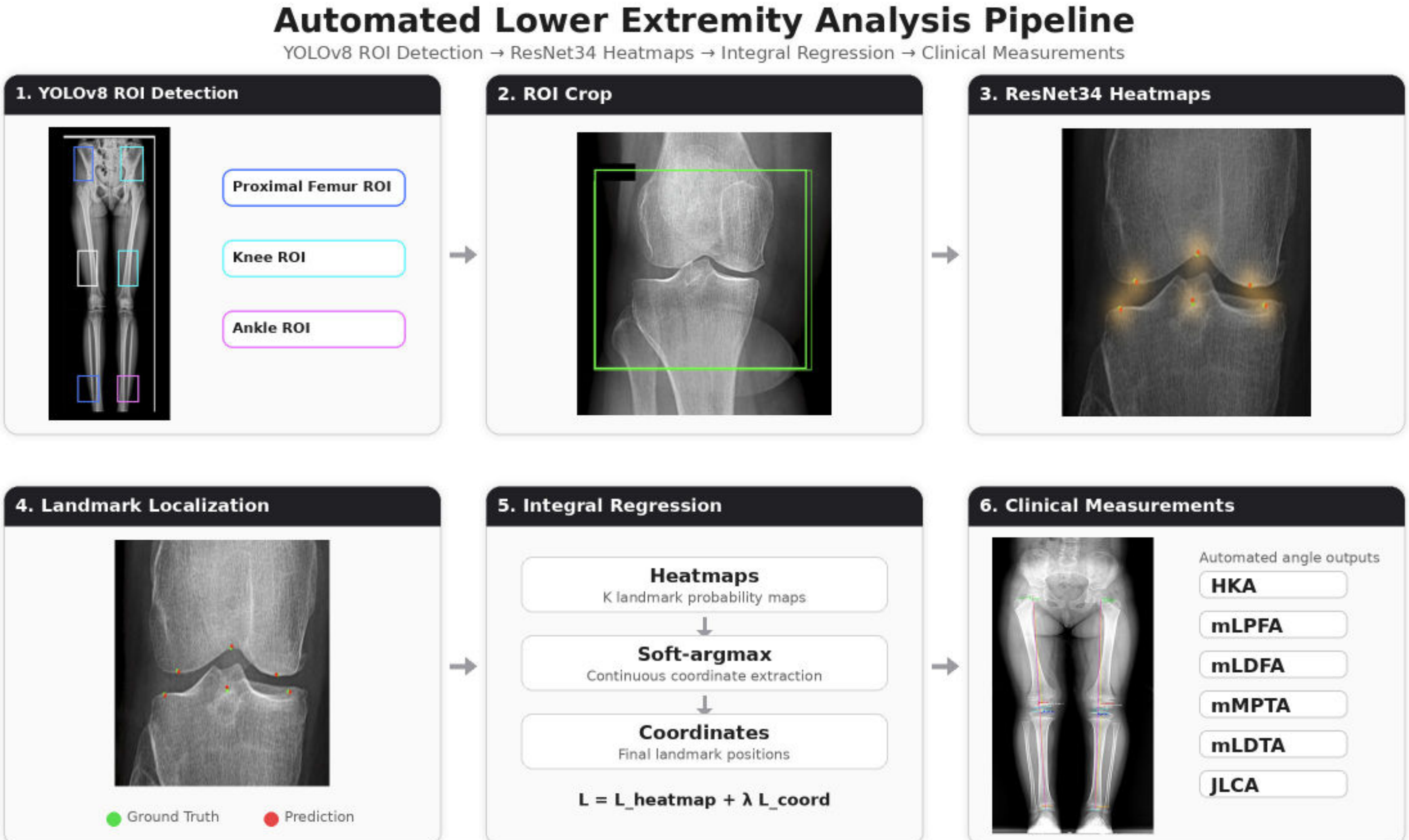
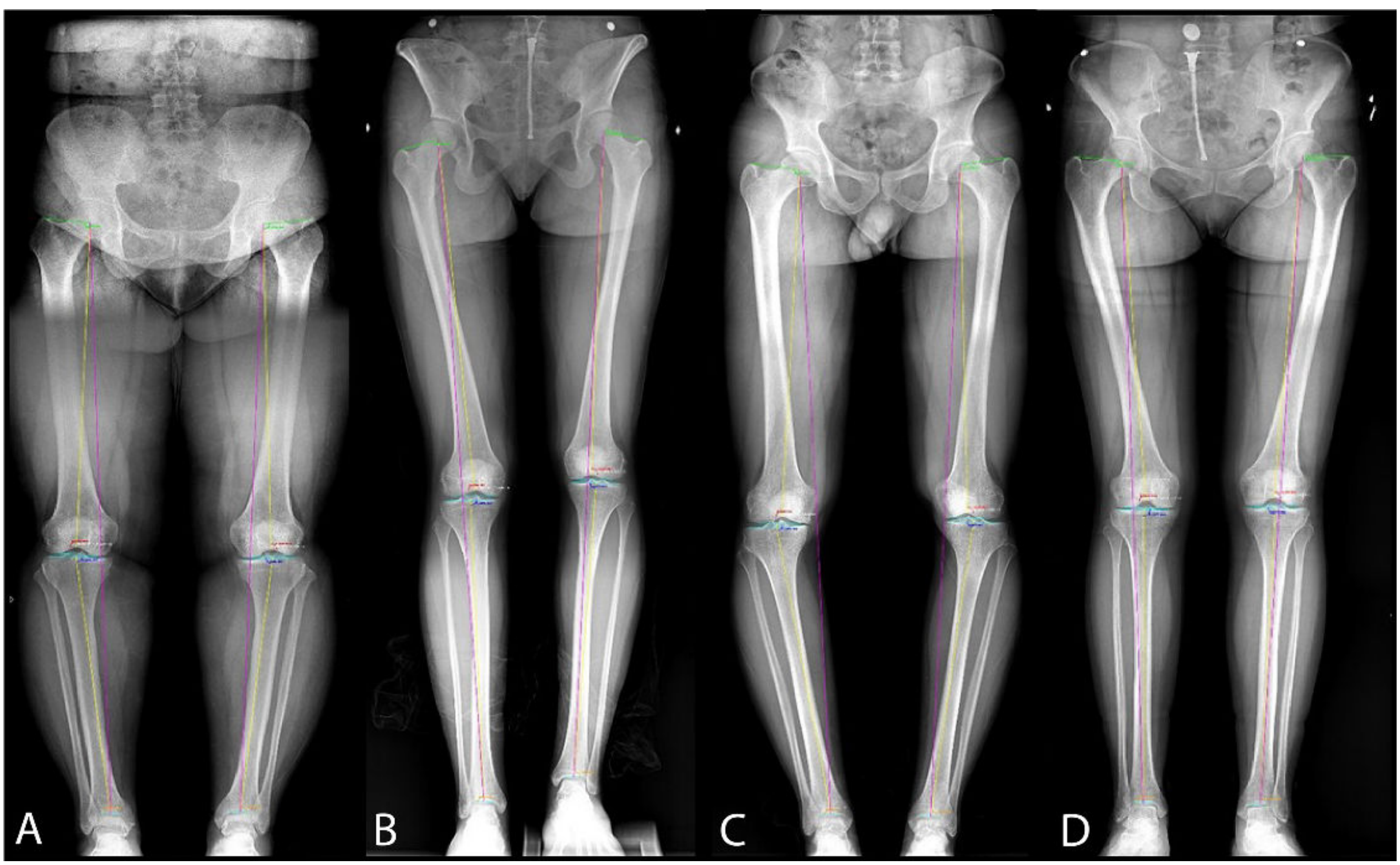
What was the question?
Can an automated artificial intelligence (AI) system perform lower-extremity deformity measurements on standing full-length radiographs with accuracy and reliability comparable to those of an experienced deformity surgeon, while reducing observer-dependent variability? In addition, does AI assistance improve the accuracy of manual measurements, particularly for less experienced clinicians, and reduce the time required for deformity analysis in the routine workflow?

How did you answer the question?
We developed a multistage deep-learning-based AI system that automatically identifies regions of interest on standing AP full-length lower-extremity radiographs, detects anatomical landmarks, and computes six standard alignment parameters (HKA, mLPFA, mLDFA, mMPTA, mLDTA, and JLCA). We then conducted a retrospective validation study using 80 standardized standing AP full-length lower-extremity radiographs (160 limbs). The same radiographs were measured manually by three clinicians with different experience levels, each repeating the measurements in three separate sessions. An experienced deformity surgeon served as a reference for the agreement analyses. Reliability and accuracy were evaluated using intraclass correlation coefficients (ICC), mean absolute error (MAE), and Bland-Altman methods, with subgroup analyses by laterality, age group (pediatric vs. adult), and deformity level. We also performed an additional workflow analysis to quantify the impact of AI assistance on the accuracy of manual measurements and analysis time.

What are the results?
Eighty patients (160 limbs) were analyzed (41 male/39 female; 58 adults/22 children). Our AI system produced identical outputs in repeated runs (intra-run ICC=1.00). Compared with the experienced deformity surgeon, the AI showed excellent agreement for the primary mechanical angles: HKA (ICC 0.966, MAE 0.74°), mLPFA (ICC 0.944, MAE 1.26°), mLDFA (ICC 0.952, MAE 0.61°), mMPTA (ICC 0.964, MAE 0.52°), and mLDTA (ICC 0.930, MAE 1.08°). The JLCA demonstrated lower agreement (ICC 0.728) but maintained a low absolute error (MAE 0.61°). Manual measurement performance worsened with decreasing experience, most prominently for mLPFA (trainee vs. expert: ICC 0.407, MAE 6.83°), while AI remained close to expert values (mLPFA MAE 1.26°). The AI agreement was consistent across the right and left limbs and across the pediatric and adult cohorts, and remained strong in knee-level deformity cases (e.g., HKA ICC 0.978), with reduced agreement in proximal femur deformity for mLPFA (ICC 0.816) and ankle deformity for mLDTA (ICC 0.805). In an additional workflow analysis, AI assistance improved the accuracy of manual measurements, especially for less experienced raters, and reduced the analysis time.

What are your conclusions?
Automated AI-based lower-extremity deformity analysis on standing long-leg radiographs demonstrated high agreement with expert measurements for key mechanical alignment parameters and provided fully repeatable results, reducing observer-dependent variability. AI support can also improve the accuracy of manual measurements (especially for less experienced clinicians) and shorten the analysis time, supporting more standardized and efficient preoperative planning. The JLCA remains comparatively more challenging than the primary mechanical angles, indicating an area for continued refinement and expanded training data.


Automated Lower Extremity Analysis Pipeline
YOLOv8 ROI Detection → ResNet34 Heatmaps → Integral Regression → Clinical Measurements
1. YOLOv8 ROI Detection
Proximal Femur ROI
Knee ROI
Ankle ROI
2. ROI Crop
3. ResNet34 Heatmaps
4. Landmark Localization
Ground Truth
Prediction
5. Integral Regression
Heatmaps
K landmark probability maps
Soft-argmax
Continuous coordinate extraction
Coordinates
Final landmark positions
L = L_heatmap + λ L_coord
6. Clinical Measurements
Automated angle outputs
HKA
mLPFA
mLDFA
mMPTA
mLDTA
JLCA


A
B
C
D

Implant Fracture Following Lower Limb Osseointegration: Clinical Outcomes and Material Considerations

Prof. Munjed Al Muderis; Atiya Oomatia; William Lu
atiya@osseointegrationaustralia.com.au

What was the question?
While osseointegration has significantly improved outcomes for lower limb amputees, implant fracture is one of the most significant long-term complications in lower limb osseointegration, directly impacting implant survival and patient outcomes. Implant stems can be manufactured using a variety of materials and techniques, with evolving technologies introducing new designs that may influence biomechanical behaviour and failure risk. The emergence of 3D-printed titanium stems, enabled by additive manufacturing techniques such as selective laser sintering (SLS), and electron beam melting (EBM), has facilitated the development of highly porous implants aimed at enhancing osseointegration. The need for 3D-printed stems was initially driven by tibial applications, where limited diaphyseal bone stock presents challenges for fixation. However, these processes inherently generate microstructural heterogeneities such as internal porosity, lack-of-fusion defects, and anisotropic grain structures that serve as stress raisers and reduce fatigue life under cyclic loading. As the implant serves as the principal load-bearing component, its mechanical reliability and resistance to fatigue failure are paramount. The aim of this study was to (1) analyse the incidence of implant fracture in lower limb osseointegration (2) and how does it vary by implant material and manufacturing method

How did you answer the question?
A retrospective analysis was conducted of patients undergoing osseointegration procedure. Cases of implant fracture were identified and analysed with respect to implant material, time to failure, and subsequent management. Where available, implant material was classified as cobalt-chrome (CoCr), 3D-printed titanium, or conventional titanium stems. Denominators for each implant type were derived from a privately maintained osseointegration database (CoCr: n=186; 3D-printed titanium: n=75; titanium: n=524).

What are the results?
A total of 916 osseointegration procedures were reviewed, of these 131 cases were excluded due to limited access to earlier, humanitarian, and custom implant cases; leaving 785 cases for analysis. Nine implant fractures were identified, corresponding to an overall fracture rate of 1.15% (9/785). Of the fractures, 6 were femoral and 3 tibial, occurring in 7 males and 2 females. Five fractures occurred in cobalt-chrome stems and four in 3D-printed titanium stems. The fracture rate was approximately 2.7% (5/186) for cobalt-chrome implants and 5.3% (4/75) for 3D-printed titanium implants. The mean time to failure for fractured implants was 5.52 years (range 0.83-10.51 years). Following implant fracture, 8 of 9 patients elected to undergo repeat osseointegration. No implant fractures were recorded in conventional titanium stems (0/524). A total of 35 revision events were recorded in this group (n=524), representing an overall revision rate of approximately 6.7% (35/524), none of which were due to implant fracture. Indications for revision included aseptic loosening (1.5%, 8/524), failure of osseointegration (0.8%, 4/524), infection (2.9%, 15/524), pain (1.1%, 6/524), and other causes (0.4%, 2/524).

What are your conclusions?
Implant fracture remains an uncommon but clinically significant complication of lower limb osseointegration; however, in this cohort, fractures occurred exclusively in cobalt-chrome and 3D-printed titanium stems, with none observed in conventional titanium stems. While non-mechanical failures such as infection and loosening occur across all implant materials, fracture as a failure mode was confined to CoCr and 3D-printed stems, suggesting manufacturing method as the dominant risk factor for mechanical failure. The highly porous architecture of 3D-printed implants also presents substantial challenges during revision when fractured, often requiring complex extraction techniques. Collectively, these findings support a shift away from 3D-printed stems toward more reliable conventional titanium designs to minimise implant fracture risk.

Session XI:

Best Practice in Limb Reconstruction Surgery: Perspective from the British Limb Reconstruction Society

Moderators

David A. Podeszwa, MD & Amir Qureshi, MBChB