32ND IMAST GLASGOW, SCOTLAND

Powered by the Scoliosis Research Society

SRS
Scoliosis Research Society

32ND International Meeting on Advanced Spine Techniques

FINAL PROGRAM

APRIL 2-5, 2025 **WWW.SRS.ORG/IMAST2025**

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32ND IMAST VENUE

Scottish Event Campus (SEC)
Exhibition Way
Glasgow G3 8YW, United Kingdom

FUTURE EDUCATIONAL EVENTS

Annual Meeting

60th Annual Meeting
September 16-20, 2025 | Charlotte, North Carolina, USA

61st Annual Meeting
October 7-10, 2026 | Sydney, Australia

62nd Annual Meeting
September 14-18, 2027 | New Orleans, Louisiana, USA

63rd Annual Meeting
September 12-16, 2028 | Vancouver, BC, Canada

International Meeting on Advanced Spine Techniques

33rd IMAST
April 15-17, 2026 | Toronto, ON, Canada

34th IMAST
April 7-9, 2027 | Copenhagen, Denmark

CHAIRS' MESSAGE

Dear Delegates and Attendees,

Welcome to the misty lands of Glasgow, Scotland and the 32nd International Meeting for Advanced Spine Techniques (IMAST), powered by the Scoliosis Research Society (SRS).

Glasgow, in addition to being one of the oldest cities in Scotland, is also home to a BioCorridor focused on research, development, the production of bioinformatics, and medical technology. Hosting THE leading innovation meeting where professionals treating complex spinal conditions meet to share, discuss and demonstrate groundbreaking research is the perfect pairing.

The theme of this year's meeting is "Changing Practice with New Innovation" and includes six instructional course sessions including one EUROSPINE session and one British Association for Spine Surgeons (BASS) session.

As always, one of the highlights of this meeting is Cases and Cocktails, which in honor of the distillers of the Highlands has been renamed Spine and Scotch: Cases on the Rocks. This year's topics will cover Complication Avoidance in Adolescent Idiopathic Scoliosis, New Technology for Adult Spine Deformity, and Innovation in Minimally Invasive Surgery.

We are also hosting – for the second time in IMAST history – a keynote speaker. Mr. Derek Cawley, a Consultant Spine Surgeon from Dublin, Ireland is presenting "Sustainability in Hospitals and The Carbon Footprint of Spine Surgery."

This year's "don't miss" session is the SRS Adult Deformity Task Force session, The Latest and Greatest: Making Innovation Work for You. This session features expert surgeons discussing the latest innovations they are using prior to and during surgery to improve their outcomes and offers insights on how you can transform and improve your practice.

Additionally, we reviewed 831 abstracts and have selected 98 with a new review category that focuses on AI & Machine Learning. And, in addition to the Thomas E. Whitecloud Award for best paper we will again have the award for the most innovative IMAST presentation.

We offer a special thank you to our industry partners for their continued support. Plan your schedule accordingly so that you can see all of the latest innovations in the exhibit hall and during the Hands-on Workshops. More information on these can be found beginning on page 171.

We cannot wait for you to experience this exceptional IMAST. We will see you in Glasgow!

Kristen E. Jones MD, FAANS
IMAST co-chair

Meric Enercan, M.D.
IMAST co-chair

IMAST APP

A mobile app delivering content, networking, engagement, and navigation all in one convenient location is available to all delegates during the meeting.

DOWNLOADING THE APP

1. Go to your device's app store and search for SRS IMAST 2025.
2. Select the meeting app and install.

PUSH NOTIFICATIONS

Apple and Android device users who have downloaded the meeting app can receive push notifications including reminders and schedule changes. Upon downloading the app, you must provide permission to receive these notifications on your device. You can update these permissions at any time within the Settings area of your device if necessary.

USING THE APP

1. Open the downloaded app and enter your email address to sign up or log in.
2. If you already have an account, you will be asked to enter your password. If you do not already have an account, you will be prompted to create a password and add profile information (optional).
3. The app can also be accessed by entering the URL, https://eventmobi.com/imast25 on any current internet browser.
4. Once you are logged in, all event information will be readily available.

USER DASHBOARD

Click the icon in the top-right corner to access the User Dashboard. Here, you can find your personal schedule, notes you have taken, companies you have added to your favorites, documents you have added to your collection, and your chat inbox.

GAMIFICATION

Gamification within the SRS IMAST Meeting app is a unique way to interact with your peers and engage with the presenters by collecting codes to earn points. To get you started, enter St. James for free points.

The app includes the details on points available and other ways to earn them. Delegates with the most points will win prizes.

The app also includes a leader board so you can see who is earning the highest points throughout the week. Stop by the SRS Registration Desk to learn more about gamification and the IMAST app.

EVENT MENU

Access the event menu by clicking the Menu icon in the top-left corner. Here, you will find a list of sections that contain all of the event content, from speakers and sessions to meeting information and social media links. Select the section you are interested in and navigate through to find the information.

ASK A QUESTION IN THE APP

If you see a Q&A tab at the top of a session page, you can submit pertinent questions and comments to the moderator during that session. You can submit as many questions as you would like and view questions submitted by other attendees.

1. From the Agenda, click on the session you are in and click Q&A to see the question list.
2. From here, type your question in the text box provided and click Submit. Your question will appear within the question list.
3. To upvote someone else's question, click the upvote button to the right of the question in the list.

VOTE FOR WHITECLOUD AWARD-NOMINATED PAPERS AND E-POINT PRESENTATIONS

Cast your vote for the Whitecloud, IMAST Innovation and E-Point Award nominations. Look for the voting option on left-hand navigation in IMAST 2025 meeting app.

Voting for the Whitecloud Awards closes on Thursday, April 3 at 13:00

Voting for the IMAST Innovation and E-Point Awards closes on Friday, April 4 at 12:30.

GENERAL MEETING INFORMATION

MEETING DESCRIPTION

The 32nd IMAST will offer an in-person meeting experience where leading spine surgeons, innovative researchers and the most advanced spine technologies come together in an international forum to demonstrate and discuss recent advances in spine surgery.

IMAST MISSION & VISION STATEMENT

Mission
To freely present, discuss and debate emerging technologies used for the treatment and care of patients with complex spine conditions.

Vision
To be the premier global forum where professionals treating complex spinal conditions meet to share, discuss and demonstrate groundbreaking research with a focus on innovation

LEARNING OBJECTIVES

Upon completion of IMAST, you should be able to:

1. Assess indicators for integrating innovative technologies, such as artificial intelligence, machine learning, predictive analytics, and wearable devices, into current operative spine care practices, and evaluate the limitations of current technology.
2. Discuss current best-practices for complication avoidance by utilizing innovative technology in adult spinal deformity surgery.
3. Analyze the indications and limitations for minimally invasive and motion-preservation surgical options, including endoscopic and MIS fusion techniques, in Adult Spinal Deformity and Adolescent Idiopathic Scoliosis.
4. Improve the knowledge of operative and non-operative standard of care for early-onset scoliosis and congenital spine pathologies.

TARGET AUDIENCE

Spine surgeons (orthopaedic and neurological surgeons), residents, fellows, nurses, nurse practitioners, physician assistants, engineers, and company personnel.

ATTIRE

Business casual (polo or dress shirts, sport coats) are appropriate for IMAST sessions.

SPINE & SCOTCH: CASES ON THE ROCKS SESSIONS

Cases will be presented by faculty in three concurrent sessions on Wednesday, April 2 from 16:00 - 18:00. Attendees will have the opportunity to discuss cases in small groups with an IMAST faculty member present at each table. Each case presentation will be followed by small group discussions in which each table will debate the various treatment options and determine their action plan. Libations will continue to be served during this time so that all may continue to enjoy a relaxed atmosphere while discussing cases. All registered delegates are welcome and encouraged to attend and participate.

Spine & Scotch: Cases on the Rocks Sessions 1: Complication Avoidance in AIS
Supported, in part, by a grant from ATEC Spine

Spine & Scotch: Cases on the Rocks Sessions 2: New Technology for Adult Spinal Deformity
Supported, in part, by a grant from ATEC Spine

Spine & Scotch: Cases on the Rocks Sessions 3: Innovation in MIS
Supported, in part, by a grant from Highridge Medical

We encourage delegates to join us for the Welcome Reception, immediately following the Spine & Scotch Sessions, from 18:00 - 20:00.

CELL PHONE PROTOCOL

Please ensure that cell phone ringers, pagers and electronic devices are silenced or turned off during all sessions.

CHARGING TABLES

Delegates are welcome to use the complimentary charging tables located on the Mezzanine Level to recharge smartphones and small tablets. Please do not leave your electronic devices or any personal belongings at the charging station unattended.

GENERAL MEETING INFORMATION

CME INFORMATION

CME certificates will be available to pre-registered delegates upon the opening of the meeting at https://www.srs.org/Meetings-Conferences/IMAST/IMAST2025#cme. Delegates who registered onsite may access their certificates after 30 days.

Please note that certificates will not be mailed or emailed after the meeting. The online certificate program is the only source for this documentation. Please contact SRS at cme@srs.org for any questions. SRS asks that all CME certificates be claimed no later than December 31, 2025.

Evaluations are available to all attendees at the commencement of the meeting. Evaluations are available in the IMAST 2025 Meeting App.

ACCME Accreditation Statement

The Scoliosis Research Society (SRS) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

Credit Designation

The Scoliosis Research Society (SRS) designates this live activity for a maximum of 12.00 AMA PRA Category 1 Credit(s)TM. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

EACCME Accreditation Statement

The 32nd International Meeting on Advanced Spine Techniques, Glasgow, United Kingdom 02/04/2025 - 05/04/2025, has been accredited by the European Accreditation Council for Continuing Medical Education (EACCME®) with 12.0 European CME credits (ECMEC®s). Each medical specialist should claim only those hours of credit that he/she actually spent in the educational activity."

Through an agreement between the Union Européenne des Médecins Spécialistes and the American Medical Association, physicians may convert EACCME® credits to an equivalent number of AMA PRA Category 1 Credits™. Information on the process to convert EACCME® credit to AMA credit can be found at https://edhub.ama-assn.org/pages/applications.

Live educational activities, occurring outside of Canada, recognised by the UEMS-EACCME® for ECMEC®s are deemed to be Accredited Group Learning Activities (Section 1) as defined by the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada.

Maintenance of Certification (MOC) Credit

Successful completion of this CME activity, which includes participation in the evaluation component, enables the learner to earn credit toward the CME of the American Board of Orthopaedic Surgery's Maintenance of Certification program. It is the CME activity provider's responsibility to submit learner completion information to ACCME for the purpose of granting ABOS credit.

EMERGENCY & FIRST AID

The Scottish Event Campus (SEC) is fully prepared to handle emergency requests and first aid. Contact an SRS Staff person for support. Remember to note all emergency exits within the venue.

E-POINT PRESENTATION KIOSKS

There are over 95+ E-Point Presentations to view on the E-Point Presentation kiosks located in the Exhibit Hall (Booth #14).

NEW: Visit the **Innovation Theatre** (Hall 2) for mini-sessions highlighting top-scoring E-Points; schedule can be accessed on the meeting app or digital program. Listen to live rapid-fire presentations from each nominated paper, followed by a moderated discussion. Don't forget to also visit the E-Point Kiosks located in the Exhibit Hall (Booth #14) to view all E-Point presentations. Voting for award-nominated E-Points can be completed on the IMAST 2025 meeting app, and will remain open until Friday, April 4, 2025.

GLASGOW CONVENTION BUREAU

GLASGOW CONVENTION BUREAU

We gratefully acknowledge the support provided by Glasgow Convention Bureau.

INNOVATION CELEBRATION

Join your colleagues to close out the 32nd IMAST. The celebration takes place Friday, April 4 from 17:30-19:00 at the Radisson RED Sky Bar Lounge. Open to all registered delegates and guests of registered delegates. Tickets are $25 USD for registered delegates and $50 USD for guests and must be purchased in advance. Please stop at the IMAST registration desk to purchase tickets. Dress for the Innovation Celebration is business casual.

GENERAL MEETING INFORMATION

INTERNET ACCESS

Wireless Internet access is available throughout the meeting space of the Scottish Event Campus (SEC).

To log on select...
Network = SRS Meeting
Password = IMAST2025

LANGUAGE

Presentations and course materials will be provided in English.

LOST & FOUND

Please feel free to stop by the SRS Registration Desk if you have a lost or found an item during the course of IMAST.

NO SMOKING POLICY

Smoking is not permitted during any IMAST activity or event.

REGISTRATION DESK HOURS

Location: Hall 1

Wednesday, April 2	12:30 - 18:30
Thursday, April 3	07:00 - 18:30
Friday, April 4	07:00 - 16:30

SPEAKER READY ROOM

Presenters may upload their PowerPoint presentations in the Speaker Ready Room.

Location: Hall 1

Wednesday, April 2	15:00 - 18:00
Thursday, April 3	08:00 - 18:30
Friday, April 4	07:00 - 16:00

Please upload presentations no later than 24 hours before the session is scheduled to begin.

VIDEO RECORDING PROHIBITED

SRS does not allow personal video recording of the presentations of any kind. SRS holds the right to confiscate any and all recording taken of any of the presentations. All session rooms will be recorded and will be available to delegates after the meeting on the SRS website.

WELCOME RECEPTION

Civic Reception hosted by The Rt Hon The Lord Provost of Glasgow

All registered delegates are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, April 2 from 18:00-20:00. The reception will be hosted in the Exhibit Hall (Hall 2), where beverages and light hors d' oeuvres will be served. There is no charge for registered delegates. Registered delegates may purchase guest ticket(s) for the Welcome Reception for $50 USD, per person, at the IMAST registration desk. Dress for the Welcome Reception is business casual.

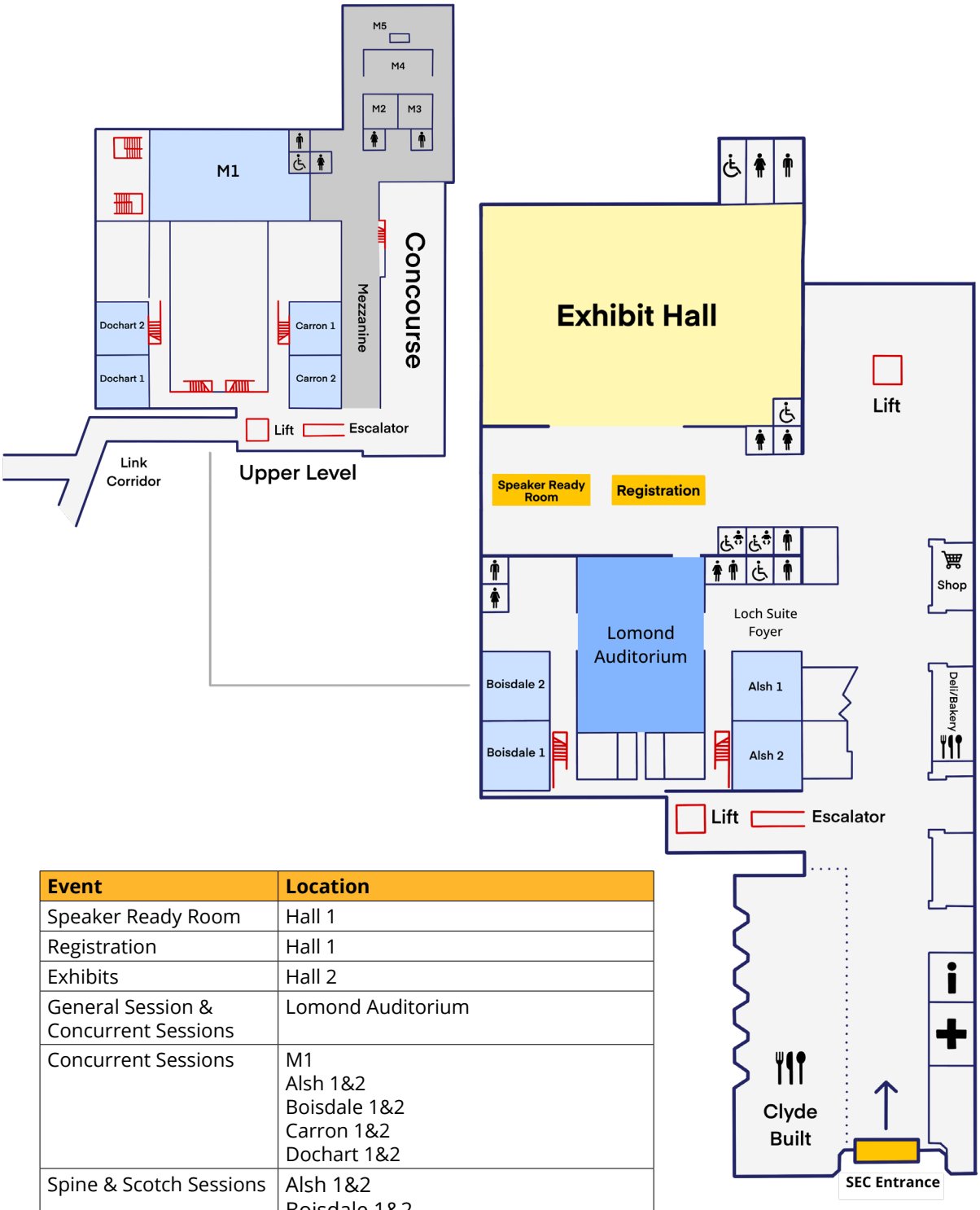
MEETING OVERVIEW

subject to change

	Wednesday, April 2	Thursday, April 3	Friday, April 4
Morning		07:00 - 18:30 Registration Open 08:00 - 09:00 Hands-On Workshop* *with breakfast* 09:00 - 09:25 Exhibit Viewing & Refreshment Break* 09:25-11:45 Abstract Session 1: Whitecloud Clinical Award Nominees 11:45 - 12:00 Exhibit Viewing & Lunch Pick-Up*	07:00 - 16:30 Registration Open 07:30 - 08:30 Concurrent Sessions (Abstract Sessions 5A - 5D) 08:30 - 09:00 Exhibit Viewing & Refreshment Break* 09:00 - 11:00 Abstract Sessions 6 11:00 - 11:30 Exhibit Viewing & Lunch Pick-Up* 11:30 - 12:30 Hands-On Workshops*
Afternoon	12:30 - 18:30 Registration Open	12:00 - 13:00 Hands-On Workshops* 13:00 - 13:30 Exhibit Viewing* 13:30 - 15:00 Concurrent Sessions (Sessions 2A & 2B) 14:30-16:30 SRS-POSNA Kids Forum* 15:00 - 15:30 Exhibit Viewing & Refreshment Break* 15:30 - 17:00 Concurrent Sessions (Sessions 3A & 3B) 17:00 - 17:30 Exhibit Viewing* 17:30 - 18:30 Education Session 4	12:30 - 12:45 Exhibit Viewing* 12:45 - 14:15 Concurrent Sessions (Sessions 7A & 7B) 14:15 - 14:30 Exhibit Viewing* 14:30 - 15 :30 Special Session* 15:30 - 16:00 Exhibit Viewing & Refreshment Break* SRS Member Information Session* 16:00 - 17:30 Education Session 8*
Evening	16:00 - 18:00 Spine & Scotch: Cases on the Rocks - Discussion Sessions 18:00 - 20:00 Welcome Reception & Exhibit Viewing*		17:30 - 19:00 Innovation Celebration*

**Denotes non-CME session*

MEETING SPACE FLOOR PLAN



Event	Location
Speaker Ready Room	Hall 1
Registration	Hall 1
Exhibits	Hall 2
General Session & Concurrent Sessions	Lomond Auditorium
Concurrent Sessions	M1 Alsh 1&2 Boisdale 1&2 Carron 1&2 Dochart 1&2
Spine & Scotch Sessions	Alsh 1&2 Boisdale 1&2 Carron 1&2
Hands-On Workshops	Alsh 1&2 Boisdale 1&2 Carron 1&2

Charging area located on the Mezzanine Level.

16:00 - 18:00

Spine & Scotch: Cases on the Rocks 1: Complication Avoidance in AIS

ALSH 1&2

This session is supported, in part, by a grant from ATEC Spine

Moderator: Baron Zarate Kalfopulos, MD

Table Moderators: Amit Jain, MD, MBA; Luiz Müller Ávila, MD; Luis Saavedra, MD; Marinus de Kluever, MD, PhD; Lawrence G. Lenke, MD; Per D. Trobisch, MD

Spine & Scotch: Cases on the Rocks 2: New Technology for Adult Spinal Deformity

BOISDALE 1&2

This session is supported, in part, by a grant from ATEC Spine

Moderator: Gregory M. Mundis Jr., MD

Table Moderators: Munish C. Gupta, MD; Serena S. Hu, MD; Praveen V. Mummaneni, MD; Eric O. Klineberg, MD; Brian J. Neuman, MD; Han Jo Kim, MD

Spine & Scotch: Cases on the Rocks 3: Innovation in MIS

CARRON 1&2

This session is supported, in part, by a grant from Highridge Medical

Moderator: Robert K. Eastlack, MD

Table Moderators: Venu Nemani, MD, PhD; Roland Kent, MD; Juan S. Uribe, MD; David O. Okonkwo, MD, PhD; Jason Bernard, MD, FRCSorth, MBchB

18:00 - 20:00

Welcome Reception*

HALL 2

The 32nd IMAST will officially begin with the Welcome Reception, a hosted reception featuring hors d'oeuvres, cocktails, and reunions with colleagues and friends and exhibitor viewing. If you would like to purchase guest ticket(s), you may do so at Registration in Hall 1.

Civic Reception hosted by The Rt Hon The Lord Provost of Glasgow

*Denotes non-CME Session

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

08:00 - 09:00

Hands-On Workshop*

See page 176 for schedule and descriptions.

Each workshop will be programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company. Please note: CME credits are not available for Hands-On Workshops.

09:00 - 09:25

Refreshment Break & Exhibit Viewing*

HALL 2

09:25 - 11:45

Abstract Session 1 - Whitecloud Award Nominated Papers

LOMOND AUDITORIUM

Moderators: Meric Enercan, MD & Kristen E. Jones, MD, FAANS

09:25 - 09:30 **Welcome from Glasgow Lord Provost**
Rt Hon The Lord Provost of Glasgow/Bailie

09:30 - 09:34 **Paper #1: Surface Carburized 3D Printed Ti-6Al-4V Biomimetic Porous Motion-Preserving Artificial Cervical Vertebra and Its Initial Clinical Application** †
Wen-Long Yang, PhD; Chaoyuan Ge, PhD

09:34 - 09:38 **Paper #2: Circulating MicroRNAs as a Prognostic Tool in Pediatric Patients with Idiopathic Scoliosis** †
Michael Lujc, MD; Michal Galko, MD; Martin Repko, MD, PhD; Jana Orličková, MS; Dagmar Al Tukmachi, MS; Milan Filipovič, MD, PhD; Ondřej Slabý, MS, PhD

09:38 - 09:42 **Paper #3: A Novel Growth Guidance System: Research and Development** †
You Du, MD; Jianguo Zhang, MD; John T. Killian, MD

09:42 - 09:55 **Discussion**

09:55 - 09:59 **Paper #4: Wearable Sensors for Pre- and Post-operative Assessment of Cervical Myelopathy** §
Steven D. Glassman, MD; Jeffrey L. Gum, MD; Justin Mathew, MD; *Charles H. Crawford III, MD*; Mladen Djurasovic, MD; Leah Y. Carreon, MD

09:59 - 10:03 **Paper #5: Development of a Cloud-Based Remote Monitoring System for Halo Gravity Traction** §
Jaysson T. Brooks, MD; Lydia Klinkerman, BS; Karl E. Rathjen; Daniel J. Sucato, MD, MS; Brandon A. Ramo, MD; Amy L. McIntosh, MD; Karina A. Zapata, PhD; Brad Niese, BS; Megan Johnson, MD

10:03 - 10:07 **Paper #6: GenAI Powered Three-Dimensional Spine Model Generation Based on Biplanar Smartphone Images of Scoliosis Patients with a Single Center Validation** §
Moxin Zhao, MS; Nan Meng, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; *Teng G. Zhang, PhD*

10:07 - 10:20 **Discussion**

10:20 - 10:24 **Paper #7: Comprehensive Skeletal Maturity Index Can Obviate the Need for Hand Radiographs for Sanders Scoring** §
Alison Dyszel, PA-C; Elyette M. Lugo, BS; Paul D. Sponseller, MD, MBA; *Amit Jain, MD, MBA*

10:24 - 10:28 **Paper #8: Quantitative Morphological Apical Intervertebral Disc Characteristics as Predictors of Curve Progression in Adolescents with Idiopathic Scoliosis** §
Conor T. Boylan, MBChB, MSc, BSc, MRCS Ed; Arin M. Ellingson, PhD; Siddhant Kapoor, MBChB, MRCS; David S. Marks, MBBS, FRCS, FRCSOrth; David W. Polly Jr., MD; Morgan Jones, FRCS

*Denotes non-CME Session

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

10:28 - 10:32 **Paper #9: Complications and Unplanned Return to the Operating Room (UPROR) at 5-Years Postoperative Vertebral Body Tethering for Idiopathic Scoliosis** §
Ron El-Hawary, MD; Firoz Miyanji, MD, FRCS(C); *Ahmad Alelaumi, MD*; Isha Prasad, RN; Jennifer K. Hurry, MASc; Flavia Alberghina, FRCS; Pediatric Spine Study Group; Stefan Parent, MD, PhD

10:32 - 10:45 **Discussion**

10:45 - 10:49 **#10: Identification of Novel Differentially Methylated Positions in Adult Spinal Deformity Patients That Experienced Perioperative Complications** §
Rohit K. Bhan, MD, MS; Quante Singleton, MD; Yu Zhang, MS; Christopher Diaz, BS; Christopher P. Ames, MD; Bo Zhang, PhD; Michael Kelly, MD; Nicholas A. Pallotta, MD, MS; *Brian J. Neuman, MD*

10:49 - 10:53 **Paper #11: IGF-1 Serum Levels are Associated with Early Recovery and In-Hospital Complications After Spinal Fusion** §
Annika Bay, MD; Han Jo Kim, MD; Atahan Durbas, MD; Luis F. Colon, MD; Stephane Owusu-Sarpong, MD; Quante Singleton, MD; Farah Musharbash, MD; Andrea Pezzi, MD; Tomoyuki Asada, MD; Chad Simon, BS; Sereen Halayqeh, MD; Adrian Lui, MD; Tarek Harhash, BS; Eric Zhao, BS; Tejas Subramanian, BS; Robert N. Uzzo, MBA; Justin Samuel, BS; Gregory Kazarian, MD; Kasra Araghi, BS; *Francis C. Lovecchio, MD*

10:53 - 10:57 **Paper #12: Selection of Upper Instrumented Vertebra in Adult Spinal Deformity: Risk Calculator and Recommendations Based on Proximal Junctional Kyphosis** §
Jamshaid Mir, MD; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Max R. Fisher, MD; Anthony Yung, MMSc; Matthew Galetta, MD; Nathan Lorentz, MD; Jordan Lebovic, MD, MBA; Pawel Jankowski, MD; *Peter G. Passias, MD*

10:57 - 11:10 **Discussion**

11:10 - 11:14 **Paper #13: Picking Up "MRI-silent" Pathologies with Dynamic MR Testing of Cervical Spine: Result of 30 Cases** §
Manish K. Kothari, MS; David Bauer, MD, MPH

11:14 - 11:18 **Paper #14: Preventing Distal Junctional Kyphosis: Choosing a Stable End for the Lowest-Instrumented Vertebra is Protective Following Adult Cervical Deformity Surgery** §
Max R. Fisher, MD; Ankita Das, BS; Oluwatobi O. Onafowokan, MBBS, MS; Jamshaid Mir, MD; Anthony Yung, MMSc; *Pawel Jankowski, MD*; Peter G. Passias, MD

11:18 - 11:22 **Paper #15: Lumbar Facet Arthroplasty for Spondylolisthesis and Stenosis: Three-Year Outcomes from a Prospective FDA Randomized Clinical Trial** §
Evalina L. Burger, MD; Vikas V. Patel, MD; Michael P. Steinmetz, MD; William C. Welch, MD; Ahmad Nassr, MD; Domagoj Coric, MD

11:22 - 11:35 **Discussion**

11:35 - 11:40 **Annual Meeting 2025 Preview**
A. Noelle Larson, MD

11:40 - 11:45 **IMAST 2026 Preview**
Amit Jain, MD, MBA & Caglar Yilgor, MD

11:45 - 12:00

Lunch Pick-Up
INSIDE WORKSHOP ROOMS

Exhibit Viewing*
HALL 2

*Denotes non-CME Session
Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

12:00 - 13:00

Hands-On Workshops*

See page 176 for schedule and descriptions.

Each workshop will be programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company. Please note: CME credits are not available for Hands-On Workshops.

13:00 - 13:30

Break & Exhibit Viewing*

HALL 2

13:00 - 13:30

E-Point Award-Nominated Papers 1*

INNOVATION THEATRE (HALL 2)

Moderator: Camilo Molina, MD

New: Visit the Innovation Theatre for a mini-session highlighting top-scoring E-Points. Listen to live rapid-fire presentations from each nominated paper, followed by a moderated discussion. Don't forget to also visit the E-Point Kiosk located in Hall 2, Booth #14 to view all E-Point presentations. Voting for award-nominated E-Points can be completed on the IMAST 2025 meeting app, and will remain open until Friday, April 4, 2025.

Please note: CME credits are not available for this session.

13:05 - 13:07 **Paper #157: Presence of Compensatory Curve Predicts Postoperative Curve Progression in Congenital Scoliosis After Thoracolumbar Hemivertebra Resection and Short Fusion**
Yanjie Xu, MD; Dongyue Li; Jie Li, MD, PhD; Zongshan Hu, PhD; *Zhen Liu, PhD*; Zezhang Zhu, PhD; Yong Qiu, PhD

13:07 - 13:09 **Paper #119: Connective Tissue Disease Patients Do Not Have Higher Rates of PJK Compared with Idiopathic EOS Following Growth Friendly Instrumentation**
Kenneth A. Shaw, DO; John T. Smith, MD; Joshua M. Pahys, MD; Pediatric Spine Study Group; Brandon A. Ramo, MD

13:09 - 13:11 **Paper #197: Optimizing Mental Health Conditions Prior to Adult Cervical Deformity Surgery: Does Preoperative Optimization Improve Surgical Outcomes?**
Anthony Yung, MMSc; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Oliver Menken, BS; Caroline Wu, MD; Alexander Parsons, MD, MSc; Isabel Prado, MD, MS; Iryna Ivasyk, MD, PhD; Nathan Lorentz, MD; Matthew Galetta, MD; Ethan Cottrill, MS; Khoi D. Than, MD; *Peter G. Passias, MD*

13:11 - 13:20 **Discussion**

*Denotes non-CME Session

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

13:30 - 15:00

Abstract Session 2A - Adolescent Idiopathic Scoliosis

LOMOND AUDITORIUM

Moderators: Michelle Welborn, MD & Suken A. Shah, MD

13:30 - 13:34 **Paper #16: Hypokyphosis is for the Skinny Kids: The Effect of Childhood Obesity on True 3D Kyphosis in Idiopathic Scoliosis**
Eliza Lovrich, BS; Moanes Shalabi, MD; Carlos Monroig-Rivera, MD; *Lydia R. Klinkerman, BS*; Megan Johnson, MD; Brandon A. Ramo, MD; Amy L. McIntosh, MD; Banahene Glover, BS; Jaysson T. Brooks, MD

13:34 - 13:38 **Paper #17: Assessment of the Utility of MRI in Preoperative Evaluation of Adolescent Idiopathic Scoliosis**
Gabrielle A. Rogie, BS; Rohini Vanodia, MD; Timothy Borden, MD; Lindsay Crawford, MD; Surya N. Mundluru, MD, MBA; Eric O. Klineberg, MD; Rex Marco, MD; Shah-Nawaz Dodwad, MD; Brennan Roper, MD; Jessica Traver, MD; Alfred Mansour, MD; Shiraz A. Younas, MD

13:38 - 13:42 **Paper #18: Tele-Scoli-Screen & Treat (TSST) Protocol for Scoliosis Treatment, Combining In-Person and Online Treatment Sessions, for Patients with Transportation Barriers**
Nikos Karavidas, PT, MSc

13:42 - 13:52 **Discussion**

13:52 - 13:56 **Paper #19: Does Vertebral Body Tethering Cause Coronal Hypermobility of Adjacent Non-Instrumented Levels?**
Hans K. Nugraha, MD; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD*; Ahmad Nassr, MD*

13:56 - 14:00 **Paper #20: Surgical Planning Tool Based on Patient's Presenting Deformity, Skeletal Maturity and Flexibility for Lumbar VBT, Validated by Multicenter Study**
Marie-Eve Fecteau; Nikita Cobetto, PhD; Marine Gay; Christiane Caouette, PhD; A. Noelle Larson, MD; Dan Hoernschemeyer, MD; Melanie E. Boeyer, PhD; Ron El-Hawary, MD; Ahmet Alanay, MD; *Carl-Eric Aubin, PhD*

14:00 - 14:04 **Paper #21: Location of Tensioned Cord in Double Row VBT Constructs Significantly Affects Flexion Extension and Lateral Bending Range of Motion: A Cadaveric Biomechanics Study**
A. Noelle Larson, MD; Amy A. Claeson, PhD; Vijay Permeswaran, PhD

14:04 - 14:14 **Discussion**

14:14 - 14:18 **Paper #22: Closed Bulb Suction Utilization After Primary Thoracoscopic Vertebral Body Tether Instead of Chest Tube**
Samantha Ahrens, BS; *Lawrence L. Haber, MD*; Hunter Starring, MD; Bhumit R. Desai, MD

14:18 - 14:22 **Paper #23: Surgical Correction of Scoliosis Restores Balance: A Prospective Motion Analysis Study**
Ria Paradkar, BS; Christina Regan, BS; Kathie Bernhardt, BS; Kenton R. Kaufman, PhD; Todd A. Milbrandt, MD, MS; *A. Noelle Larson, MD*

14:22 - 14:26 **Paper #24: Correlations Between Thoracic Kyphosis and Rod Contouring in Patients with Adolescent Idiopathic Scoliosis Indicate Ideal Contouring Prescriptions for Correction**
Norihiro Isogai, MD; Suken A. Shah, MD; A. Noelle Larson, MD; Harry L. Shufflebarger, MD; Stephen G. George, MD; Paul D. Sponseller, MD, MBA; Peter G. Gabos, MD; Burt Yaszay, MD; Joshua M. Pahys, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Harms Study Group

14:26 - 14:36 **Discussion**

14:36 - 14:40 **Paper #25: Determination of Lowest Instrumented Vertebra Using "Nanjing Rule" Achieved Shorter Fusion Safely Compared with "LSTV Rule" for Lenke 1A Curves**
Xiaodong Qin, PhD; *Zhong He, MD*; Zhen Liu, PhD; Yong Qiu, PhD; Zezhang Zhu, PhD

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14:40 - 14:44 **Paper #26: Putting the "C" Back into CSVL: Does the Method of Drawing the CSVL Affect the Last Touched Vertebra?**
Varun Ravi, BS; Carlos Monroig-Rivera, MD; Alexander Turner, BS; Emeka Andrews, BS; Y. Jordan Kenfack, BS; David C. Thornberg, BS; *Banahene Glover, BS*; Jaysson T. Brooks, MD

14:44 - 14:48 **Paper #27: Intra-operative Rib-to-Pelvis Distraction for Severe Pediatric and Adolescent Scoliosis**
Joshua S. Murphy, MD; Kenneth A. Shaw, DO; Daniel Raftis, BS; Nicholas D. Fletcher, MD; Michael Schmitz, MD; Ameer Rifai, BS; Dennis P. Devito, MD

14:48 - 15:00 **Discussion**

13:30 - 15:00

Education Session 2B - Spinal Endoscopy: From Decompression to Fusion

M1

This session is hosted by EUROSPINE

Moderators: Ahmet Alanay, MD & Christoph Siepe, MD

13:30 - 13:35 **Introduction and Welcome**
Ahmet Alanay, MD

13:35 - 13:50 **Full Endoscopic Spine Surgery of the Lumbar Spine: An Overview**
Christoph Siepe, MD

13:50 - 13:59 **Clinical Outcomes of Endoscopic Surgery: An Overview**
Shahnawaz Haleem, MSc(Tr&Orth), MRCSEd, MRCS,I ESD, EASD, FRCS(Tr&Orth)

13:59 - 14:09 **Q&A**

Debate: Endoscopic Spine Surgery vs. Traditional Open Surgery

14:09 - 14:18 **Pro Endoscopic Surgery**
Christoph Siepe, MD

14:18 - 14:27 **Pro Traditional Surgery**
Marco Teli, MD

14:27 - 14:37 **Q&A**

14:37 - 14:46 **A Comparison of Uniportal vs. Biportal Techniques**
Javier Quillo-Olvera, MD

14:46 - 14:55 **Full Endoscopic Lumbar Fusion and Beyond**
Ali Guven Yorkoglu, MD

14:55 - 15:00 **Q&A**

15:00 **Wrap up & Closing Remarks**
Christoph Siepe, MD

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14:30 - 16:30

SRS-POSNA Kids Forum*

ALSH 1&2

14:30 - 14:33 **Welcome**
Kali Tileston, MD

14:34 - 14:39 **Introduction to the Problem**
Brian Snyder, MD, PhD

14:40 - 14:45 **State of Pediatric Implants in EU**
Darren Lui, FRCS (TR & Orth)

14:46 - 14:51 **Struggles of Access to Care in EU**
Marinus de Kleuver, MD, PhD

14:52 - 14:57 **Effect of New Device Regulations in EU/UK**
Sara Rivera

14:58 - 15:03 **Device Regulations and Startups**
Timo Lehtonen

15:04 - 15:09 **The Rise and Fall of Pediatric Devices**
Jwalant Mehta , FRCS(Orth)

15:10 - 15:15 **Beyond Compliance**
Shahin Ahuja, MBBS, MS (Orth), FRCS, FRCS (Orth)

15:16 - 15:31 **Discussion**

15:32 - 15:37 **Cost of Regulations and How to Move Forward (Brownhill)**
Sarah Brownhill

15:38 - 15:43 **Registries and Data Collection**
A. Noelle Larson, MD

15:44 - 15:49 **FDA response**
Patrick J. Cahill, MD

15:50 - 15:55 **Regulatory Considerations in UK for Pediatric Devices**
Joseph Langley MEng, CEng MIMechE

15:56 - 16:01 **Success of Pediatric Orthopaedic Registries for Regulatory Purposes**
Tricia St. Hilaire

16:02 - 16:07 **What is the Future?**
Kali Tileston, MD

16:08 - 16:25 **Discussion**

16:25 - 16:30 **Closing Remarks**
A. Noelle Larson, MD

15:00 - 15:30

Refreshment Break and Exhibit Viewing*

HALL 2

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15:00 - 15:30

HALL 2

E-Point Award-Nominated Papers 2*

Moderator: Corey T. Walker, MD

New: Visit the Innovation Theatre for a mini-session highlighting top-scoring E-Points. Listen to live rapid-fire presentations from each nominated paper, followed by a moderated discussion. Don't forget to also visit the E-Point Kiosk located in Hall 2, Booth #14 to view all E-Point presentations. Voting for award-nominated E-Points can be completed on the IMAST 2025 meeting app, and will remain open until Friday, April 4, 2025.

Please note: CME credits are not available for this session.

15:05 - 15:07 **Paper #105: Radiographic and Clinical Outcome Analysis of Custom vs. Surgeon Contoured Rods for Adolescent Idiopathic Scoliosis Deformity Correction**
Matthew J. Geck, MD; Devender Singh, PhD; Ashley Duncan, RN; John Stokes, MD; Eric Truumees, MD; *Vik Kohli, MD*; Morgan Laviolette, DPT; Rory R. Mayer, MD

15:07 - 15:09 **Paper #138: Thoracic Inlet Insufficiency: A Novel Form of Thoracic Insufficiency: Diagnosis and Treatment**
Blake Montgomery, MD; Emily Eickhoff, BS; Shawn Izadi, MD; Amir Taghinia, MD; David Zurakowski, PhD; Russell W. Jennings, MD; Christopher Baird, MD; *Brian D. Snyder, MD, PhD*

15:09 - 15:11 **Paper #127: Growth Modulation Correction at 2 Years with Various Lumbar VBT Intraoperative Correction Levels in Pediatric Idiopathic Scoliosis**
Marine Gay, Nikita Cobetto, PhD; Christiane Caouette, PhD; A. Noelle Larson, MD; Isabelle Villemure, PhD; Dan Hoernschemeyer, MD; Melanie E. Boeyer, PhD; Ron El-Hawary, MD; Ahmet Alanay, MD; *Carl-Eric Aubin, PhD*

15:11 - 15:13 **Paper #118: Early Term Outcomes of Non Fusion Anterior Scoliosis Correction (NFASC) in Non-Idiopathic Scoliosis (NIS) - A Single Centre Experience**
Sajan K. Hedge, MD; Appaji K. Krishnamurthy, MD; Vigneshwara M. Badikillaya, MD; Sharan T. Achar, MS; *Harith B. Reddy, MS*

15:13 - 15:20 **Discussion**

15:30 - 17:00

Abstract Session 3A - Innovation, AI and Machine Learning

LOMOND AUDITORIUM

Moderators: Stefan Parent, MD, PhD & Peter G. Passias, MD

15:30 - 15:34 **Paper #28: DigiScolio: An AI-based Prediction Model for Individualized Assessment of Lumbar Motion and Function in Adolescent Idiopathic Scoliosis Patients**
Owen Yuechuan Zhang, MD; Yiqiao Zhang, MD; Jianguo Zhang, MD; *Qianyu Zhuang, MD*

15:34 - 15:38 **Paper #29: Predictive Model for Postoperative X-Rays of AIS After PSF Surgery Using Generative Neural Networks: SVV-Net**
Nan Wu, MD; Jianguo Zhang, MD; Yuanpeng Zhu, MD; Xiangjie Yin, MD; Xueyi Zhang, PhD; Guilin Chen, MD

15:38 - 15:42 **Paper #30: Automated Thoracic Cobb Angle Measurement in Adolescent Idiopathic Scoliosis Using Keypoint R-CNN: Development, Validation, and Performance Comparison**
Mert M. Dagli, MD; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip, BA; Kevin Bryan, BA; Jonathan Sussman, BS; Connor Wathen, MD; Yohannes Ghenbot, MD; *John Arena, MD*; Joshua L. Golubovsky, MD; John Shin, MD; Ali Ozturk, MD; Beth Winklestein, PhD; William C. Welch, MD; Jang Yoon, MD

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15:42 - 15:52 **Discussion**

15:52 - 15:56 **Paper #31: A Novel AI Classifier for Enhanced Spine Radiograph Interpretation**
Kellen Mulford, PhD; Julia Todderud, BA; Christina Regan, BS; A. Noelle Larson, MD; *Ahmad Nassr, MD*

15:56 - 16:00 **Paper #32: Multimodal Machine Learning Model for Predicting Perioperative Outcomes in Spinal Surgery**
Kyle Mani, BS; Thomas Scharfenberger, BS; Samuel Goldman, BS; Emily Kleinbart, BS; Evan Mostafa, MD; Rafael De la Garza Ramos, MD; Mitchell Fourman, MD, MPhil; Ananth S. Eleswarapu, MD

16:00 - 16:04 **Paper #33: A Novel Multi-Modal Wearable Motion Balance Surveillance Device Enhances Unsupervised Exercise Effects in Adolescent Idiopathic Scoliosis Patients**
Chengyin Wang, PhD; *Owen Yuechuan Zhang, MD*; Yiqiao Zhang, MD; Jianguo Zhang, MD; Qianyu Zhuang, MD

16:04 - 16:14 **Discussion**

16:14 - 16:18 **Paper #34: Optimization and Validation of an Extreme Gradient Boosting Model to Predict Reoperation Following Surgical Site Infection: Analysis of 96,216 Patients with ACS NSQIP Database**
Mert M. Dagli, MD; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip, BA; Kevin Bryan, BA; Connor Wathen, MD; Yohannes Ghenbot, MD; John Arena, MD; Joshua L. Golubovsky, MD; John Shin, MD; Ali Ozturk, MD; William C. Welch, MD; Jang Yoon, MD

16:18 - 16:22 **Paper #35: Can a Novel AI-Based Predictive 3D Imaging Software for Idiopathic Scoliosis Obviate the Need for Routine X-Rays?**
Abdullah AlDuwaisain, FRCS(C), MBChB; Hani Alharbi, MD, FRCS; Joel Maliakkal, BS; Carolina Ricardo, BS; Carolina Ricardo, BS; Firoz Miyanji, MD, FRCS(C)

16:22 - 16:26 **Paper #36: Development of a Machine Learning Tool to Improve Intraoperative Neurophysiological Monitoring: Proof of Concept**
Varun Arvind, MD, PhD; Omar Taha, BS; Matthew Weintraub, BSE; Anil Mendiratta, MD; *Michael G. Vitale, MD, MPH*

16:26 - 16:36 **Discussion**

16:36 - 16:40 **Paper #37: Normative Alignment Goals Using Machine Learning Finds the Sweet Spot Between Pseudarthrosis and Proximal Junctional Kyphosis in Adult Spinal Deformity**
Sarthak Mohanty, BS; Justin L. Reyes, MS; Josephine R. Coury, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; *Lawrence G. Lenke, MD*

16:40 - 16:44 **Paper #38: Comparative Analysis of Artificial Intelligence and Traditional X-Ray Parameter Measurements in Spinal Surgical Planning**
Esteban Quiceno, MD; Mohamed A.R. Soliman, MD, PhD; Asham Khan; Jacob Greisman, MD; John Pollina, MD; *Jeffrey Mullin, MD*; Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), D Orth

16:44 - 16:48 **Paper #39: Machine Learning Models Capable of Predicting Spine Surgery Outcomes Using Smartphone Accelerometer Data**
Daksh Chauhan, BS; Hasan Ahmad, BS; Ryan Turlip, BA; Harmon Khela, BS; Omkar Anaspure, BS; Kevin Bryan, BA; Robert Subtirelu, BS; Yohannes Ghenbot, MD; Michael Y. Wang, MD; Jang Yoon, MD

16:48 - 17:00 **Discussion**

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15:30 - 17:00

Education Session 3B - Innovation to Elevate Clinical Practice: Monitoring New Implants, Registries and Outcomes Beyond PROMs.

Updates from The British Association of Spine Surgeons and The British Scoliosis Society

M1

Moderators: Edward Bayley, MRCSEd & Girish N. Swamy, FRCS

15:30 - 15:33 **Introduction**

15:33 - 15:48 **Incorporating Modern Technology to Assess Clinical Outcomes and Beyond PROMS and PREMS**
Benjamin Davies, MBChB(Hons), BSc (Hons), MRCS

15:48 - 15:54 **Discussion**

15:54 - 16:09 **ODEP and Beyond Compliance: Monitoring New Implants**
Sashin Ahuja, FRCS

16:09 - 16:15 **Discussion**

16:15 - 16:30 **How Should National Spine Registries Evolve?**
Ashley Cole, MD

16:30 - 16:36 **Discussion**

16:36 - 16:51 **Emerging Technologies and Innovations in Non-surgical Management of Spinal Metastasis**
Tom Marshall, MD

16:51 - 17:00 **Discussion**

17:00 - 17:30

Break & Exhibit Viewing*

HALL 2

17:30 - 18:30

Education Session 4 - Changing Practice with New Innovation

LOMOND AUDITORIUM

Moderators: Charles H. Crawford III, MD & Per D. Trobisch, MD

17:30 - 17:36 **How I Started Using Navigation for AIS and Why I Went Back to Free-Hand**
David L. Skaggs, MD, MMM

17:36 - 17:42 **VBT: A Good Tool with a Learning Curve**
Per D. Trobisch, MD

17:42 - 17:48 **The Rise and Fall of MGCR In My Practice**
Jwalant S. Mehta, FRCS(Ortho)

17:48 - 18:00 **Discussion**

18:00 - 18:06 **Wearable Sensor Technology**
Charles H. Crawford III, MD

18:06 - 18:12 **Predictive Analytics and AI in the Management of Sagittal Spinal Deformity**
Ferran Pellisé, MD, PhD

18:12 - 18:18 **Understanding Coronal Malalignment: Insights and Advances through Innovation**
Ibrahim Obeid, MD

18:18 - 18:30 **Discussion**

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07:30 - 08:45

Abstract Session 5A - Pediatric Deformity

ALSH 1&2

Moderators: A. Noelle Larson, MD & Firoz Miyanji, MD, FRCS

07:30 - 07:34 **Paper #40: Impact on Pre- and Post- Fusion Quality of Life of Failed Brace Treatment or Vertebral Body Tethering in Idiopathic Scoliosis**
Jeanne Loubeyre, MD; Julie Joncas, RN; Soraya Barchi, BSc; Felix L. Brassard, MD; *Stefan Parent, MD, PhD*

07:34 - 07:38 **Paper #41: Spinal Ultrasound to Quantify In-Brace Correction Before Nighttime Brace Fabrication in Adolescent Idiopathic Scoliosis**
Dineke G. van de Fliert, MD; Peter P. Lafranca, MD; Arthur Arets; Indy van Loon; Moyo C. Kruyt, MD, PhD; René M. Castelein, MD, PhD; Tom P. Schlosser, MD, PhD

07:38 - 07:42 **Paper #42: Comparison of In-Brace Curve Correction and Curve Progression Between Night-Time and Full-Time Bracing in Thoracic AIS - A Matched Cohort Study**
Martin Heegaard, MD, PhD; Lærke C. Ragborg, MD, PhD; Amy L. McIntosh, MD; Anne-Marie Datcu, BS; Regina Velarde, BS; Martin Gehrchen, MD, PhD; Daniel J. Sucato, MD, MS; Benny T. Dahl, MD, DMSci; *Megan Johnson, MD*; Soren Ohrt-Nissen, MD, PhD

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper #43: MRI Generated Synthetic CT in Pediatric Spine Patients**
George Michael, BS; Suhas Etigunta, BS; Andy Liu, BS; *David L. Skaggs, MD, MMM*; Meliza Perales, RN, BSN; Cristabelle Alexander, MS; Christopher Watterson, MD; Daniel Hoghougi, MRSO; Norman Gellada, BHS; Kenneth D. Illingworth, MD

07:56 - 08:00 **Paper #44: Understanding Technical Difficulties and Recognized Errors in Pediatric Robotic Spine Surgery**
Margaret L. Sullivan, BS; *Grant D. Hogue, MD*; Craig M. Birch, MD; M. T. Hresko, MD; Mark A. Erickson, MD; Roger F. Widmann, MD; Jessica H. Heyer, MD; Kirsten Ross, MD; Robert F. Murphy, MD; Dennis P. Devito, MD; Shanika De Silva, PhD, MS; Daniel J. Hedequist, MD

08:00 - 08:04 **Paper #45: Initial Results of Posterior Dynamic Distraction Device in Surgical Treatment for Adolescent Idiopathic Scoliosis**
Angela Lu, DNP, FNP-C, RNFA; Madelyn Hill, MPH; *Michael C. Albert, MD*

08:04 - 08:08 **Paper #46: Posterior Dynamic Distraction for AIS: Minimum 2-Year Follow Up Results of 80 Consecutive Patients**
Geoffrey F. Haft, MD; Michael C. Albert, MD; Timothy Oswald, MD; Gilbert Chan, MD; Alvin C. Jones, MD, MS; Ryan E. Fitzgerald, MD; Kevin M. Neal, MD; A. Noelle Larson, MD; Todd A. Milbrandt, MD, MS; Baron S. Lonner, MD; Christina K. Hardesty, MD; John T. Anderson, MD; Ron El-Hawary, MD

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper #47: Does an Efficient, Steady, or Dual-Surgeon Approach Produce the Best Outcomes in Pediatric Patients Undergoing Spine Surgery?**
Vishal Sarwahi, MD; Effat Rahman, BS; Katherine Eigo, BS; Yungtai Lo, PhD; Jon-Paul P. DiMauro, MD; *Terry D. Amaral, MD*

08:22 - 08:26 **Paper #48: Intraspinal Anomalies in Presumed AIS Does Not Increase the Risk of Intraoperative Neuromonitoring Changes During Posterior Spinal Fusion**
Bill Woodhams, BS; Michael Benvenuti, MD; John T. Anderson, MD; *Kenneth A. Shaw, DO*; Connor J. Mathes, MD

08:26 - 08:30 **Paper #49: False Negative Intraoperative Neuromonitoring Alerts during Pediatric Spinal Deformity Surgery: The Dreaded Outcome**
Chris Bozorgmehr, BS; Hilton C. Braithwaite IV, BS; *Scott J. Luhmann, MD*

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08:30 - 08:34 **Paper #50: Unilateral Intraoperative Neuromonitoring (IONM) Alerts in Cord Level Surgeries for Severe Spinal Deformities - Etiology and Recovery Patterns - Results from International SDIM Study**
Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Colby Oitment, MD, FRCS(C); Stephen J. Lewis, MD, FRCS(C); Lawrence G. Lenke, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; Justin S. Smith, MD, PhD; Nasir Quraishi, MB, ChB, BSc, MRCS, LLM, FRCS, PhD; Yong Qiu, PhD

08:34 - 08:45 **Discussion**

07:30 - 08:45

Abstract Session 5B - EOS, Neuromuscular, Basic Science

BOISDALE 1&2

Moderators: Linday M. Andras, MD & Ron El-Hawary, MD

07:30 - 07:34 **Paper #51: Cured Patients With Early Onset Idiopathic Scoliosis (EOIS) After Serial Casting are at Risk of Recurrence at Intermediate Follow-up**
Rayyan Abid, BA; Abigail E. Manning, BS; Craig M. Birch, MD; *Peter F. Sturm, MD*; Ying Li, MD; Michal Szczodry, MD; Michael P. Glotzbecker, MD; Pediatric Spine Study Group

07:34 - 07:38 **Paper #52: Outcomes of Traditional Dual Growing Rods (TDGR) with Apical Control Techniques for the Treatment of Early-Onset Scoliosis: Comparison to Patients Treated with TDGR-Only with a Minimum 2-Year Follow-Up After Graduation**
Chenkai Li, MD

07:38 - 07:42 **Paper #53: Sagittal Spinal Profile in Patients with Lumbosacral Hemivertebrae: Preoperative Status and Postoperative Evolution at more than 7.5 year Follow-up**
Owen Yuechuan Zhang, MD; Zhuosong Bai, MD; Jianguo Zhang, MD; *Qianyu Zhuang, MD*

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper #54: One year Safety- and Efficacy- correcting Neuromuscular or Syndromic Early Onset Scoliosis with the Spring Distraction System (SDS) or the One Way Self-Expanding Rod (OWSER)**
Justin V. Lemans, MD; Casper S. Tabeling, MD; Jeroen Renkens, MD; Hilde W. Stempels; Lotfi Miladi, MD; *René M. Castelein, MD, PhD*; Moyo C. Kruyt, MD, PhD

07:56 - 08:00 **Paper #55: Designated Spine Anesthesia Teams Improve Perioperative Outcomes for Complex Scoliosis**
Neelufar Raja, BS; Arianne Salunga, DO; Talissa Genoroso, MD; Nicole Pham, MPH; Hiba Naz, BS; Amishi Jobanputra, MS; Stephanie Pan, MD; *Kali R. Tileston, MD*; John S. Vorhies, MD

08:00 - 08:04 **Paper #56: Don't Sweat It: Impact of Raising Room Temperature on Patient Temperature During Pediatric Spine Surgery**
Lindsay M. Andras, MD; Abigail Padilla, BS; Michael J. Heffernan, MD; Tyler A. Tetreault, MD; Tishya Wren, PhD

08:04 - 08:08 **Paper #57: Complications in Halo Gravity Traction: A 40-Year Longitudinal Review**
Anne-Marie Datcu, BS; Anna McClung-Booth, BSN; David C. Thornberg, BS; *Jaysson T. Brooks, MD*; Daniel J. Sucato, MD, MS; Karl E. Rathjen; Brandon A. Ramo, MD

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper #58: Transcriptional Profiling of Paravertebral Muscles in Patients with Adolescent Idiopathic Scoliosis Reveals Genes Involved in Satellite Cell Differentiation and Muscle Fiber-Type Specification**
Jessica McQuerry, MD; *Stephanie Ihnow, MD*; Darius Ramkhalawan, MS; Gloria Vazquez, BS; Nigel J. Price, MD; Robert Decker, MD; Nadja Makki, PhD

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08:22 - 08:26 **Paper #59: Dystrophinopathy in Paravertebral Muscle of Adolescent Idiopathic Scoliosis: A Prospective Cohort Study**
Junyu Li, MD; Danfeng Zheng, MD; Zekun Li, MD; Jiaxi Li, MD; Zexi Yang, MD; Xiang Zhang, MD; Yingshuang Zhang, MD; Miao Yu, MD

08:26 - 08:30 **Paper #60: Evaluation of a Novel Bone Graft with Sclerostin Inhibiting Small Molecule in Sheep Lumbar Interbody Fusion**
Debra Ellies, PhD; F S. Kimball, PhD; Harold Aberman, PhD; Steven Peckham, PhD; Douglas C. Fredericks, BS; *Sigurd H. Berven, MD*

08:30 - 08:34 **Paper #61: Dental Composite Offers Comparable or Greater Pullout and Shear Strength to Lateral Mass Screw Fixation in a Human Cadaveric Model**
Javier Castro, MD; *James Mok, MD*; Karl Bruckman, MD; Calvin Chan, MS; Anna Karnowska, PhD; Harsh Wadhwa, MD; Olivia Okoli, BS; Jayme Koltsov, PhD; Serena S. Hu, MD

08:34 - 08:45 **Discussion**

07:30 - 08:45

Abstract Session 5C - Cervical and Complex

CARRON 1&2

Moderators: Zeeshan Sardar, MD & Christopher M. Bonfield, MD

07:30 - 07:34 **Paper #62: A Classification System to Assess Cervical Spine Alignment and Guide Surgical Treatment for Adult Cervical Deformity: A Multi-Ethnic Alignment Normative Study (MEANS)**
Zeeshan M. Sardar, MD; *Roy Miller, MD*; Justin L. Reyes, MS; Alexandra Dionne, BS; Josephine R. Coury, MD; Riley Sevensky, BS; Matan Malka, BA; Fthimnir Hassan, MPH; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Michael Kelly, MD; Lawrence G. Lenke, MD

07:34 - 07:38 **Paper #63: The Extraordinary Changes of Herniated Intervertebral Disc After LAMP for Cervical Spondylotic Myelopathy Associated with Disc Herniation**
Xuhong Xue, MD, PhD; Sheng Zhao, MD

07:38 - 07:42 **Paper #64: Radiographic Fusion Rates in Anterior Cervical Discectomy and Fusion: Analysis of FDA IDE Trials**
Elyette M. Lugo, BS; K. Daniel Riew, MD; Samuel K. Cho, MD; *Amit Jain, MD, MBA*; AO Spine Knowledge Forum Degenerative

07:42 - 07:53 **Discussion**

07:53 - 07:57 **Paper #65: Does Intra-Operative Methylprednisolone Improve Outcomes of Surgery for Degenerative Cervical Myelopathy? - A Prospective Randomized Study**
Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; *Kushal R. Gohil, MBBS, MS, DNB*

07:57 - 08:01 **Paper #66: Transarticular Atlantooccipital and Condylar Screw Fixation for Occipital Cervical Stabilization in Pediatric Patients: Case Series with at Least 1 Year Follow Up**
David F. Bauer, MD, MPH

08:01 - 08:05 **Paper #67: Cervical Disc Replacement versus Anterior Cervical Discectomy and Fusion in Patients with Preoperative Cervical Myelopathy**
George Abdelmalek, MD; *Harjot Uppal, MD*; Neil Patel, MD; Daniel Coban, MD; Stuart Changoor, MD; Nikhil Sahai, MD; Kumar Sinha, MD; Ki S. Hwang, MD; Arash Emami, MD

08:05 - 08:09 **Paper #68: The Role of Occiptocervical Lordsis in Assessing Upper Cervical Alignment and its Associations with Sagittal Spinal Parameters: A Multi-Ethnic Alignment Normative Study**
Roy Miller, MD; Justin L. Reyes, MS; Alexandra Dionne, BS; Josephine R. Coury, MD; Fthimnir Hassan, MPH; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Michael Kelly, MD; Lawrence G. Lenke, MD;
Zeeshan M. Sardar, MD

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08:09 - 08:21 **Discussion**

08:21 - 08:25 **Paper #70: A Retrospective Single-Center Review of the Performance of Polymer-Embedded Biphasic Calcium Phosphate Bone Graft With Submicron Needle-Shaped Technology Used Standalone in Transforaminal Lumbar Interbody Fusion**
Justin Davis, MD; Brian Everist, MD; Casey Butrico, PhD; Katherine Sage, MS, DO, FAOAO, FAAOS

08:25 - 08:29 **Paper #71: Localization of Low Back Pain Source by S1R PET/MRI**
Ethan Schonfeld, MS, BS; Ghani Haider, MD; Neelan J. Marianayagam, MD, PhD; Kelly Yoo, MD, PhD; Gordon Li, MD; Sandip Biswal, MD; Anand Veeravagu, MD

08:29 - 08:33 **Paper #72: Efficacy of Ultrasound Guided Bilateral Erector Spinae Block with Conventional Anesthesia Care Vs General Anesthesia In Patients Undergoing Single Level Transforaminal lumbar Interbody Fusion Surgery (TLIF): Double Blinded Prospective Randomized Control Study**
Harith B. Reddy, MS; Sharan T. Achar, MS; Akshyaraj Alagarasan, MS; Vigneshwara M. Badikillaya, MD; Appaji K. Krishnamurthy, MD; Sajan K. Hegde, MD; Dr. Vasantha Roopan, MD, DNB

08:33 - 08:45 **Discussion**

07:30 - 08:45

Abstract Session 5D - Degenerative and Kyphosis

DOCHART 1&2

Moderators: Javier Pizones, MD, PhD & Joshua M. Pahys, MD

07:30 - 07:34 **Paper #73: The Impact of Open Lumbar Posterolateral Instrumentation and Fusion versus Minimally-Invasive Techniques: A Propensity-Matched Post-Hoc Analysis of a Randomized Controlled Trial**
Eric Zhao, BS; Robert Cecere, BS; Gregory Kazarian, MD; Arsen Omurzakov, BS; Tomoyuki Asada, MD; Tejas Subramanian, BS; Izzet Akosman, BS; Nishtha Singh, BS; Annika Bay, MD; Kasra Araghi, BS; Olivia Tuma, BS; Atahan Durbas, MD; Adin Ehrlich, BS; Sereen Halayqeh, MD; Tarek Harhash, BS; Adrian Lui, MD; Andrea Pezzi, MD; Sheeraz Qureshi, MD; Sravisht Iyer, MD

07:34 - 07:38 **Paper #74: Five Years Follow up after MIS TLIF vs MIS Decompression for Grade 1 Spondylolisthesis: Is There any Difference in Outcomes?**
Andrew K. Chan, MD; *Vardhaan Ambati, MS*; Dean Chou, MD; Mohamad Bydon, MD; Erica F. Bisson, MD, MPH; Steven D. Glassman, MD; Kevin T. Foley, MD; Christopher I. Shaffrey, MD; Eric A. Potts, MD; Mark E. Shaffrey, MD; Domagoj Coric, MD; John J. Knightly, MD; Paul Park, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Jonathan R. Slotkin, MD; Anthony L. Asher, MD; Michael S. Virk, MD, PhD; Regis W. Haid Jr., MD; Praveen V. Mummaneni, MD, MBA

07:38 - 07:42 **Paper #75: Optimizing Lateral Lumbar Interbody Fusion: Is Expandable Technology Worth It?**
Samuel Ezeonu, BA; Nicholas Vollano, MBS; Alyssa Capasso, BS; Juan Rodriguez-Rivera, BS; Constance Maglaras, PhD; Tina Raman, MD; *Themistocles S. Protopsaltis, MD*

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper #76: Long-Term Reoperation Rates After Single-Level Lumbar Discectomy: A Nationwide Cohort Study**
Suhas Etigunta, BS; Andy Liu, BS; Adeesya Gausper, BA; David L. Skaggs, MD, MMM; *Corey T. Walker, MD*; Alexander Tuchman, MD

07:56 - 08:00 **Paper #77: MRI Signal Intensity in Lumbar Disc Herniation Correlates with Failure of Nonoperative Treatment**
Jonathan H. Garfinkel, MD; Nicholas Taylor, BA; Mihir Tandon, BA; Kelley E. Banagan, MD

*Denotes non-CME Session

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

08:00 - 08:04 **Paper #78: Endoscopic Lumbar Decompression in Obese vs. Non-Obese Patients: Comparable Outcomes Across BMI**
Ryan Turlip, BA; Hasan Ahmad, BS; Yohannes Ghenbot, MD; Daksh Chauhan, BS; Mert M. Dagli, MD; Kevin Bryan, BA; John Arena, MD; Connor Wathen, MD; Dominick Macaluso, PhD; Zarina Ali, MD; Eric Zager, MD; Jang Yoon, MD

08:04 - 8:08 **Paper #79: Does Hip Osteoarthritis Increase Risk for Revision Surgery for Adjacent Segment Disease after Multilevel Lumbar Fusion?**
Akil Paturi, MD; Alexandra Yiachos, BS; Kingsley Ogelle, BS; Juan Rodriguez-Rivera, BS; Constance Maglaras, PhD; *Themistocles S. Protopsaltis, MD*; Tina Raman, MD

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper #80: Management of Giant Calcified Thoracic Disc Herniation Causing Severe Canal Stenosis and Myelopathy using Partial Vertebrectomy: Clinical and Radiological Outcomes of a Novel Posterior-only Technique**
Baris Peker, MD; Hamisi M. Mraja, MD; Mehmet Zamanoglu, MD; Inas Daadour, MD; Sepehr Asadollahmonfared, MD; Onur Levent Ulusoy, MD; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

08:22 - 08:26 **Paper #81: Risk Factors for Post-Operative Cognitive Dysfunction Following Multilevel Lumbar Spinal Fusion**
Mladen Djurasovic, MD; Steven D. Glassman, MD; Jeffrey L. Gum, MD; Morgan Brown, MS; Christy L. Daniels, MS; Colleen Mahoney, BS; Benjamin Kostic, BS; Leah Y. Carreon, MD; *Justin Mathew, MD*

08:26 - 08:30 **Paper #82: Radiographic Predictors of Functional and Pain Outcomes in Scheuermann's Kyphosis: A ROC-Based Minimal Clinically Important Difference (MCID) Analysis**
Matthew J. Geck, MD; Devender Singh, PhD; *Vik Kohli, MD*; Rory R. Mayer, MD; John Stokes, MD; Eeric Truumees, MD

08:30 - 08:34 **Paper #83: Surgery for Scheuermann's Kyphosis (SK) Normalizes Lumbar Lordosis but not Cervical Alignment when Compared to Asymptomatic Adults**
Riley Sevensky, BS; Zeeshan M. Sardar, MD; Justin L. Reyes, MS; Josephine R. Coury, MD; Oluwademilade O. Tega, BS; *Fthimnir Hassan, MPH*; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD

08:34 - 08:45 **Discussion**

08:45 - 09:00

Refreshment Break & Exhibit Viewing*
HALL 2

09:00 - 11:00

Abstract Session 6 - Adult Spinal Deformity & Keynote Speaker
LOMOND AUDITORIUM

Moderators: Serena S. Hu, MD & Ferran Pellisé, MD, PhD

09:00 - 09:04 **Paper #84: A Novel 3D Coupler for Automated Correction of Spinal Deformities: In Vitro Precision and Functionality Testing**
Hazem B. Elsebaie MD, FRCS; Behrooz Akbarnia, MD; Robert Eastlack, MD; Ron El-Hawary, MD; Darryl D'Lima MD, PhD; Mostafa Abousoliman, MS; *Gregory M Mundis Jr., MD*

*Denotes non-CME Session
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09:04 - 09:08 **Paper #85: Increased Cell Saver to Blood Loss Ratio is Associated with a Higher Risk of Pulmonary Embolism After Adult Spinal Deformity Surgery**
Fthimnir Hassan, MPH; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD; Sarthak Mohanty, BS; Peter G. Passias, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Shay Bess, MD; Justin S. Smith, MD, PhD; D. Kojo Hamilton, MD, FAANS; Jeffrey L. Gum, MD; Renaud Lafage, MS; Jeffrey P. Mullin; Michael Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Breton G. Line, BS; Han Jo Kim, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis Jr., MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

09:08 - 09:12 **Paper #86: Topical Tranexamic in Adult Spinal Deformity Surgery (TTADS): A Double-Blinded, Placebo Controlled Randomized Controlled Trial‡**
Han Jo Kim, MD; Kyle W. Morse, MD; Gregory Kazarian, MD; Michael Mazzucco, BS; Jordan A. Gruskay, MD; Stephane Owusu-Sarpong, MD; Kasra Araghi, BS; Rachel L. Knopp, MPH; Justin Samuel, BS; Matthew E. Cunningham, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; Francis C. Lovecchio, MD

09:12 - 09:16 **Paper #87: Pre-Operative GLP-1 Agonists Reduce Postoperative Length of Stay in Spinal Surgery**
Samuel Goldman, BS; Kyle Mani, BS; Emily Kleinbart, BS; Thomas Scharfenberger, BS; Rafael De la Garza Ramos, MD; Mitchell Fourman, MD, MPhil; Ananth S. Eleswarapu, MD

09:16 - 09:24 **Discussion**

09:24 - 09:28 **Paper #88: Utilizing Thoracic Kyphosis Normative Data to Identify Abnormal Spinal Alignments in Adult Spinal Deformity Surgery: Implications for the Definition of Proximal Junctional Kyphosis (PJK)**
Marc Khalifé, MD, MS; *Renaud Lafage, MS*; Alan H. Daniels, MD; Bassel G. Diebo, MD; Jonathan Charles Elysée, BS; Christopher P. Ames, MD; Shay Bess, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

09:28 - 09:32 **Paper #89: Disparities in Presentation and Outcomes of Symptomatic Proximal Junctional Kyphosis Based on Over and Under Correction in Adult Spinal Deformity Corrections**
Jamshaid Mir, MD; Peter G. Passias, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; D. K. Hamilton, MD; Bassel G. Diebo, MD; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Alan H. Daniels, MD; Breton G. Line, BS; Darryl Lau, MD; Nima Alan, MD; David O. Okonkwo, MD, PhD; Nitin Agarwal, MD; Juan S. Uribe, MD; Kai-Ming G. Fu, MD, PhD; Richard G. Fessler, MD, PhD; Pierce D. Nunley, MD; Neel Anand, MD, Mch Orth; Adam S. Kanter, MD; Alekos A. Theologis, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; Khaled M. Kebaish, MD; *Jeffrey P. Mullin, MD*; Justin K. Scheer, MD; Praveen V. Mummaneni, MD, MBA; Themistocles S. Protopsaltis, MD; Dean Chou, MD; Richard Hostin, MD; Munish C. Gupta, MD; Lawrence G. Lenke, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD

09:32 - 09:36 **Paper #90: Predicting Proximal Junctional Kyphosis after Surgical Correction and Fusion from Lower Thoracic Spine to Pelvis in Degenerative Scoliosis: Is there a Role of Thoracic Flexibility**
Hui Xu, MD; Zezhang Zhu, PhD; *Zhen Liu, PhD*; Yong Qiu, PhD; Jie Li, MD, PhD; Zongshan Hu, PhD

09:36 - 09:40 **Paper #91: Pre-contoured Rods in Deformity Surgery: Is the Juice Worth the Squeeze?**
Gautham Prabhakar, MD; Yusef Jordan, MD; *Gregory M. Mundis Jr., MD*

09:40 - 09:48 **Discussion**

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09:48 - 09:52 **Paper #92: Age-Adjusted Alignment Goals Inadequately Represent Asymptomatic Adults and are Prone to Undercorrection**
Sarthak Mohanty, BS; Justin L. Reyes, MS; Fthimnir Hassan, MPH; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Michael Kelly, MD; Zeeshan M. Sardar, MD; *Lawrence G. Lenke, MD*

09:52 - 09:56 **Paper #93: Gait Analysis of Patients with Suboptimal Clinical Outcomes Following Deformity Correction in Adult Spinal Deformity**
Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Gil Han, MD; Cheol-Hyun Jung, MD; *Hong-Sik Park, MD*; Woo-Jae Jang, MD

09:56 - 10:00 **Paper #94: Analysis of Bone Mineral Density of Lumbar Vertebrae after Sagittal Correction in Adult Spinal Deformity Using Computed Tomography Imaging**
Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Gil Han, MD; Cheol-Hyun Jung, MD; Hong-Sik Park, MD; *Woo-Jae Jang, MD*

10:00 - 10:04 **Paper #95: Neurocognitive Changes Following Adult Spinal Deformity Surgery: A Prospective Study with 12-Month Follow-Up**
Tej D. Azad, MD; John F. Burke, MD, PhD; Justin K. Scheer, MD; Terry Nguyen, BS; Jaemin Kim, BS; Vedat Deviren, MD; Christopher P. Ames, MD

10:04 - 10:12 **Discussion**

10:12 - 10:16 **Paper #96: T4-L1 Pelvic Angle Mismatch as a Potential Risk Factor for Mechanical Complications After Long-Level Fusion Surgery**
Myung-Hoon Shin, MD, PhD

10:16 - 10:20 **Paper #97: The Benefit to Prone Lateral Approach in Minimally Invasive Adult Spinal Deformity Surgery: Cost-Benefit Analysis of Single Position vs. Staged/Flipped Procedures**
Ankita Das, BS; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Anthony Yung, MMSc; Matthew Galetta, MD; Nathan Lorentz, MD; Jordan Lebovic, MD, MBA; *Peter G. Passias, MD*

10:20 - 10:24 **Paper #98: Use of a Novel Screw Fusion Implant for Pelvic Fixation: Results from a Prospective Multicenter Trial**
Richard P. Menger, MD; Christopher J. Kleck, MD; Jeffrey P. Mullin; Kara Ashcraft, PhD

10:24 - 10:28 **Paper #99: Oral Synthetic Tetrahydrocannabinol (osTHC) was Safe but not Effective at Reducing Opioid Consumption After 1-3 Level Lumbar Fusions: A Double-Blind, Randomized, Controlled Trial**
Jeffrey L. Gum, MD; Leah Y. Carreon, MD; Morgan Brown, MS; Colleen Mahoney, BS; Christy L. Daniels, MS; Bren Hines, RN; *Steven D. Glassman, MD*

10:28 - 10:35 **Discussion**

10:35 - 10:40 **Introduction of the Keynote**
Laurel C. Blakemore, MD

10:40 - 11:00 **Keynote Address: Sustainability in Hospitals and the Carbon Footprint of Spine Surgery**
Derek T. Cawley, MMedSc, MCh, FRCS Orth

11:00 - 11:30

Lunch Pick-Up
INSIDE WORKSHOP ROOMS

Exhibit Viewing*
HALL 2

*Denotes non-CME Session
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11:00 - 11:30

HALL 2

E-Point Award-Nominated Papers 3*

Moderator: Alekos Theologis, MD

New: Visit the Innovation Theatre for a mini-session highlighting top-scoring E-Points. Listen to live rapid-fire presentations from each nominated paper, followed by a moderated discussion. Don't forget to also visit the E-Point Kiosk located in Hall 2, Booth #14 to view all E-Point presentations. Voting for award-nominated E-Points can be completed on the IMAST 2025 mobile app, and will remain open until Friday, April 4, 2025.

Please note: CME credits are not available for this session.

11:05 - 11:07 **Paper #177: Decoding The No-Show: What Predicts Postoperative Visit Cancellations in AIS?**
Sydney Lee, BA; Shanika De Silva, PhD, MS; M. Timothy Hresko, MD; Craig M. Birch, MD; Ata Kiapour, PhD, MS; Erin Trousdale, BS; Nazgoi Tavabi, PhD; *Grant D. Hogue, MD*

11:07 - 11:09 **Paper #111: Intraoperative Cranio-Pelvic Traction: A Novel Aid For The Correction of Neuromuscular and Syndromic Scoliosis**
Patton Robinette, MD; Emily Peairs, MD*; Robert K. Lark, MD, MS*

11:09 - 11:11 **Paper #117: Evolution of Spinal Deformities in SMA to Assess Their Deformity Patterns and Their Management Outcomes**
Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Ayon Ghosh, MS; Dhruv Patel, MS

11:11 - 11:13 **Paper #187: Bipolar Fixation Technique Versus Traditional Posterior Fusion in Underweight Pediatric Patients With Neuromuscular Scoliosis**
Carlos Huaiquilaf, MD; Karen A. Weissmann, MD; Francoise Descazeaux, MD

11:13 - 11:20 **Discussion**

11:30 - 12:30

Hands-On Workshops*

See page 176 for schedule and descriptions.

Each workshop will be programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company. Please note: CME credits are not available for Hands-On Workshops.

12:30 - 12:45

Break and Exhibit Viewing*

HALL 2

12:45 - 14:15

Education Session 7A - Hot Topics in Minimally Invasive Deformity

LOMOND AUDITORIUM

Moderators: Neel Anand, MD, Mch Ortho & Amit Jain, MD, MBA

Panel 1

12:45 - 12:47 **Case Presentation**
Neel Anand, MD, Mch Ortho

12:47 - 12:55 **Why Mess with Classic? Open ALIF Posterior Fusion Always Works**
Zeeshan M. Sardar, MD

12:55 - 13:03 **There is Nothing I can't Fix with CMIS Lateral Posterior Fusion**
Corey T. Walker, MD

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13:03 - 13:11 **See the Light: Prone Lateral is the Way to Go**
Juan S. Uribe, MD

13:11 - 13:17 **Rebuttal**
Zeeshan M. Sardar MD; Corey T. Walker, MD & Juan S. Uribe, MD

13:17 - 13:30 **Discussion**

Panel 2

13:30 - 13:32 **Case Presentation**
Amit Jain, MD, MBA

13:32 - 13:40 **Computer Navigation is a Must for the Modern Surgeon**
Brett Rocos, MD

13:40 - 13:48 **Augmented Reality is Navigation Done Better!**
Safdar N. Khan, MD

13:48 - 13:56 **The Navigation Assisted Robot is the Best: Why Would You Look Back?**
Richard A. Hynes, MD

13:56 - 14:02 **Rebuttal**
Brett Rocos, MD; Safdar N. Khan, MD & Richard A. Hynes, MD

14:02 - 14:15 **Discussion**

12:45 - 14:15

Education Session 7B - Challenges in Early Onset and Congenital Scoliosis: Best Practices and Modern Methods

M1

Moderators: Han Jo Kim, MD & Caglar Yilgor, MD

12:45 - 12:50 **Compression-, Distraction- or Guidance-based Constructs: What Does the Future Hold**
Michelle C. Welborn, MD

12:50 - 12:55 **New Technologies in EOS Management and Outcomes**
Tom PC Schlosser, MD, PhD

12:55 - 13:00 **Contemporary Results of Casting and Bracing for EOS Deformities**
Grant D. Hogue, MD

13:00 - 13:15 **Discussion**

13:15 - 13:20 **MRI-based Radiation-Free Navigation Options in Pediatrics**
A. Noelle Larson, MD

13:20 - 13:25 **Non-MRI-based Radiation-Free Navigation Options in Pediatrics**
Stefan Parent, MD, PhD

13:25 - 13:30 **Robotics Applications in EOS Deformities**
Burt Yaszay, MD

13:30 - 13:45 **Discussion**

13:45 - 13:50 **Timing and Modern Surgical Indications for Congenital Scoliosis Management**
Amer F. Samdani, MD

13:50 - 13:55 **Surgery for Cervicothoracic Congenital Scoliosis: With or Without Coronal Imbalance**
Jianguo Zhang, MD

13:55 - 14:00 **Evolution and Future of the Treatment of Syrinx/Chiari/Tethered Cord in EOS**
Christopher M. Bonfield, MD

14:00 - 14:15 **Discussion**

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14:15 - 14:30

Break & Exhibit Viewing*
HALL 2

14:30 - 15:30

Special Session: Medical Device Regulations: What You, As A Surgeon, Should Know Worldwide Impact on Your Practice and Your Patients*
ALSH 1&2

Moderators: Marinus de Kleuver, MD, PhD & Dominique Rothenfluh, MD

14:30 - 14:40 **I Understand the Need, but I Have Concerns**
Marinus de Kleuver, MD, PhD

14:40 - 15:00 **Overview of Medical Device Regulations, Focusing on the European Medical Device Regulations (EUMDR) and the US Food & Drug Administration (FDA)**
- What is required for device approval
- Perspectives of the Notified Bodies and their Clinical Reviewers

Matthias Fink, MD

15:00 - 15:20 **Panel: Perspective of MedTech: The Challenges of Introducing New Technology: R&D decisions, timelines, etc.**
Rebecca Whitney & Ryan Watson (Highridge Medical)
Erin McEachren & Sara Rivera (Medtronic)

15:20 - 15:30 **What can you and the SRS do? Using the Pediatric Device Task Force experience with the US FDA**
A. Noelle Larson, MD

15:30 - 16:00

Refreshment Break & Exhibit Viewing*
HALL 2

SRS Member Information Session*
INNOVATION THEATRE (HALL 2)

16:00 - 17:30

Education Session 8 - The Latest and Greatest: Making Innovation Work for You*
LOMOND AUDITORIUM

Moderators: Meric Enercan, MD & Kristen E. Jones, MD, FAANS

16:00 - 16:10 **Presentation of the Whitecloud and Innovation Award Winning Papers**
Meric Enercan, MD & Kristen E. Jones, MD, FAANS

16:10 - 16:15 **Case Presentation**
Emmanuelle Ferrero, MD, PhD

16:15 - 16:30 **Use of AI in Preoperative Risk Modification**
Christopher P. Ames, MD

16:30 - 16:45 **Patient Specific Surgical Planning**
Camilo A. Molina, MD

16:45 - 17:00 **What AI Cannot Do For You**
Ronald A. Lehman Jr., MD

17:00 - 17:15 **Incorporating Innovation into My Practice Over the Years**
Lawrence G. Lenke, MD

17:15 - 17:25 **Case Discussion**

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17:30 - 19:00

Innovation Celebration*

RADISSON RED HOTEL GLASGOW (RADISSON RED SKYBAR)

Open to all registered delegates and registered guests. Tickets are $25 for registered delegates and $50 for registered guests and must be purchased in advance. A limited number of tickets may be available onsite. If you would like to purchase ticket(s), please visit Registration in Hall 1.

Cast your vote for the Whitecloud Awards on the Meeting App:

1. Select "Polls & Surveys" from the app home screen
2. Select the Whitecloud Awards voting polls
3. Cast your vote!

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PODIUM PRESENTATION ABSTRACTS

1. Surface Carburized 3D Printed Ti-6Al-4V Biomimetic Porous Motion-Preserving Artificial Cervical Vertebra and Its Initial Clinical Application †

Wen-Long Yang, PhD; Chaoyuan Ge, PhD

Hypothesis
The surface ceramic treatment of 3D printed TC4 prosthesis is carried out in order to increase its service life.

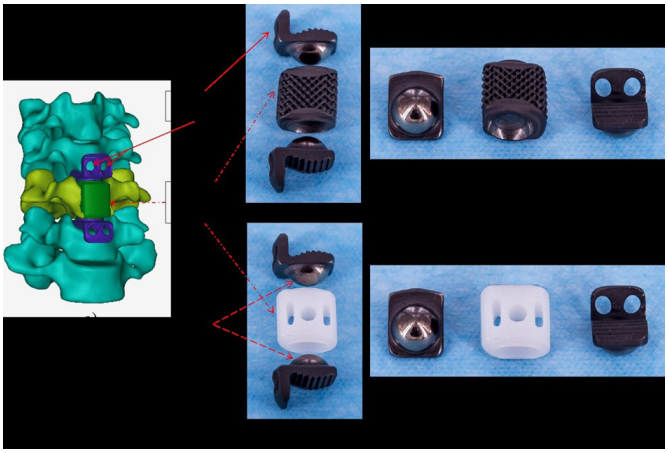
Design
Intervention study

Introduction
The general surgical treatment of cervical spondylotic myelopathy is anterior decompression and fusion, which has significant effect. But the non physiological compensatory movement after surgery may accelerate the degeneration of adjacent segments. We developed a 3D printed Ti-6Al-4V biomimetic porous motion-preserving artificial cervical vertebra implant. However, the inherent wear resistance of Ti-6Al-4V material is poor, and the prosthesis will fail due to excessive wear in a short time after implantation.

Methods
(1) The surface ceramic modification of 3D printed Ti-6Al-4V was carried out by using glow plasma hydrogen-free carburizing technology. (2) Using spine and joint motion simulator to carry out friction experiment of the prothesis. (3) Suitable patient were chosen to implant the artificial cervical vertebra, evaluating the short-term efficacy and in-vivo service performance of the prosthesis.

Results
(1) A layer of TiC ceramics was formed on the surface of the samples after carburizing, and the surface hardness was nearly 3 times higher than that before treatment. (2) After 5 million cycles, for the self-matching joint, the total wear rate of the ball and socket was an order of magnitude lower than that of commercial artificial cervical intervertebral discs, for the titanium-polyethylene pair, the wear rate was 8 times larger than that of commercial artificial cervical disc CoCrMo/UHMWPE. (3) Imaging examination of clinical case showed that the position of the prosthesis was normal and the motion of the surgical area was preserved.

Conclusion
(1) Carburizing technology can improve wear resistance of the 3D printed Ti-6Al-4V movable artificial cervical vertebra without changing the biocompatibility. (2) For the titanium alloy self-matching pair, the total wear rate was much lower than that of commercial artificial cervical intervertebral discs.(3) Anterior decompression + surface ceramic movable artificial cervical vertebra implantation retained the physiological motion function of the operating area, which was a useful innovation and exploration for the surgical treatment of single-segment cervical vertebral diseases.



3D printed Ti-6Al-4V biomimetic porous motion-preserving artificial cervical vertebra

2. Circulating MicroRNAs as a Prognostic Tool in Pediatric Patients with Idiopathic Scoliosis †

Michael Lujc, MD; Michal Galko, MD; Martin Repko, MD, PhD; Jana Orličková, MS; Dagmar Al Tukmachi, MS; Milan Filipovič, MD, PhD; Ondřej Slabý, PhD, MS, Prof.

Hypothesis
We hypothesize that there are specific miRNAs detectable in serum which are deregulated in patients with a high risk of disease progression. We further hypothesize that these miRNAs are involved in osteoclastogenesis and therefore deregulation of their levels correlates with serum markers of bone and sex hormones metabolism reflecting aberrant bone development.

Design
Prospective mono-centric study.

Introduction
80% of scoliotic cases are of unknown origin and idiopathic scoliosis is considered a multifactorial disease. Currently, there are no clinical biomarkers of the progression of idiopathic scoliosis available. Such biomarkers could be circulating microRNAs. microRNA expression levels were previously shown to be altered under various pathologic conditions. This study aims to evaluate the prognostic potential of circulating microRNAs in idiopathic scoliosis.

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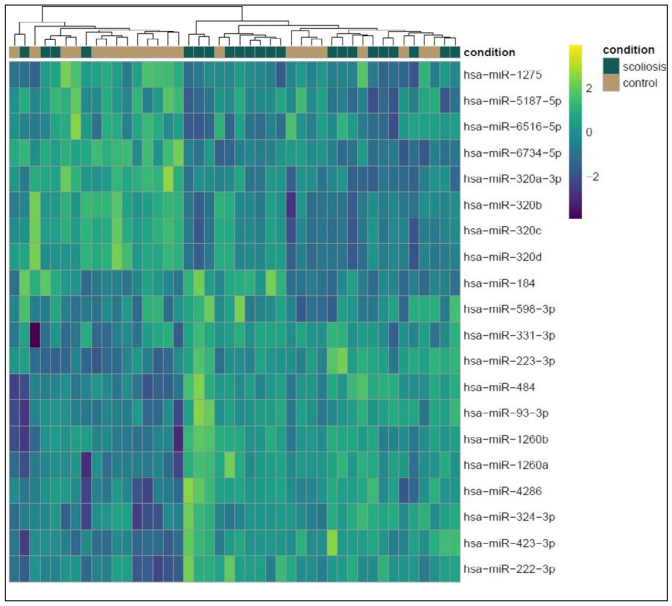
Methods
Blood plasma samples from patients (24 exploration, 90 validation) diagnosed with juvenile or adolescent idiopathic scoliosis and 90 healthy controls were included. Blood plasma samples from patients were collected in two time points (T0, T1) and patients were subdivided according to their risk of progression (using clinical parameters). Total RNA was isolated using miRNeasy Serum/Plasma kit (QIAGEN, USA). cDNA libraries were prepared using Qiaseq miRNA UDI Library Kit (QIAGEN, USA). The sequencing analysis was performed using NovaSeq 6000 S1 v1.5 Kit - 100 cycles using the NovaSeq 6000 instrument (both Illumina). After preprocessing of sequencing data, reads were mapped against database miRBase v 22 using the miraligner tool v 3.2. Obtained data were statistically evaluated in R environment v 4.0.4. Differential expression analysis was performed using the DESeq2 package v 1.30.1.

Results
When patients with controls were compared 4 miRNAs have been found to be significantly dysregulated (p>0.05) in both explorative and validation phase. Patients with high risk of progression can be distinguished from low-risk patients using a multi-miRNA model (AUC>0.8).

Conclusion
Our findings suggest that circulating miRNAs could serve as potential biomarkers of progression in pediatric idiopathic scoliosis.



Heat map and cluster dendrogram of miRNAs with altered expression (p<0.05) in IS patients and healthy controls.

3. A Novel Growth Guidance System: Research and Development †
You Du, MD; Jianguo Zhang, MD; John T. Killian, MD

Hypothesis
A Novel Growth Guidance System can reduce metal debris and decrease sliding friction.

Design
In vitro and in vivo experiments.

Introduction
Our study team developed a novel growth guidance system. Two major modifications were made to the traditional Shilla system, including the use of ultra-high molecular weight polyethylene (UHMWPE) gaskets to avoid direct contact between the screw and rod, and polishing the surface of sliding part of the rod.

Methods
The fatigue test and the displacement test were conducted. The maximum sliding displacement of the system was measured after a 300 cycles of dynamic compressive loads in a sinusoidal waveform. The in vivo experiments were also conducted by implant the system in miniature pigs. X-rays, CT scan and MRI were taken to assess the ability of spinal growth preservation. Blood metal ion concentrations and histological examination were conducted to assess the metal debris reaction and histo-compatibility.

Results
After the fatigue test, all the UHMWPE gaskets samples showed some of the fretting on the edge, but still isolated and avoided the friction between the screws and rods. No sign of metallic fretting around the screws and rods. The average wear mass of the gaskets was 0.002 ± 0.001g, less than 1.7% of the original mass. In the sliding test, the novel growth guidance system demonstrated the best sliding capacity, with an average maximum sliding distance (AMSD) of 35.75 ± 5.73mm, significantly better than the traditional Shilla implants. Six miniature pigs underwent surgeries, with an immediate postoperative mean spinal fixation length of 20.1 ± 0.7cm and 23.5 ± 0.7cm at 12 weeks postoperatively. CT and MRI scans showed no signs of degeneration of the facet joints or discs in the instrumented spine. There were no significant changes in titanium concentrations. Gross anatomy revealed no metal debris around the sliding screws. Histological reaction scoring indicated that the tissue response to the implantation of the novel sliding screws was either non-irritating or mildly irritating.

Conclusion
The novel growth guidance system demonstrated excellent wear resistance and sliding performance

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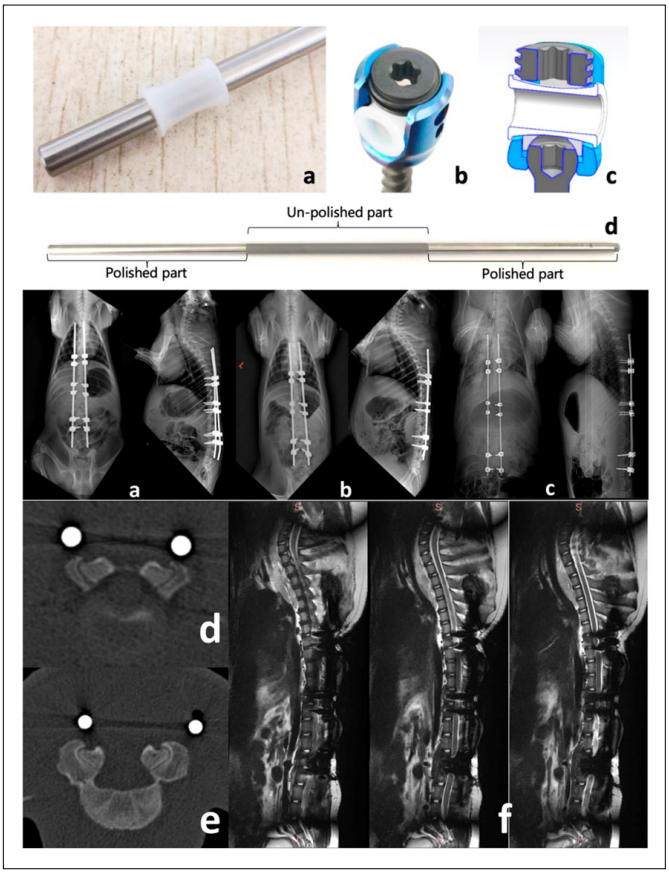
in vitro. In vivo experiments revealed sliding capabilities of the system, preserving spinal growth potential while causing no damage or degeneration to intervertebral discs and facet joints. The system also exhibited no irritation to local soft tissues and displayed favorable biocompatibility.



A novel growth guidance system

4. Wearable Sensors for Pre- and Post-operative Assessment of Cervical Myelopathy §

Steven D. Glassman, MD; Jeffrey L. Gum, MD; Justin Mathew, MD; *Charles H. Crawford III, MD*; Mladen Djurasovic, MD; Leah Y. Carreon, MD

Hypothesis
Wearable sensor technology provides objective measurements of post-operative improvement in patients treated for cervical myelopathy

Design
Prospective observational cohort.

Introduction
Clinical evaluation of CSM is limited, as Hoffmann's sign, Romberg testing and Tandem Gait are largely subjective and binary, making deterioration or improvement difficult to document accurately.

Methods
Twenty-six patients scheduled for surgical treatment of CSM underwent in-office and 24-hour continuous at-home data collection using a single wearable sensor. In-office testing consisted of Standing, Romberg testing, Tandem Gait and Timed Up & Go (TUG). Testing was repeated 6-months post-operatively.

Results
Statistically significant improvements were seen following surgical treatment in the Romberg test eyes-open maximum antero-posterior sway (p=0.010), eyes-open total path traveled (p=0.048); in Tandem Gait speed (p=0.021), duration (p=0.002), antero-posterior sway (p=0.046) and initial peak acceleration (p=0.001). There was no statistically significant difference in TUG testing. At-home gait pattern revealed a trend toward decreased lateral sway post-operatively (p=0.062) and fewer sleep turns (p=0.078).

Conclusion
Wearable sensor data effectively quantifies standard exam findings and identifies new metrics with the potential to assess more accurately pre-operative and post-operative function in patients with CSM. Previously unreported pre-operative to 6-month post-operative changes were seen in speed of gait and ground impact force during Tandem Gait. These metrics were more sensitive as compared to the normal antero-posterior and lateral sway assessment. 24-hour sensor data showed decreased number of turns during sleep post-operatively. This study suggests that wearable sensor data will be a viable source for quantifiable data with the potential to guide treatment for patients with CSM. This capability is based partly on better quantification of existing binary measures, but also on identification of unanticipated patterns within the data.

5. Development of a Cloud-Based Remote Monitoring System for Halo Gravity Traction §

Jaysson T. Brooks, MD; Lydia Klinkerman, BS; Karl E. Rathjen; Daniel J. Sucato, MD, MS; Brandon A. Ramo, MD; Amy L. McIntosh, MD; Karina A. Zapata, PhD; Brad Niese, BS; Megan Johnson, MD

Hypothesis
In patients undergoing spring based HGT, the dynamic forces and overall traction compliance can be reliably and remotely measured.

Design
Prospective case-series

Introduction
Spring based halo gravity traction (HGT) has been utilized since the 1980s, however to date, no data exists on the actual dynamic forces transmitted to the spine of these children. Children with large stiff curves may undergo inpatient HGT between 4 to12

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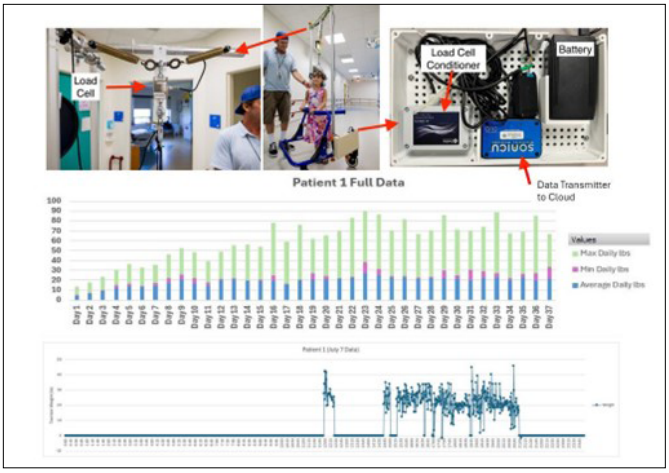
weeks; however this treatment is costly to the hospital system and can disrupt the lives of the patients and their families. In addition, concerns exist on the safety of sending patients home with HGT, given the inability to monitor traction compliance or applied weight. More widespread adoption of HGT might be possible if it could be reliably monitored in a patient's home. In this pilot study we present the findings of a novel cloud-based remote monitoring system used on 4 children undergoing HGT.

Methods
The force applied to the spring based HGT system is measured using a load cell sensor; the load cell is hard wired to a load cell conditioner which both powers the load cell and outputs the load using a milli-amp signal into the transmitting unit which uploads the milli-amp value to cloud storage via mobile or WIFI connectivity. In the cloud, this milli-amp signal is converted into pounds-force using the calibration curve of the load cell (Figure). Signals were transmitted to the cloud every minute.

Results
After receiving IRB approval, four patients, all female, requiring HGT were consecutively enrolled between June and July 2024. Patients were aged 6, 10, 12, and 13 years old, and diagnoses were infantile idiopathic, syndromic, juvenile idiopathic, and congenital, respectively. For each patient, a remote monitoring system was added to their halo walker and wheelchair. Traction compliance was measurable in all patients during their inpatient HGT treatment. Example Force data for Patient #1 during the entire traction period and each minute during a 24 hour period is displayed in the Figure. All patients achieved their goal traction prior to definitive fusion or growing rod instrumentation. The mean curve magnitude pre-HGT was 104 (range 83-120) degrees and at completion of HGT was 78 (range 63 to 87) degrees.

Conclusion
In this pilot study, we have proven that traction compliance can successfully be remotely monitored along with the magnitude of traction weight transmitted to the spine.



HGT System

6. GenAI Powered Three-Dimensional Spine Model Generation Based on Biplanar Smartphone Images of Scoliosis Patients with a Single Center Validation §

Moxin Zhao, MS; Nan Meng, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; *Teng G. Zhang, PhD*

Hypothesis
The AI-generated 3D spine models based on 2D RGB images of the patients' trunks taken by smartphones are acceptable by clinicians for scoliosis monitoring.

Design
Technology development with a single center prospective validation.

Introduction
Radiographic examinations are critical for diagnosing and monitoring children with scoliosis, but accumulatively increased radiation exposure during disease monitoring is inevitable. 2D RGB images taken by smartphones powered by AI offer an accessible alternative for frequent monitoring of deformity progression without radiation. However, 2D RGB images analyzed by AI lack clinically interpretable results. Thus, we aim to develop and validate a three-dimensional (3D) spinal model generation pipeline with a transformer as the backbone (EUFormer) using biplanar trunk images of scoliosis participants as inputs to predict 3D spine morphologies.

Methods
3,516 consecutive patients (mean age 14yrs; 76% female) were recruited in our scoliosis clinic between November 2020 and June 2024. Individuals with psychological, systemic neurological conditions, and/or inability to consent were excluded. For the remaining 2908 participants, demographic information, biplanar (posterior and right lateral) images of the patient's unclothed trunk, and biplanar radiographic images (EOS imaging) were collected. The 3D spine

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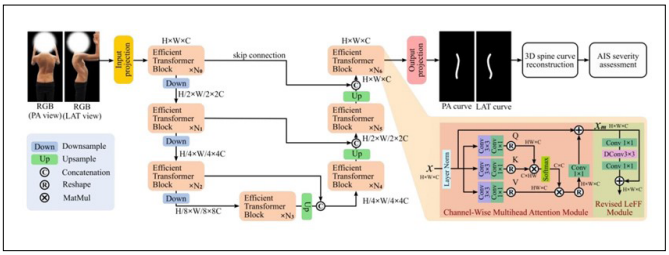
models developed from biplanar radiographs were used as the ground truth (GT). EUFormer was developed using the 2,908 participants' data and prospectively validated on an independent cohort (n = 608).

Results
For all 608 prospective participants, the 3D spine models generated by EUFormer were visually assessed by a senior spine deformity surgeon and 80.3% of the results were considered comparable with the GT spine model. Quantitative similarity comparisons revealed 75.1% similarity between the generated 3D spine model with the GT spine model.

Conclusion
This study demonstrates that EUFormer can generate 3D models directly from biplanar trunk images captured by smartphones, increasing the understandability of the AI results for clinicians, streamlining screening, and facilitating large-scale clinical trials with follow-ups. We suspect the errors in spine model generation may have a relationship with the deformity type and the lateral RGB image acquisition directions. Increased experiments and validations need to be completed for future studies.



EUFormer pipeline

7. Comprehensive Skeletal Maturity Index Can Obviate the Need for Hand Radiographs for Sanders Scoring §

Alison Dyszel, PA-C; Elyette M. Lugo, BS; Paul D. Sponseller, MD, MBA; *Amit Jain, MD, MBA*

Hypothesis
The combination of Risser (R), triradiate cartilage (TRC), proximal femur maturity index(PFMI), and proximal humerus ossification system (PHOS) indicators into a comprehensive skeletal maturity index (RTFH) correlates well with the Sanders score from hand radiographs, providing an alternative method to assess peak height velocity (PHV) in scoliosis patients.

Design
Restrospective

Introduction
Scoliosis radiographs are commonly used to assess spinal curvature and skeletal maturity in pediatric patients. However, the Sanders score, derived from hand radiographs, remains the gold standard for determining skeletal maturity and peak height velocity (PHV). On scoliosis radiographs, growth indicators such as Risser staging, triradiate cartilage (TRC), proximal femur maturity index (PFMI), and proximal humerus ossification system (PHOS) are also assessed. This study explores whether a combination of these four indicators into a single skeletal maturity index (RTFH) can serve as a reliable alternative to the Sanders score for evaluating skeletal maturity and PHV in scoliosis patients.

Methods
We retrospectively analyzed 205 paired scoliosis and hand radiographs from pediatric scoliosis patients (2017-2024) who had both types of radiographs taken on the same day. Each scoliosis radiograph was graded using four growth indicators: Risser (0-5), TRC (0-2), PFMI (0-6), and PHOS (1-5). These scores were combined into the RTFH index, ranging from 2 to 18. The RTFH scores were compared with the Sanders scores from the hand radiographs. An RTFH score of <6 was considered pre-PHV, 6-10 indicated PHV, and >10 indicated post-PHV, corresponding to Sanders scores of <3, 3-4, and >4, respectively.

Results
Of the 205 radiographs analyzed, 96.10% of RTFH scores matched the Sanders scores. Specifically, 83% of RTFH scores <6 accurately predicted pre-PHV, 100% of scores between 6 and 10 matched Sanders scores indicating PHV, and 95.4% of scores >10 identified post-PHV. In 3.90% of cases that did not match, the RTFH overestimated skeletal maturity in 6 patients and underestimated it in 2 patients compared to the Sanders score.

Conclusion
There is a strong correlation between the RTFH skeletal maturity index and the Sanders score, suggesting that RTFH could be a viable alternative for evaluating skeletal maturity and PHV in scoliosis patients, potentially reducing the need for additional hand radiographs and associated radiation exposure.

8. Quantitative Morphological Apical Intervertebral Disc Characteristics as Predictors of Curve Progression in Adolescents with Idiopathic Scoliosis §

Conor T. Boylan, MBChB, MSc, BSc, MRCS Ed; Arin M. Ellingson, PhD; Siddhant Kapoor, MBChB, MRCS; David S. Marks, MBBS, FRCS, FRCSOrth; David W. Polly Jr., MD; Morgan Jones, FRCS

Hypothesis
This novel disc morphological analysis tool will provide detailed information on in-vivo disc morphology

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and facilitate accurate forecasting of disease progression in adolescents with scoliosis.

Design
Retrospective case-control study at a single tertiary referral centre for spinal deformity surgery.

Introduction
Quantitative disc analysis is a promising method to assess intervertebral disc morphology in patients with adolescent idiopathic scoliosis (AIS) and may improve our ability to predict disease progression and need for early surgical intervention. The novel tool used in this study allows detailed cross-sectional analysis of disc morphology in live patients that can be used in conjunction with traditional measures to predict disease progression.

Methods
Patients who had MRI scoliosis protocol performed at baseline were selected, 50 of which were known to require surgery within 5 years and 50 of which did not. Data on nucleus pulposus (NP) and disc signal intensity, NP area, NP location, transition zone slopes and disc asymmetry indices were calculated using a novel disc analysis tool. Baseline characteristics and disc morphology were compared between cohorts. Backward input binary logistic regression was used to develop an optimal predictive model for surgical status at 5-years.

Results
Detailed disc morphology maps were generated using the tool and numerical data was extracted to inform statistical modelling. Patients in the surgical cohort were younger (p=0.007), had larger Cobb angles (p<0.001), and were more likely to have a double thoracic curve type (p=0.001). Surgical patients also had greater mean NP signal intensity (p=0.008), more well-defined concave transition zones (p=0.008) and an overall greater disc coronal transition zone symmetry (p=0.036). A model was developed to predict which patients would require early surgical intervention with 85.0% accuracy (p<0.001, AUC 0.904), which is greater than with Cobb angle alone. Predictors included were age, Cobb angle, Lenke type, NP signal intensity, NP location (weighted) in the coronal plane and coronal asymmetry index.

Conclusion
This study has identified several factors predictive of need for early surgery in patients with AIS, many of which have not been examined with this level of scrutiny before. It begins to validate this novel disc analysis tool and indicates its value in a clinical setting.

9. Complications and Unplanned Return to the Operating Room (UPROR) at 5-Years Postoperative Vertebral Body Tethering for Idiopathic Scoliosis §

Ron El-Hawary, MD; Firoz Miyanji, MD, FRCS(C); *Ahmad Alelaumi, MD*; Isha Prasad, RN; Jennifer K. Hurry, MASc; Flavia Alberghina, FRCS; Pediatric Spine Study Group; Stefan Parent, MD, PhD

Hypothesis
Our hypothesis is that there will be a higher rate of postoperative complications at 5-year follow up as compared to 2-years follow up for this group of patients.

Design
Multicenter study, prospectively collected clinical and radiographic data analyzed retrospectively.

Introduction
Our group previously published 2-year post-operative VBT complication rates for a cohort of 120 patients that is now 5 years post-operative. There is a paucity of data in the literature on longer term complications for patients undergoing VBT. Now that our previously published cohort is 5 years post-operative, our goal is to re-examine its post-operative complication rate at 5-year follow-up.

Methods
All 120 patients treated with VBT had 5-year follow up and were included in this study. Prospectively collected clinical and radiographic data was analyzed retrospectively.

Results
Pre-operatively, the mean patient age was 12.6 year (8.2-15.7 year), Risser 0-3, with mean main thoracic scoliosis 51° (40-70°). All patients underwent thoracoscopic VBT with immediate post-operative scoliosis improvement to 27° (6-53°, p< 0.01), which was maintained at 1-year post-operative 23° (-11 – 50°; p<0.01), at 2-year post-operative 26° (-5 – 52°; p= 0.64), and at 5-year post-operative 33° (-31–59°; p< 0.01 compared to post-op). Pre-operative global kyphosis was 29° (2-64°) which did not change at 1-year post-operative 29° (6-65°) or at 2-year post-operative 29° (6-67°); however, kyphosis did increase at 5-years post-operative 41° (-17–93°; p< 0.01). By 5 years post-operative, using the modified Clavien Dindo Sink classification, there were 39 grade 0 occurrences, of which 38 were failure of the tether cable that was noted radiographically on follow up visits without curve progression or UPROR. There were 9 grade I, 2 grade II, 20 grade 3b, and 2 grade 4a complications. There were no grade 4b or grade 5 complications. There was a 9% minor complication rate (mCDS 1 and 2) and an 18% major complication

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rate (mCDS 3 and 4) for an overall complication rate of 27.5%. There was an 18% UPROR rate.

Conclusion
For the same cohort of patients, our previously published 2-year rate of complications (16%) increased to 27.5% at 5-year follow up and the 2-year rate of UPROR (7%) increased to 18% at 5-year follow up.

10. Identification of Novel Differentially Methylated Positions in Adult Spinal Deformity Patients That Experienced Perioperative Complications §

Rohit K. Bhan, MD, MS; Quante Singleton, MD; Yu Zhang, MS; Christopher Diaz, BS; Christopher P. Ames, MD; Bo Zhang, PhD; Michael Kelly, MD; Nicholas A. Pallotta, MD, MS; *Brian J. Neuman, MD*

Hypothesis
Epigenetic differences in differentially methylated positions (DMPs) may predispose patients to complications after adult spinal deformity (ASD) surgery.

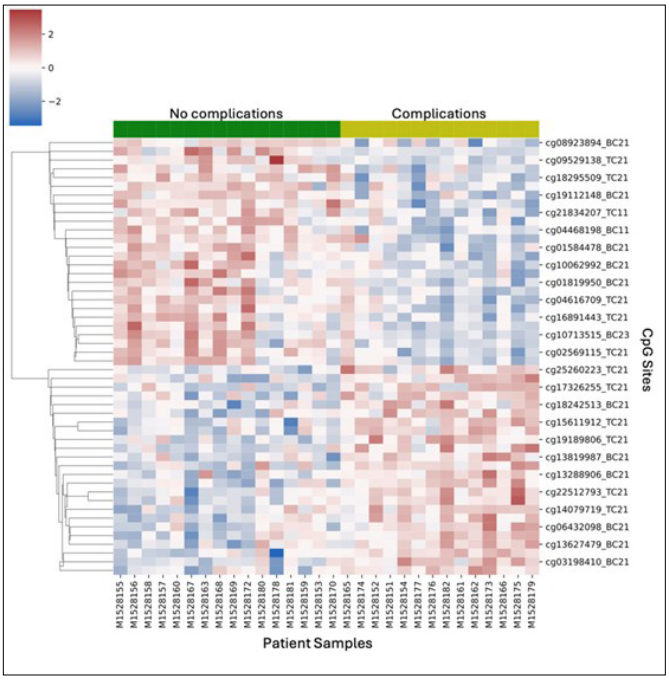
Design
Prospective

Introduction
The rising prevalence of ASD in an aging population, with surgical complication rates of 37%-71%, highlights the importance of pre-surgical risk assessment. Traditional risk factors like age and frailty partially account for perioperative complications, pointing to the need for patient-specific risk stratification. DNA methylation at certain CpG sites reflect aging and disease, which may predispose to perioperative complications. We aim to link DNA methylation profiles from ASD patients to the risk of postoperative complications.

Methods
ASD patients provided blood on the day of surgery. DNA methylation of peripheral blood mononuclear cells (PBMCs) was analyzed using IlluminaEPIC v2.0 BeadChip. Differential analysis between complication groups was performed in Minfi software. X and Y chromosomes were excluded to avoid sex bias. DMPs were defined such that $p<0.001$ and absolute methylation difference between two groups was set to 0.05.

Results
A total of 30 surgical ASD patients were enrolled. 15 (50%) were revisions, 21 patients (70%) received all-posterior surgery, and 9 (30%) underwent anterior-posterior surgery. 7 (23%) received a three-column osteotomy and average levels fused were 11.9 (SD=3.7). 47% (N=14) experienced a post-operative complication, including pulmonary emboli (N=2), death (N=1), dehiscence (N=1), AMS (N=5), and AKI (N=4). 50 significant DMPs were identified. 26 DMPs were hypomethylated and 24 were hypermethylated in the complication group. These sites had opposing methylation patterns in the non-complication group. Genes tagged were highly associated with immune response and lymphocyte function, such as LRBA and NFACT2. DMPs tagged with regulators of the EGFR and WNT pathways (EPS8, APC2) were hypermethylated in the complication group.

Conclusion
We identified 50 significant DMPs in patients that experienced complication after ASD surgery. These differences are linked to genes involved with lymphocyte and immune response, coinciding with increased epigenetic age. Further work could yield a differential methylation-based risk score specific to ASD. We aim to further evaluate these markers for enhancing pre-surgical risk assessment and precision-medicine.



Heatmap of DMPs

11. IGF-1 Serum Levels are Associated with Early Recovery and In-Hospital Complications After Spinal Fusion §

Annika Bay, MD; Han Jo Kim, MD; Atahan Durbas, MD; Luis F. Colon, MD; Stephane Owusu-Sarpong, MD; Quante Singleton, MD; Farah Musharbash, MD; Andrea Pezzi, MD; Tomoyuki Asada, MD; Chad Simon, BS; Sereen Halayqeh, MD; Adrian Lui, MD; Tarek Harhash, BS; Eric Zhao, BS; Tejas Subramanian, BS; Robert N. Uzzo, MBA; Justin Samuel, BS; Gregory Kazarian, MD; Kasra Araghi, BS; *Francis C. Lovecchio, MD*

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Hypothesis
Baseline IGF-1 levels associate with postoperative outcomes after spinal fusion

Design
Retrospective cohort study

Introduction
Sterile trauma is followed by a hormonal response that promotes a catabolic state - a survival response. This response leads to patient fatigue and catabolism of lean muscle, promoting convalescence, a known risk factor for medical complications. Post-surgical catabolism is mediated by a decrease in insulin-like growth factor (IGF-1), of which human growth hormone (HGH) is a direct agonist. The effect of the HGH/IGF-1 axis in recovery after spinal surgery is unknown.

Methods
Preoperative serum IGF-1 levels were collected within one month before spinal fusion surgery and assessed using standardized sex- and age-adjusted Z-scores. Primary outcome included medical complications (AO-ISSG classification) and self-sufficiency at discharge, defined as discharge home without the need for home health care (vs daily home nursing or rehab). Independent predictors were identified using multivariate logistic regressions adjusted for age, number of levels, EBL, BMI, CCI and IGF-1 Z-score levels.

Results
Seventy-nine patients with a mean age of 68 years, 3.2 levels fused, and 44% female were prospectively enrolled. Medical complications, discharge needs, and progress with physical therapy were associated with IGF-1 Z-scores (Table 1). A logistic regression model (p=0.036) identified IGF-1 Z-score as independent predictor for medical complications (p=0.025) with the model classifying 92% correctly. Self-sufficiency was significantly linked to a higher IGF-1 Z-score (p=0.021), fewer levels fused (p<0.001) and reduced blood loss (p<0.001). Regression analysis found IGF-1 Z-score (p=0.037) and BMI (p=0.026) to be independently associated with self-sufficiency at discharge in a model (p<0.001) classifying 71% correctly.

Conclusion
Higher preoperative IGF-1 Z-score levels are independently associated with fewer medical complications and increased rate of self-sufficiency at discharge. The HGH/IGF-1 axis may be a target for therapeutic interventions designed to improve early recovery.

12. Selection of Upper Instrumented Vertebra in Adult Spinal Deformity: Risk Calculator and Recommendations Based on Proximal Junctional Kyphosis §

Jamshaid Mir, MD; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Max R. Fisher, MD; Anthony Yung, MMSc; Matthew Galetta, MD; Nathan Lorentz, MD; Jordan Lebovic, MD, MBA; Pawel Jankowski, MD; *Peter G. Passias, MD*

Hypothesis
A UIV risk index score will optimize surgical outcomes.

Design
Retrospective cohort.

Introduction
The surgical correction of adult spinal deformity (ASD) presents a complex and multifaceted challenge, further intensified by the need for revision surgery. Determination of the upper instrumented vertebra can often be challenging.

Methods
We included operative ASD patients with a minimum of a 2-year follow-up undergoing fusion from at least L1 and proximal to the sacrum. Patients without PJK were isolated to determine predictive thresholds based on patient and surgical factors. Variable importance was determined utilizing random forest analysis to determine the weighting of variables with multivariable logistic regression. Conditional inference tree (CIT) determined threshold values predictive of UIV level in those who didn't develop PJK.

Results
334 patients met inclusion. (Age 63±10, 77% F, BMI 27.6±5.1 kg/m2, frailty 3.5±1.5, CCI 1.9±1.7). The model for predicting PJK was significant for osteoporosis, LL, TK, TLPA, with posterior UIV and IBD UIV (p<.05). Table 1. Baseline UIV slope of >42.4 had a higher rate of PJK postoperatively (63% vs 27%, p<.001). Evaluating factor importance for the selection of UIV determined UIV slope to have the greatest weight, with T1PA, PJK prophylaxis, PI-LL, frailty, osteoporosis, and CCI following in those who didn't have PJK. For those with UIV slope <12.7, selection of upper thoracic UIV was contingent on T1PA being <7 (p=0.018). Patients with UIV slope >27 and T1PA >30 were likely to have UIV in the upper thoracic (T4 mean) in those who didn't develop PJK. Whereas, those with a UIV slope between 12.7 to 30 with T1PA >30 were less likely to develop PJK with a lower thoracic UIV (p<.001).

Conclusion
The selection of UIV was strongly correlated to UIV slope and T1PA for avoidance of proximal junction-

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al kyphosis. Frailty and lumbar lordosis were important contributors to the model for the selection of optimal UIV.

13. Picking Up "MRI-silent" Pathologies with Dynamic MR Testing of Cervical Spine: Result of 30 Cases §

Manish K. Kothari, MS; David F. Bauer, MD, MPH

Hypothesis
Can dynamic MRI testing change the treatment plan in medically recalcitrant cervical spondylotic cases?

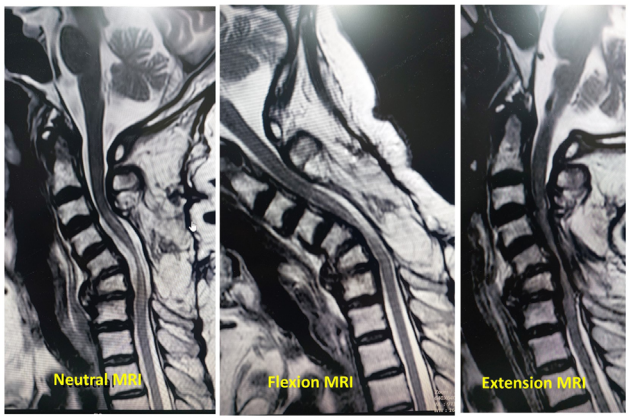
Design
prospective consecutive case series

Introduction
MRI is gold standard test for cervical spine symptoms. Symptoms in the setting of non-compressive MRI picture is a challenging situation and referred to other specialities for non-surgical management. In this study, we sought to look beyond routine testing to ascertain the cause of symptoms unexplainable by routine MRI

Methods
Inclusion criteria included medically recalcitrant patients with the following 1) radiculopathy and/or myelopathy 2) patients with existing MRI showing non-significant compression 3) dynamic x rays not showing obvious spondylolisthesis. Both primary and previously operated cases were included. Exclusion criteria: 1)patients with only axial neck pain 2)patients with adjacent segment disease 3)non-degenerative pathologies. All patients underwent dynamic MRI testing at our centre with 3D MRI sequence. Arm pain VAS for radiculopathy and mJOA for myelopathy was recorded pre op and post op at follow up.

Results
Total of 30 patients were enrolled. 23 were primary cases. New level of pathology were detected in 83.33 % of the recalcitrant cases. 7 were previously operated. 18 out of 23 primary cases showed worsening of neural element compression on dynamic MRI at levels other than that seen on neutral MRI. The compression was anterior in five cases, posterior in 2 cases and combined (anterior-posterior) in 11 cases. 16 out of 18 underwent a procedure which would not have been offered to the patient without dynamic MRI. Other two (radiculopathy) refused interventional treatment and were lost to follow up. All patients that underwent interventional procedures showed immediate relief in symptoms at 2 weeks and at last follow-up. There was statistically significant improvement ($p<0.05$) in arm pain VAS (in radiculopathy group) and mJOA ($p<0.05$) in myelopathy patients. In the previously operated group, all 7 out of 7 showed compression of the spinal cord on dynamic MRI. Four patients had combined antero-posterior compression while 2 had pure posterior compression. 6 out of seven underwent surgery with significant improvement in mJOA score ($p<0.05$). One refused surgery due to milder symptoms and is under follow up.

Conclusion
Dynamic MRI can alter decision making and help surgeon decide surgical approach multilevel compression on extension MRI



14. Preventing Distal Junctional Kyphosis: Choosing a Stable End for the Lowest-Instrumented Vertebra is Protective Following Adult Cervical Deformity Surgery §

Max R. Fisher, MD; Ankita Das, BS; Oluwatobi O. Onafowokan, MBBS, MS; Jamshaid Mir, MD; Anthony Yung, MMSc; *Pawel Jankowski, MD*; Peter G. Passias, MD

Hypothesis
Placement of the LIV at a stable end vertebra has protective effects against distal junctional kyphosis.

Design
Retrospective cohort.

Introduction
The Stable Sagittal Vertebra is a common anatomic landmark for guidance of LIV placement in adolescent idiopathic scoliosis. The definition of a Stable End Vertebra (SEV) in adult cervical deformity and its impact on prevent structural complications has yet to be investigated.

Methods
CD patients with baseline (BL) and 2-year (2Y) data included. High risk patients in need of SEV defined by increasing BL deformity and frailty, worsening osteoporosis despite medical optimization, or existing DJK requiring reoperation. Components of a SEV: LIV inclination angle above -10°, LIV at or distal to the SSV, LIV greater than 210 HUs. Patients stratified by

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meeting SEV and not meeting SEV. Primary outcome: DJK. Means comparison test assessed differences in outcomes based on presence of SEV. SEV patients further tested against those fused past thoracic apex (T10). Multivariate regression controlling for age and BL deformity determined odds ratios for developing DJK by 2Y.

Results
120 CD patients included: Age 58.5±10Y, 60%F, BMI 28.2±6.6kg/m2, CCI.93. Mean HU for LIV 272±79, LIV+1 252±71, C3 338±109, C7 294±97. By 2Y, 20.6% developed DJK and 6.3% developed DJF. 41 patients met SEV. Patients meeting SEV had lower NDI (1.19 v 4.5;p<.05). No SEV had greater likelihood of DJK (0% v 40%;p<.05). Rates of having total complication rates were lower for SEV patients (16.7% v 40%;p<.001). Patients fused past T10 had increasing rates of complications over 2Y compared to SEV (25% v 16.7%;p=.045). Multivariate regression showed that SEV had 72% lower odds of DJK within 2Y (OR: .28;p<.05) and 97% less likely to develop DJF (OR .03;p=.018). SEV 98% less likely to undergo reoperation within 2Y (OR: .01;p<.001). Those fused past T10 had 2x higher chances of DJK occurrence (OR 2.43; p<.05) and 23% more likely for reoperation compared to SEV patients (OR 1.23;p=.022).

Conclusion
The quality and orientation of the lowest-instrumented vertebra plays a consequential role in the outcomes and complications following cervical deformity surgery. Careful consideration in choosing a stable end vertebra during surgical planning can pay marked long-term dividends following adult cervical deformity surgery.

15. Lumbar Facet Arthroplasty for Spondylolisthesis and Stenosis: Three-Year Outcomes from a Prospective FDA Randomized Clinical Trial §

Evalina L. Burger, MD; Vikas V. Patel, MD; Michael P. Steinmetz, MD; William C. Welch, MD; Ahmad Nassr, MD; Domagoj Coric, MD

Hypothesis
N/A

Design
Multi-center, prospective, randomized, Investigational Device Exemption trial.

Introduction
In June 2023, a new lumbar facet replacement technology was approved by FDA following a multi-center, prospective, randomized, Investigational Device Exemption trial. The primary endpoint reviewed by FDA demonstrated that facet replacement was superior to fusion in overall clinical success at 2 years. To understand if the advantages of facet replacement vs fusion are maintained long-term, this analysis presents 3 year outcomes from the ongoing IDE trial which continues follow-up of enrolled patients as part of the post-approval requirements.

Methods
A total of 302 patients, randomized 2:1, were evaluated comparing the facet arthroplasty (FA) group (n=207) to the Fusion control (TLIF) group (n=95). At the time of this analysis 152 patients (FA =117; TLIF= 35) have completed 3 years of follow-up. The primary endpoint was the percentage of subjects achieving minimum clinically important difference (MCID) in the Oswestry Disability Index (ODI) and VAS back and leg pain. MCID was defined as a minimum improvement of 15 points from baseline for ODI and 20 points for back and leg pain.

Results
At 36 months, the percentage of subjects achieving MCID on ODI were 94.1% for the facet arthroplasty groups vs 83.3% for the TLIF group (p=0.079). The percentage of subjects achieving MCID on VAS low back pain were 85.5% for the facet arthroplasty groups vs 71.4% for the TLIF group (p=0.076). The percentage of subjects achieving MCID on VAS leg pain were 97.4% for the facet arthroplasty groups vs 91.4% for the TLIF group (p=0.135). Rate of reoperation was 5.7% for facet arthroplasty compared to 8.3% for TLIF.

Conclusion
Lumbar facet replacement continues to demonstrate clinically meaningful improvements compared to TLIF through 3 years. The results, while not statistically significant, continue to show similar trends in the difference in outcomes between groups that were observed at 24 months. Continued follow-up is required to validate these findings and evaluate differences between facet arthroplasty and fusion.

16. Hypokyphosis is for the Skinny Kids: The Effect of Childhood Obesity on True 3D Kyphosis in Idiopathic Scoliosis

Eliza Lovrich, BS; Moanes Shalabi, MD; Carlos Monroig-Rivera, MD; *Lydia Klinkerman, BS*; Megan Johnson, MD; Brandon A. Ramo, MD; Amy L. McIntosh, MD; Banahene Glover, BS; Jaysson T. Brooks, MD

Hypothesis
Obese patients with AIS requiring PSF present with larger preoperative kyphosis compared to healthy BMI patients

Design
Retrospective chart review

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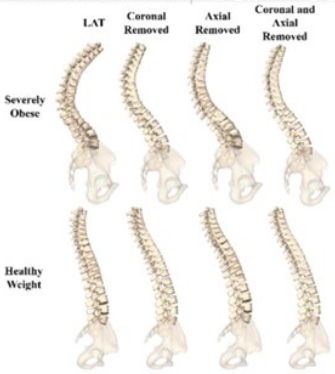
Introduction
It is well known that traditional and low dose biplanar radiographs (LDBR) evaluate the spine only in 2-D. When the sagittal plane is evaluated in 3-D, with the coronal deformity and axial rotation controlled for, AIS patients are significantly more hypokyphotic in the thoracic spine. Previous studies have reported that obese AIS patients have more baseline thoracic kyphosis than normal weight AIS patients, however these studies were all done with 2-D radiographs. The purpose of this study is to quantify the true 3-D kyphosis in AIS patients, stratified by their body mass index (BMI) percentile.

Methods
The LDBR data, from an AIS database was analyzed with a previously validated, custom MATLAB program which measures 3-D kyphosis in the sagittal plane for each spinal motion segment. True 3-D T5-T12 kyphosis was produced by the MATLAB program by removing the coronal tilt and axial rotation of each vertebral segment and then restacking the de-rotated vertebrae. Global T5-T12 kyphosis is referenced off the pelvis, with no restacking or derotation of the vertebra performed; it is a proxy for 2-D sagittal measurements of spine radiographs. BMI-for-age percentile was calculated, with patients categorized into normal weight (5th to 85th %ile), overweight (85th to 95th %ile), obese (>/= 95th %ile), and severely obese (120% of the 95th %ile).

Results
175 patients were included in the study: 10 (6%) severely obese, 23 (13%) obese, 18 (10%) overweight, and 124 (71%) normal weight. There was no difference in global T5-T12 kyphosis based on BMI. However, when 3-D T5-T12 kyphosis was measured, there was a significant difference, with 3-D kyphosis increasing as the patient's BMI increased (Figure). When BMI-for-age percentile was correlated as a continuous variable to 3D and global kyphosis, there was a significant but weak correlation both for 3D T5-T12 kyphosis (0.12, p=0.03) and global T5-T12 kyphosis (0.16, p=0.04).

Conclusion
Hypokyphosis in AIS is more common in normal-weight children, while higher BMI significantly increases 3-D thoracic kyphosis. The impact of this increased kyphosis on surgical correction and intraspinal abnormalities requires further study.

	BMI-FOR-AGE CATEGORY				P-VALUE
	Normal Weight	*Overweight*	*Obese*	*Severely Obese*	
MEAN GLOBAL T5-T12 KYPHOSIS	24.8° ± 14°	24.6° ± 12°	31.2° ± 16°	30.8° ± 17°	0.17
MEAN 3-D T5-T12 KYPHOSIS	4.9° ± 15°	8.5° ± 15°	13.3° ± 14°	17.3° ± 16°	0.01



Table

17. Assessment of the Utility of MRI in Preoperative Evaluation of Adolescent Idiopathic Scoliosis

Gabrielle A. Rogie, BS; Rohini Vanodia, MD; Timothy Borden, MD; Lindsay Crawford, MD; Surya N. Mundluru, MD, MBA; Eric O. Klineberg, MD; Rex Marco, MD; Shah-Nawaz Dodwad, MD; Brennan Roper, MD; Jessica Traver, MD; Alfred Mansour, MD; Shiraz A. Younas, MD

Hypothesis
MRI is critical in detection of neural axis deformities in pre-operative assessment for AIS patients undergoing PSIF.

Design
Retrospective

Introduction
The current standard treatment of moderate to severe Adolescent Idiopathic Scoliosis (AIS) deformity at risk of progression is posterior spinal fusion and instrumentation (PSIF). The necessity of MRI in preoperative evaluation has been debated, with some clinicians advocating for routine use while others reserve it for those with neurological signs. MRI can reveal conditions necessitating additional surgery prior to PSIF. This study aimed to assess the utility of MRI in preoperative evaluation for AIS.

Methods
This IRB-approved study analyzed all pediatric AIS patients who underwent PSIF over the past 14 years at a single institution excluding those with diagnosed syndromic, congenital, or neuromuscular scoliosis. Data collected through chart review included neurological findings from history and physical exams, along with MRI results. If MRI results indicated abnormalities, it was recorded whether a neurological

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consult was ordered and if the consult influenced surgical planning.

Results
233 patients were analyzed. 24 patients (10.5%) had positive MRI findings and 5 (20.8%) required neurosurgical intervention prior to proceeding with PSIF. Among these, 4 had Chiari malformation with associated syringomyelia and one had a tethered spinal cord. Pre-MRI findings included one patient whose curve pattern suggested undiagnosed neuromuscular scoliosis (later confirmed). The remaining 4 patients lacked significant findings in history or examination. In contrast, among the 19 patients not requiring neurosurgical intervention, only 2 had identifiable findings: one with episodic arm paresthesia diagnosed with minimal cerebellar ectopia, and another exhibiting hyperreflexia with positive clonus, diagnosed with borderline low conus. Both these patients were followed by neurosurgery post-operatively, but did not warrant any intervention prior to PSIF.

Conclusion
This study underscores the importance of MRI in preoperative assessment for AIS. Overall, 21 of 24 patients (87.5 %) had a positive MRI without neurologic findings and furthermore 4 of these 24 patients without findings (16.7%) required neurosurgical intervention. The decision to use MRI should be based on comprehensive history and examination, recognizing that not all underlying conditions are clinically evident.

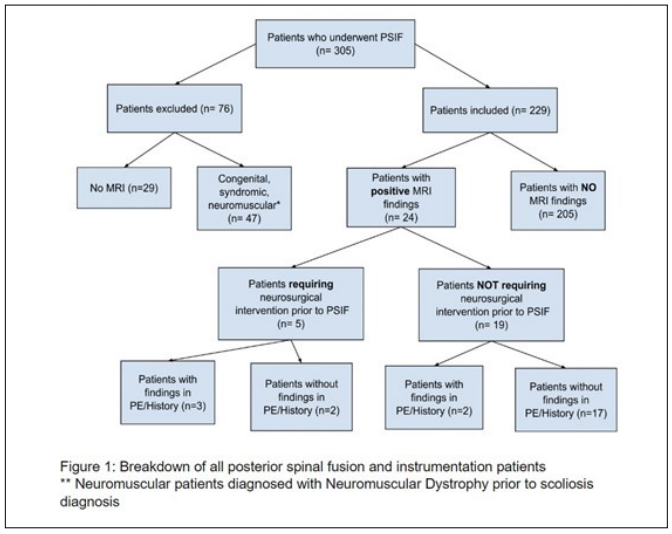

Figure 1: Breakdown of all posterior spinal fusion and instrumentation patients
** Neuromuscular patients diagnosed with Neuromuscular Dystrophy prior to scoliosis diagnosis

18. Tele-Scoli-Screen & Treat (TSST) Protocol for Scoliosis Treatment, Combining In-Person and Online Treatment Sessions, for Patients with Transportation Barriers

Nikos Karavidas, PT, MSc

Hypothesis
A combination of online and in-person non-operative treatment for AIS can improve treatment outcomes

Design
Retrospective matched case-control study

Introduction
Adherence to treatment protocol is important prognostic factor for successful result in AIS treatment with bracing and/or Physiotherapeutic Scoliosis Specific Exercises (PSSE). However, patients living away from specialized centers, have travelling and financial obstacles to receive proper care. Our clinic developed a specific protocol for online evaluation and treatment sessions.

Methods
Our online evaluation required patient digital radiographs and eight standardized clinical photos, in standing and forward bending positions. An intensive in-person program was prescribed, to allow adequate teaching of PSSE or brace manufacturing when needed. Then, the patients followed a home-program of exercises, having regular online supervised sessions. They were asked to re-visit our clinic every 3-6 months. Our online intervention group (OIG) (combined in-person and online treatment) was consisted of 118 patients (103 females-15 males, mean Cobb angle 29.4o, Risser 0.8, age 12.6 years). Our inclusion criteria were Cobb angle 10o – 40o, Risser 0-2, < 1-year post-menarche for girls, and permanent residence outside of our region. We used a retrospective matched-control group (MCG) with similar characteristics that received only in-person treatment (106 patients, 92 females-14 males, mean Cobb angle 27.1o, Risser 1.1, age 12.9 years). In the last 3 years totally 3092 online sessions were done for the OIG. Compliance was self-reported in both groups. Independent sample t-test were used for statistical analysis. Mean follow-up was 29.7 months.

Results
Compliance with exercises was significantly better (p=0.006) in OIG (78.3% > 3 days/week) compared to MCG (52.8% > 3 days/week). In OIG 35% improved, 54% remained stable and 11% progressed, while in MCG 24% improved, 57% stable and 19% progressed (p=0.04). The loss to follow-up was also significantly lower (p=0.03) in the OIG (6 subjects, 5.1%) compared to MCG (10 subjects, 10.9%).

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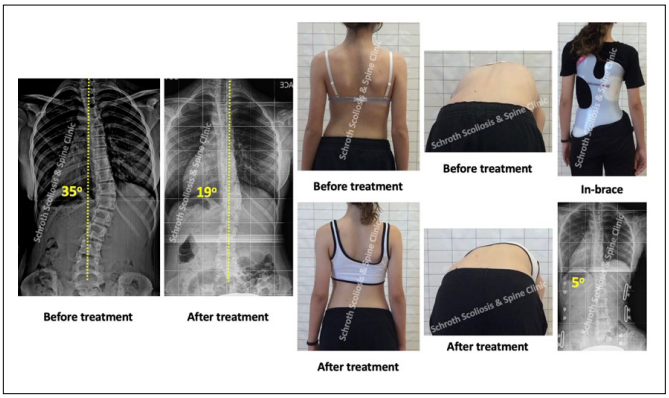
Conclusion
Our TSST protocol significantly improved compliance, monitoring, and final treatment result in AIS patients at high risk of progression. Online supervision can keep patient's motivation, allowing proper follow-up and can be used for patients with transportation barriers.



19. Does Vertebral Body Tethering Cause Coronal Hypermobility of Adjacent Non-Instrumented Levels?

Hans K. Nugraha, MD; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD; *Ahmad Nassr, MD*

Hypothesis
Vertebral body tethering (VBT) surgery preserves the coronal arc of motion distal to the lower instrumented vertebra (LIV) in adolescent idiopathic scoliosis (AIS) patients without the development of hypermobility observed following fusion surgery.

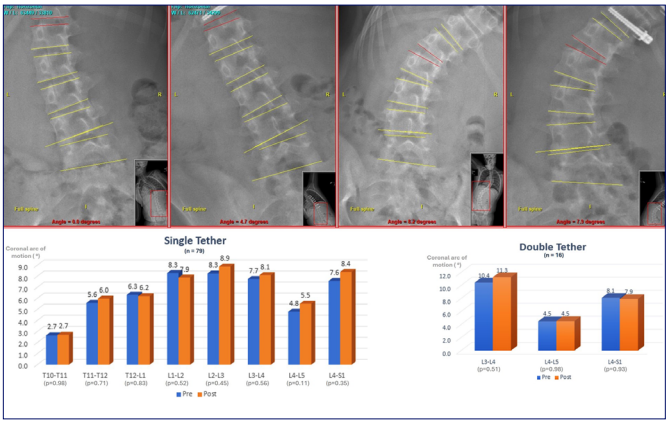
Design
Retrospective Cohort

Introduction
Fusion into the lumbar spine with LIV of L2 and below results in hypermobility of the unfused segments, potentially contributing to early wear and degenerative arthritis. VBT is a motion-preserving surgery for AIS, but no data has been available about its effect on the uninstrumented segments distal to the LIV.

Methods
After obtaining institutional IRB, a single-center retrospective review was done on patients with AIS who underwent VBT surgery in the past 9 years. Bending films were collected as standard of care preoperatively and at 1-year postop. All images are obtained in the standing position in a low dose slot scanning imaging system according to our institutional protocol. Patients are instructed to achieve maximum effort on side bending. To obtain the coronal arc of motion, radiographic measurement of the intervertebral angles was measured digitally with a clinical image viewer software (QReads 5.15.3) at each level from the disc directly distal to LIV to S1, as described in previous literature. All statistical analysis was performed using GraphPad Prism 10.2.0 (GraphPad Software Inc.; San Diego, CA, USA)

Results
Ninety-five patients who had a prospectively collected 1-year follow-up (average 1.6 year, median 1.21) were included in this study. In total, there were 2,086 segments measured. Sixteen patients had bilateral tether procedures and were analyzed in a separate group. Compared with preoperative values over the same levels, paired t-test showed no significant difference in all coronal arc of motion of segments distal to the LIV in either single or double tether group. Further one-way analysis of variance on the single-tether subset showed no relationship between more distal instrumented vertebrae and coronal arc of motion of segments distal to the LIV.

Conclusion
Normal segmental motion on lateral bend was preserved on the non-instrumented segments following VBT. In contrast to fusion, there was no evidence of lumbar hypermobility following VBT. This may be protective against adjacent segment disease and early arthritis seen in long fusions.



20. Surgical Planning Tool Based on Patient's Presenting Deformity, Skeletal Maturity and Flexibility for Lumbar VBT, Validated by Multicenter Study

Marie-Eve Fecteau; Nikita Cobetto, PhD; Marine Gay; Christiane Caouette, PhD; A. Noelle Larson, MD; Dan Hoernschemeyer, MD; Melanie E. Boeyer, PhD; Ron El-Hawary, MD; Ahmet Alanay, MD; *Carl-Eric Aubin, PhD*

Hypothesis
The lumbar VBT planning tool based on patient's presenting skeletal maturity, deformity and flexibility can predict 2-year correction within 3°.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Design
Computational validation study using multicentric retrospective cases with lumbar VBT

Introduction
Vertebral body tethering (VBT) for lumbar curves is gaining increasing interest due to greater growth potential than thoracic spine, in addition to benefits associated with preserving spinal mobility. However, revision rates remain high (14%-32%), with complications such as under/over-correction of the curve, cable breakage and adding-ons. The aim is to validate a planning tool for lumbar VBT surgery using a patient-specific finite element model (FEM) of the spine including growth and mechanobiological growth modulation.

Methods
29 patients with idiopathic scoliosis from 3 centers who underwent lumbar VBT with or without thoracic VBT were included in the retrospective study. For each, a personalized FEM was built using a 3D reconstruction of the spine, pelvis and rib cage, based on preoperative biplanar X-rays. The FEM was calibrated to represent patient flexibility, weight and skeletal maturity, and was linked to an algorithm integrating growth and growth modulation. The growth rate was established using preoperative Sanders Score. VBT was simulated to replicate immediate post-op correction and predict growth modulation correction over two years. For validation, simulated thoracic (MT) and thoracolumbar/lumbar (TLL) Cobb angles were compared with immediate postoperative and two-year radiographic measurements.

Results
Mean presenting Cobb angles were 39±13° (MT) and 49±10° (TLL). Immediately after surgery, these were corrected by 39±16% and 60±16% respectively. After 2 years, correction was 47±25% and 75±22%. There was no significant difference between simulated and actual Cobb angles immediately (3°±2° MT; 2°±1° TLL) and after two years (4°±2° MT; 3°±2° TLL) ($p<0.05$, equivalence test).

Conclusion
The patient-specific FEM accurately predicted immediate and 2-year correction (statistical power of 85%; given the number of cases currently included). The study is ongoing to include 45 cases to reach target statistical power of 95%.

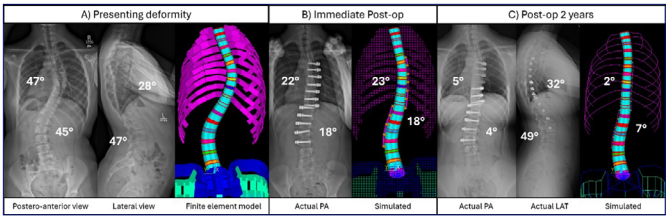


Figure 1 - A) Case example (11-year-old/Sanders 3A) Biplanar radiographs and 3D patient-specific FEM; B) Actual and simulated immediate post-op correction; C) Actual and simulated 2-yr correction

21. Location of Tensioned Cord in Double Row VBT Constructs Significantly Affects Flexion Extension and Lateral Bending Range of Motion: A Cadaveric Biomechanics Study

A. Noelle Larson, MD; Amy A. Claeson, PhD; Vijay Permeswaran, PhD

Hypothesis
Cord tension and location of VBT screws impact both the amount and plane of ROM reduction.

Design
Cadaveric

Introduction
Vertebral body tethering (VBT) is emerging as a motion preserving procedure for treatment of adolescent idiopathic scoliosis. Screws and a tensioned cord are implanted laterally with VBT to apply corrective forces on the growing spine, preventing further curve progression. A secondary row of implants is now used by some clinicians to apply greater corrective forces, especially in the thoracolumbar spine. In this cadaveric biomechanics study, we investigate the impact of a secondary row on spinal range of motion (ROM).

Methods
Six thoracolumbar (T11-L5) specimens were tested with an MTS spine simulator while optoelectronic markers measured ROM. Each specimen was tested in the native state to assess baseline ROM. Then two rows of VBT screws were implanted at T12-L4, with one screw placed slightly posteriorly and the other slightly anteriorly. Experimental interventions (INT) included: INT2 anterior cord 300N; INT3 primary anterior 300N, secondary posterior 30N; INT4 anterior and posterior cords 300N; INT5 primary posterior 300N, secondary anterior 30N; and INT6 posterior cord 300N. A one-way ANOVA assessed statistical differences between interventions ($\alpha=0.05$).

Results
In flexion extension (FE), one cord tensioned to 300N posteriorly (INT2) did not affect ROM. Introducing a second cord anteriorly at 30N tension (INT3) significantly decreased ROM from 98% to 84% of native

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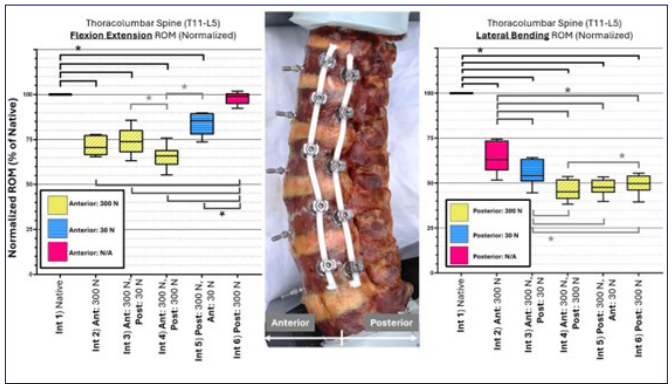
(p<0.05). When the secondary anterior cord was also tensioned to 300N (INT4), FE ROM decreased to 65% of native. When the anterior cord was tensioned primarily to 300N, with (INT5) or without (INT6) a secondary cord tensioned to 30N posteriorly, FE ROM was significantly reduced (p<0.05) but still maintained 71% and 74% of native ROM. In lateral bending (LB), the presence of a posterior cord tensioned to 300N resulted in significant reductions in ROM (p<0.05, INT4: 46%, INT5: 48%, INT6: 49%). LB ROM was significantly greater without a 300N posterior cord (p<0.05, INT2: 64%, INT3: 56%), though still significantly reduced from native (p<0.05).

Conclusion

Cord tension and location of VBT screws impact both the amount and plane of ROM reduction; screws placed anteriorly have greater effect on FE ROM, while screws placed posteriorly have greater effect on LB ROM.



22. Closed Bulb Suction Utilization After Primary Thoracoscopic Vertebral Body Tether Instead of Chest Tube

Samantha Ahrens, BS; *Lawrence L. Haber, MD*; Hunter Starring, MD; Bhumit R. Desai, MD

Hypothesis

The closed bulb suction with bulb reservoir is a safe option for drainage after VBT, in place of a traditional chest tube and atrium (CT) with low complication rates and improved patient comfort.

Design

A retrospective review of a single-center consecutive series of 91 primary thoracoscopic VBT surgeries. All patients had a closed bulb suction placed for post operative drainage and were reviewed to assess its safety and effectiveness.

Introduction

Traditionally, drainage after thoracoscopic surgery has included a formal chest tube with an atrium (CT). We previously published a 3 center retrospective review comparing the effectiveness of the closed bulb suction to CT. That study indicated that closed bulb suction may offer advantages over CT but included a much smaller initial cohort of closed bulb suction subjects (30). Closed bulb suction is considered to be less painful for patients than a larger CT. This review confirms safety and efficacy in a much larger cohort.

Methods

Retrospective consecutive case series with quantitative data from the 91 cases including operative time, length of hospital stay, estimated blood loss (EBL), duration of drain placement, and total drainage volume. Qualitative variables include type of drain and caliber of drain tube.

Results

91 consecutive thoracoscopic VBT cases utilized a 10-French closed bulb suction. All cases performed from 2019 to 2024. Mean EBL was 63+50cc, length of stay 3.1 days (2-5 days), and operative time of 288+62 minutes. Patients had a drain in place on average of 2.81 days (1-5 days) with 368+186cc of drainage. There was one asymptomatic mild effusion early in the series after the drain was removed, which resolved without treatment. No other events were noted.

Conclusion

This 91 case series demonstrates safety and efficacy of utilizing closed bulb suction after thoracoscopic VBT. Smaller drains with a bulb are better tolerated than a larger conventional CT with an atrium, allowing easier mobilization post operatively.

23. Surgical Correction of Scoliosis Restores Balance: A Prospective Motion Analysis Study

Ria Paradkar, BS; Christina Regan, BS; Kathie Bernhardt, BS; Kenton R. Kaufman, PhD; Todd A. Milbrandt, MD, MS; *A. Noelle Larson, MD*

Hypothesis

Our hypothesis is that reactive balance is improved in post-VBT scoliosis patients compared to post-fusion scoliosis patients.

Design

This prospective motion analysis study investigates gait stability in post-fusion, post-VBT, pre-op scoliosis, and control patients using treadmill postural perturbations.

Introduction

Traditional fusion leads to a loss of spine mobility. Vertebral body tethering (VBT) aims to increase flexibility and maintain spinal mobility. However, its functional benefits are unclear. In a prospective study, we previously found that posterior stepping thresholds are predictive of falls in older adults. This

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study examines changes in gait stability in patients with scoliosis following VBT and fusion surgery.

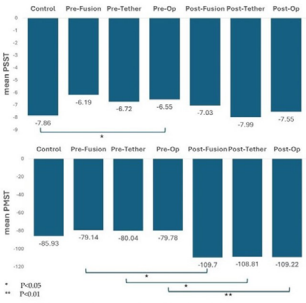
Methods
79 subjects underwent postural perturbations, which simulated trips, using a computer-controlled treadmill while subjects were harnessed for safety. Subjects included 21 healthy controls, 18 patients at least one-year post-VBT, 15 patients at least one-year post-fusion, and 25 pre-op scoliosis patients. Weight, height, and treadmill acceleration were used to determine anteroposterior single (ASST, PSST) and multiple (AMST, PMST) stepping thresholds, describing the maximum torque a patient could withstand before failing to recover from the simulated trip. T-tests were run to compare data.

Results
Significant differences in posterior stepping thresholds were observed across groups. Pre-op scoliosis patients had significantly lower PSST than healthy controls (p = 0.041). Post-VBT and Post-Fusion patients exhibited significantly higher PMSTs than Pre-VBT (p=0.039) and Pre-Fusion (p=0.030) patients respectively. There was also a significant difference in PMST between the combined post-ope group (Post-Fusion and Post-VBT) compared to the combined pre-op group (Pre-Fusion and Pre-VBT) with post-op patients sustaining greater torques before failure (p=0.002). There was no significant difference in anterior stepping thresholds between any of the groups.

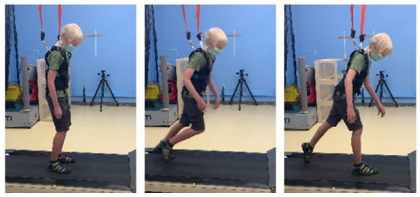
Conclusion
Healthy controls had a greater mean PSST, reflecting better balance than pre-op scoliosis patients. Interestingly, there was no significant difference in reactive balance measures between control and post-op scoliosis patients. Post-VBT and post-fusion patients demonstrated improved reactive balance compared to their pre-op counterparts, indicating improved gait stability following surgical treatment of scoliosis.

Significance Tests for Reactive Balance Measures

	Group	p-value
Anterior Single Stepping Threshold	Control vs. Pre-Op	0.599
	Control vs. Post-Op	0.264
	Pre-Fusion vs. Post-Fusion	0.468
	Pre-Tether vs. Post-Tether	0.898
	Pre-Op vs. Post-Op	0.500
Posterior Single Stepping Threshold	Control vs. Pre-Op	0.041
	Control vs. Post-Op	0.597
	Pre-Fusion vs. Post-Fusion	0.213
	Pre-Tether vs. Post-Tether	0.177
	Pre-Op vs. Post-Op	0.113
Anterior Multiple Stepping Threshold	Control vs. Pre-Op	0.214
	Control vs. Post-Op	0.111
	Pre-Fusion vs. Post-Fusion	0.978
	Pre-Tether vs. Post-Tether	0.579
	Pre-Op vs. Post-Op	0.578
Posterior Multiple Stepping Threshold	Control vs. Pre-Op	0.579
	Control vs. Post-Op	0.052
	Pre-Fusion vs. Post-Fusion	0.030
	Pre-Tether vs. Post-Tether	0.039
	Pre-Op vs. Post-Op	0.002



Computer-controlled Treadmill Simulation Set-up with Patient in Harness



24. Correlations Between Thoracic Kyphosis and Rod Contouring in Patients with Adolescent Idiopathic Scoliosis Indicate Ideal Contouring Prescriptions for Correction

Norihiro Isogai, MD; Suken A. Shah, MD; A. Noelle Larson, MD; Harry L. Shufflebarger, MD; Stephen G. George, MD; Paul D. Sponseller, MD, MBA; Peter G. Gabos, MD; Burt Yaszay, MD; Joshua M. Pahys, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Harms Study Group

Hypothesis
Ideal rod contouring targets can be formulated using preoperative and target sagittal and coronal alignment.

Design
Retrospective review of a prospectively collected multi-center cohort

Introduction
There has been some preliminary work on sagittal plane restoration in adolescent idiopathic scoliosis (AIS), but little information exists on the relationship between rod contouring and thoracic kyphosis (TK) restoration that takes into account the amount of preoperative 3DTK and the axial plane.

Methods
A cohort of 727 AIS patients with 1, 2, or 3 type curves, who underwent PSF was examined. Demographic data, radiographic data including curve magnitude, thoracic kyphosis (T5-12) (2D-TK), three-dimensional thoracic kyphosis (T5-12) (3D-TK), and pre-insertion rod contour and angle were evaluated (see Fig). We measured 2D and 3D rod to spine contour (2D-RSC and 3D-RSC) as the difference between preoperative 2D- and 3D-TK and the pre implantation rod angle, and kyphosis change (2D-KC and 3D-KC)

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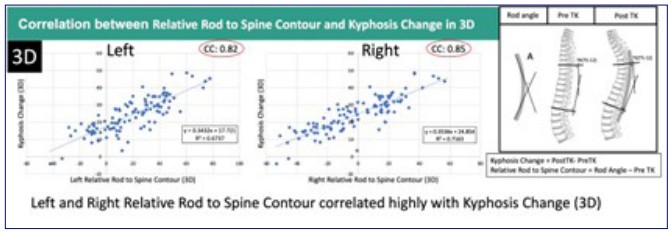
as the difference between preoperative and postoperative 2D- and 3D-TK. Patients with sagittal modifier +, left convex curves, in-situ bending, rod diameters/materials other than 5.5mm CoCr and those without rod tracings were excluded from this study.

Results
One-hundred and eleven patients were included and mean main thoracic Cobb angle improved from 55 ± 8 to 17 ± 6 degrees and mean 2D-TK improved from 18 ± 12 to 23 ± 5 degrees after surgery. There was a strong positive correlation with both left (0.82) and right rods (0.85) with 3D-RSC and 3D-KC, indicating that TK restoration is highly affected by rod contouring (see Fig). The correlation coefficient with the 3D variables was higher than the 2D variables (0.78). Formulas were created using linear analysis (R2=0.72) and then converted to actionable targets that were programmed into an app for future intraoperative use.

Conclusion
Ideal rod contouring can be calculated in detail using preoperative and target alignment of the 3D sagittal plane for ideal TK restoration. Existing data sets can be used to apply standardized rod contouring targets to our patients with AIS to establish ideal coronal, sagittal and axial alignment. Moreover, differential rod contouring can be customized to affect TK and axial correction collectively.



Left and Right Relative Rod to Spine Contour correlated highly with Kyphosis Change (3D)

25. Determination of Lowest Instrumented Vertebra Using "Nanjing Rule" Achieved Shorter Fusion Safely Compared with "LSTV Rule" for Lenke 1A Curves

Xiaodong Qin, PhD; *Zhong He, MD*; Zhen Liu, PhD; Yong Qiu, PhD; Zezhang Zhu, PhD

Hypothesis
For AIS with Lenke 1A curves, using "Nanjing Rule" to guide the selection of lowest instrumented vertebra (LIV) could achieve shorter fusion safely compared with "last substantially touching vertebra (LSTV) Rule".

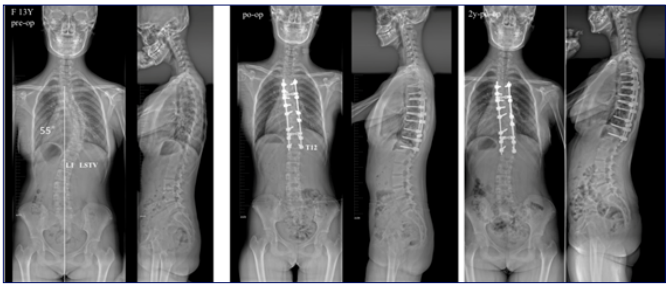
Design
A prospective case-control study

Introduction
It keeps controversial regarding the choice of LIV for Lenke 1A curves. Lenke et al. proposed the "LSTV Rule", while our group developed a set of LIV selection criteria known as the "Nanjing Rule." This study aims to compare the clinical outcomes of these two LIV selection rules.

Methods
The "Nanjing Rule" was defined as follows: when Risser ≥ 3, main curve length ≤ 8 segments, LSTV-1 rotation ≤ I°, LSTV-1 deviation from the CSVL < 20mm, preoperative coronal balance < 10mm, and the intervertebral disc between LSTV-1 and LSTV opens bidirectionally on bending films, the LIV can be selected as LSTV-1; if these conditions are not met, LIV should be selected as LSTV. A prospective consecutive collection of 120 cases were enrolled. Patients with odd numbers were guided by the "LSTV Rule," while those with even numbers followed the "Nanjing Rule". The duration of follow-up was at least two years. Radiographical parameters were measured at the final follow-up, and a comparison was made between the two groups.

Results
The average duration of follow-up was 33.1±6.3 months for the "LSTV Rule" group and 32.8±7.5 months for the "Nanjing Rule" group. At the last follow-up, the incidence of distal adding-on was 15.0% in the "LSTV Rule" group and 16.7% in the "Nanjing Rule" group, with no significant difference between the two groups. The main curve correction rates were 74.8±10.5% and 73.2±12.3%, respectively, with no significant difference. The "LSTV Rule" group had an average fused segment of 10.5±1.7, while the "Nanjing Rule" group was significantly lower at 9.7±1.5 segments (p=0.003). Additionally, the LIV in the "Nanjing Rule" group was on average at the T12-L1 level, whereas in the "LSTV Rule" group, it was at the L1-L2 level (p=0.004).

Conclusion
Both the "Nanjing Rule" and the "LSTV Rule" for guiding LIV selection can achieve satisfactory correction outcomes. Choosing LIV based on the "Nanjing Rule" allows for the preservation of distal fusion segments and demonstrates better clinical applicability.


Choosing LIV based on the "Nanjing Rule" saved one distal level than the "LSTV Rule"

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PODIUM PRESENTATION ABSTRACTS

26. Putting the "C" Back into CSVL: Does the Method of Drawing the CSVL Affect the Last Touched Vertebra?

Varun Ravi, BS; Carlos Monroig-Rivera, MD; Alexander Turner, BS; Emeka Andrews, BS; Y. Jordan Kenfack, BS; David C. Thornberg, BS; *Banahene Glover, BS*; Jaysson T. Brooks, MD

Hypothesis
In patients with idiopathic scoliosis and pelvic obliquity, the method used to draw the central sacral vertical line (CSVL) will significantly affect the selection of the last touched vertebra (LTV), with the iliac method (iCSVL) resulting in different LTV selection compared to the traditional sacral method (sCSVL), particularly in cases where pelvic obliquity exceeds 2.4 degrees.

Design
Retrospective Study

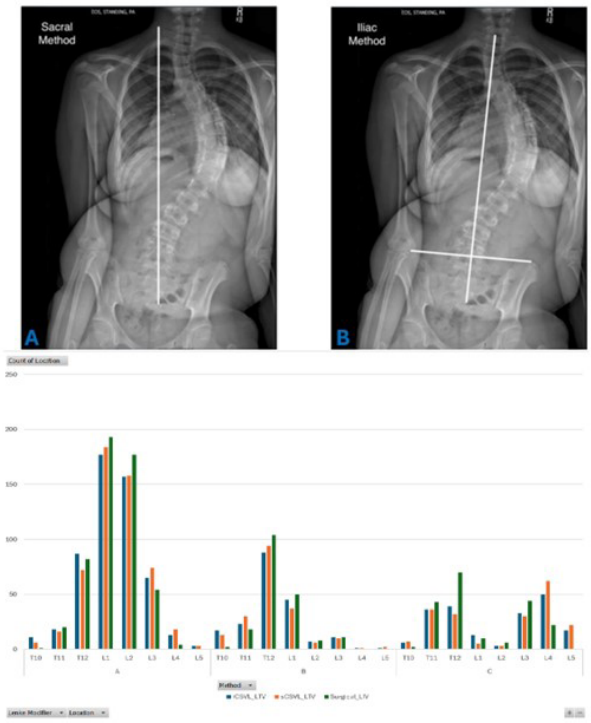
Introduction
Traditionally, the central sacral vertical line is a line drawn parallel to the vertical axis in the middle of the sacrum (sCSVL). However, in patients with a leg length difference or pelvic obliquity (PO), the last touched vertebra (LTV) selected by the sCSVL can vary substantially. A recent alternative "iliac" method (iCSVL), involves drawing a line tangent to the iliac wings, followed by a perpendicular vertical line centered on the sacrum. There is no literature evaluating the impact of a CSVL method on the selection of the LTV, which often influences selection of the lowest instrumented vertebra (LIV). The purpose of this study is to determine if the method used to draw the CSVL affects the selection of the LTV and evaluate how PO affects the LTV.

Methods
A review of 921 Lenke 1 idiopathic scoliosis (IS) patients who underwent PSF between January 2002 and April 2018, was conducted. Both the iCSVL and sCSVL were drawn on each radiograph, and the LTV selected by each CSVL method was recorded. Additionally, PO was measured in all cases, and the actual LIV instrumented by the surgeon was documented.

Results
In 72.3% (N=666) of patients, the iCSVL and sCSVL method selected the same LTV. In 97% of patients (n=894), the iCSVL and sCSVL selected a LTV within one level of each other. In the remainder of patients (3%, n=27) the iCSVL and sCSVL selected a LTV > 1 level cranial or caudal from the other. Sub-group ROC analysis identified that when a patient's pelvic obliquity exceeded 2.4 degrees, the iCSVL and sCSVL were significantly more likely to select LTVs > 1 level from each other.

Conclusion
In the majority of patients, both the iCSVL and sCSVL methods selected the same LTV or a LTV within 1 level of each other. Careful consideration should be taken when choosing a CSVL method in patients with pelvic obliquity, as the LTV selected may vary significantly.

Figure 1: Posteroanterior (PA) Radiographs Comparing the Sacral CSVL (A) and Iliac CSVL (B) Methods



Figure

27. Intra-operative Rib-to-Pelvis Distraction for Severe Pediatric and Adolescent Scoliosis

Joshua S. Murphy, MD; Kenneth A. Shaw, DO; Daniel Raftis, BS; Nicholas D. Fletcher, MD; Michael Schmitz, MD; Ameer Rifai, BS; Dennis P. Devito, MD

Hypothesis
The utilization of an intraoperative distraction technique will facilitate gradual curve correction with a low complication rate in severe scoliotic deformities.

Design
Retrospective Case Series

Introduction
Classic management of severe scoliotic deformities has included intra-operative traction, intra-operative distraction, and/or halo-gravity traction when performing a posterior spinal fusion (PSF). Although these techniques facilitate significant deformity correction and lower rates of complications there remain limitations. In this study, we describe a

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novel percutaneous intra-operative distraction technique that allows gradual distraction across the deformity while allowing the spine to remain freely mobile in space.

Methods

A retrospective review was performed at a single pediatric tertiary care center of children who underwent a PSF for severe scoliotic deformities and the use of a novel percutaneous intra-operative distraction technique. Inclusion criteria were any patient who underwent intra-operative distraction for a PSF. Exclusion criteria included any patient that first underwent pre-operative halo-gravity traction or intra-operative traction. The technique involves percutaneous screw fixation to the ileum and proximal rib fixation above the maximum spinal deformity. Chart and radiographic reviews were performed and descriptive statistics utilized to summarize this patient cohort.

Results

Twenty-two patients were treated with a PSF utilizing this technique (13 females, 8 males, mean age 14 years). One patient was excluded secondary to pre-operative halo-gravity traction leaving 21 patients for review. Diagnoses included idiopathic and syndromic scoliosis. Median major curve magnitude was 86 degrees (76 to 91 degrees). Patients had a median 13 (11 – 14 levels) levels fused and 78% correction (62% - 84%). Median blood loss was 540 ml (300 – 800 ml) and operative time 326 minutes (266 – 386 min), with median hospital length of stay of 3 days (2.57 – 3.44). There was 1 intra-operative complication and 3 patients with neuromonitoring changes that returned to baseline by the conclusion of the procedure. No patients had documented post-op neurologic deficit.

Conclusion

Implementation of percutaneous rib-to-pelvis distraction can assist in safely maximizing deformity correction in severe pediatric and adolescent scoliosis while maintaining a low rate of neurologic injury.

	Pre-Operative[1]	Post-Operative[1]	Post-operative Change	Percent correction[1]
Proximal Thoracic	34.1 (22.5, 41.4)	6.3 (2.3, 10.6)	-27.2 (-34.9, -9.6)	-77.7 (-92.0, -63.7)
Main Thoracic	86.2 (76.4, 91.6)	18.9 (13.4, 25.1)	-66.3 (-77.9, -50.4)	-78.3 (-83.7, -62.4)
Lumbar	43.5 (36.0, 55.3)	15.3 (9.8, 24.7)	-31.1 (-39.2, -22.2)	-66.1 (-73.9, -53.6)
Kyphosis				
K-T2-T12	43.4 (20.5, 55.6)	36.8 (27.8, 48.7)	-0.1 (-19.6, 10.8)	0.1 (-42.8, 45.5)
K-T2-T5	5.5 (1.7, 19.1)	9.7 (6.0, 18.0)	3.2 (-9.5, 7.4)	59.9 (-22.5, 594.8)
K-T5-T12	28.1 (13.5, 52.1)	28.4 (19.7, 34.1)	-4.1 (-18.5, 10.6)	-14.9 (-39.7, 56.4)
Lordosis				
T12-S1.	56.6 (50.4, 68.4)	59.6 (50.6, 63.8)	-0.1 (-8.9, 7.3)	-0.2 (-17.5, 13.7)

[1] Median (IQR)

Table 1

28. DigiScolio: An AI-based Prediction Model for Individualized Assessment of Lumbar Motion and Function in Adolescent Idiopathic Scoliosis Patients

Owen Yuechuan Zhang, MD; Yiqiao Zhang, MD; Jianguo Zhang, MD; *Qianyu Zhuang, MD*

Hypothesis

Our AI-based prediction model generated from previous collected computed tomography scan results and smartphone videos can effectively predict the lumbar motion and function status of adolescent idiopathic scoliosis (AIS) patients, while avoiding further radiation.

Design

Medical engineering development and prospective clinical validation

Introduction

The current assessment methods in AIS patients are mostly static, thus unable to provide dynamic visualization of lumbar motion and function characteristics. In addition, accumulated radiation may contribute to increased lifetime oncological risk. Therefore, we aim to develop a simple, intelligent, radiation-free and dynamic method to analyze the lumbar motion and function of AIS patients during the follow-up.

Methods

We recruited 30 AIS patients with Lenke type 5 curve. Smartphone videos and a pre-trained AI model were used to perform body-shape modeling and cursory skeleton modeling. Finite element analysis was then adopted to establish an individualized 3D reconstruction model. Then we merge the aforementioned data to build up DigiScolio model. In order to verify the accuracy of DigiScolio, the patients were asked to move towards different directions while the whole process being recorded. At each apex and midpoint of bending, we took two radiographs simultaneously. The radiographs parameters were measured by three experienced spine surgeons separately, then were compared with the automatic measurement via DigiScolio.

Results

Age at examination averaged 15.3 years (range 13.4 to 16.2). The average curve is 53.3° (range 47° to 70°). The average C7PL-CSVL is 3.3 mm (X-ray) and 3.1 mm (DigiScolio) ($p>0.05$). The lumbar tilt angle averaged 16.7° (L1) and 19.3° (L5) for X-ray and 17.3° (L1) and 18.9° (L5) for DigiScolio ($p>0.05$). The convex bending curve ranges from 5° to 11°, averages 7.3° (X-ray), and 7° to 9°, averages 8.2° (DigiScolio, $p=0.053$). The overall accuracy rate for DigiScolio is 92.3% at the start point or at the endpoint ($p<0.01$), and 86.1% at the midpoint ($p<0.05$).

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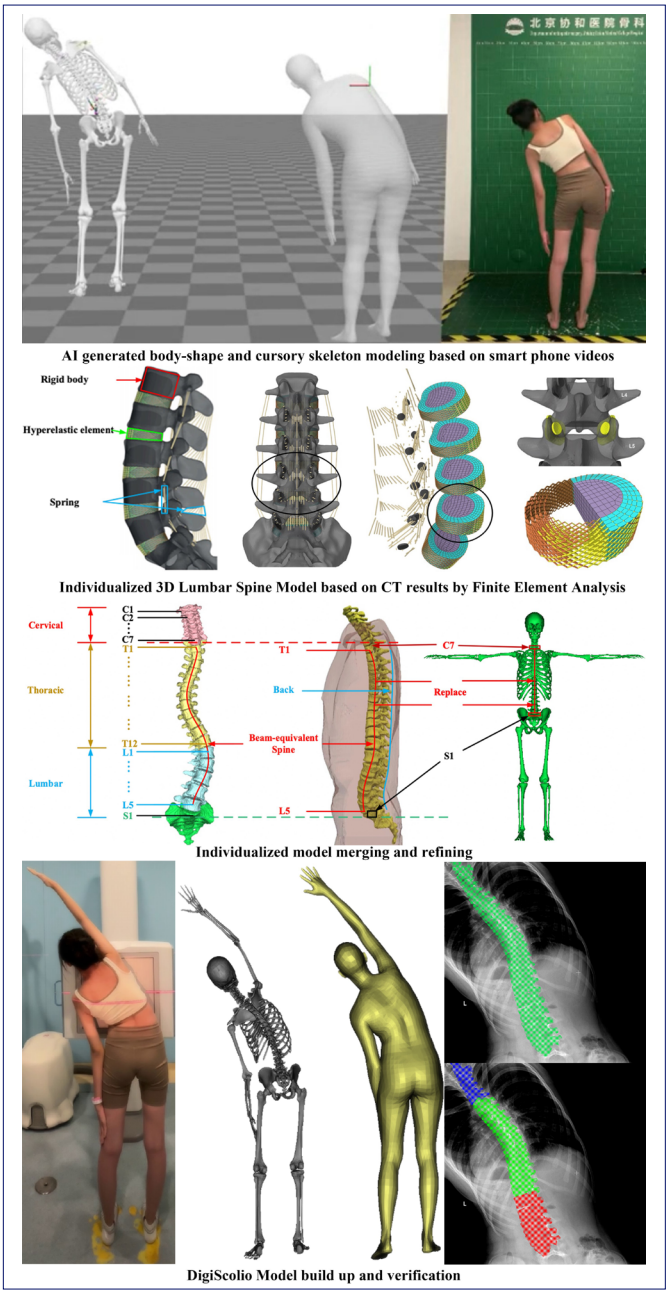
Conclusion
To our knowledge, this is the first AI-based prediction model which can predict dynamic lumbar motion and functional characteristics based on previously obtained CT data and smart phone videos. The model can provide reliable surveillance follow-up, avoiding radiation exposure and potential lifetime oncological risk for AIS patients.



29. Predictive Model for Postoperative X-Rays of AIS After PSF Surgery Using Generative Neural Networks: SVV-Net

Nan Wu, MD; Jianguo Zhang, MD; Yuanpeng Zhu, MD; Xiangjie Yin, MD; Xueyi Zhang, PhD; Guilin Chen, MD

Hypothesis
We hypothesize that generative neural networks can generate immediate postoperative X-rays by integrating pre-operative images with clinical data.

Design
We aimed to use conditional generative neural networks to generate immediate postoperative X-rays after PSF, offering a reference for AIS surgeries and exploring broader medical applications.

Introduction
Accurately predicting PSF outcomes in AIS patients is essential for helping surgeons make informed decisions.

Methods
We retrospectively included patients who underwent PSF surgery at a single center for training and test cohorts, while prospectively enrolling AIS patients scheduled for surgery. We developed the SVV-Net (Scoliosis-VQ-VAE) model, which includes an Encoder, Codebook, Decoder, and Transformer to integrate pre-operative X-ray features with surgical data for post-operative images. The design and training process is shown in Figure 1A. Model effectiveness was evaluated through image quality analysis, postoperative parameter assessment, and clinical review, using six metrics to compare generated and real X-rays. CCC measured agreement between generated and real Cobb angles. Two orthopedic surgeons rated the generated X-rays on clarity, authenticity, accuracy, reasonableness, and usability on a scale of 0 to 10.

Results
A total of 720 patients met the inclusion criteria and were randomly divided into training (n=540, mean age 14.4±1.7 years, 87.8% female) and test cohorts (n=180, mean age 14.4±1.7 years, 85.0% female), with an additional 79 patients (mean age 14.5±1.6 years, 89.9% female) in the prospective cohort. Patients with different severities and spinal curve types are shown to illustrate our model's performance (Figure 1B). SVV-Net outperformed other generative models across six image quality metrics. The Cobb angles from generated images showed strong consistency with real images (CCC: 0.90 [internal] and 0.91 [prospective]), while the Cobb angle improvements also demonstrated high consistency (CCC: 0.97 [internal] and 0.96 [prospective]). Differences in UIVs and LIVs were minimal in both cohorts. Evaluator 1 rated clarity and authenticity highest (7.61 and 7.54), while

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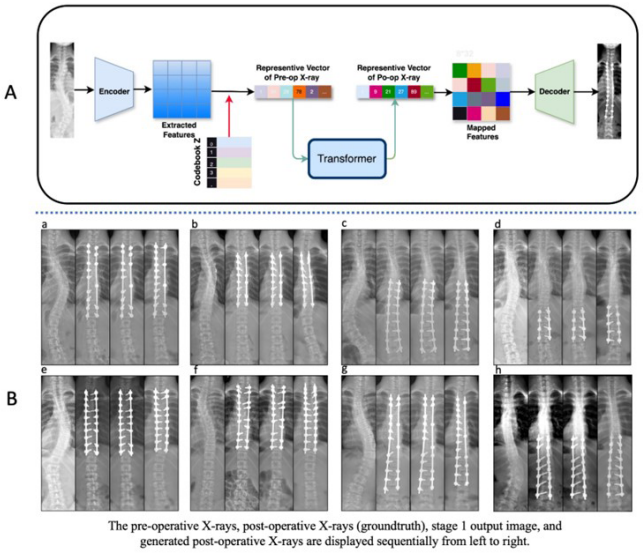
Evaluator 2 gave the highest scores for usability and reasonableness (7.58 and 7.57).

Conclusion
We developed and validated a model to predict immediate postoperative X-rays from preoperative images in AIS patients, showing its potential to assist clinicians.



The pre-operative X-rays, post-operative X-rays (groundtruth), stage 1 output image, and generated post-operative X-rays are displayed sequentially from left to right.

Figure

30. Automated Thoracic Cobb Angle Measurement in Adolescent Idiopathic Scoliosis Using Keypoint R-CNN: Development, Validation, and Performance Comparison

Mert M. Dagli, *MD*; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip, BA; Kevin Bryan, BA; Jonathan Sussman, BS; Connor Wathen, MD; Yohannes Ghenbot, MD; *John Arena, MD*; Joshua L. Golubovsky, MD; John Shin, MD; Ali Ozturk, MD; Beth Winklestein, PhD; William C. Welch, MD; Jang Yoon, MD

Hypothesis
A keypoint region-based convolutional neural network (R-CNN) will accurately automate thoracic Cobb angle measurements from whole-spine radiographs, outperforming existing models in precision and reliability, thereby enhancing scoliosis screening and surgical planning.

Design
Retrospective Study Design

Introduction
Adolescent idiopathic scoliosis (AIS) affects a significant portion of the adolescent population, leading to severe spinal deformities if untreated. Surgical planning heavily relies on measuring the thoracic Cobb angle (TCA) using anteroposterior spinal radiographs. This study aimed to develop and validate an AI tool utilizing a R-CNN to automate these TCA measurements. Secondary outcomes included comparison of model performance to other models prior reported in the literature.

Methods
Funded by NIH (R21AR075971), this retrospective study adhered to STROBE, TRIPOD+AI, and CLAIM guidelines with IRB approval from Penn Medicine and CHOP. The R-CNN was trained using SpineWeb's "Dataset 16" (609 AIS X-rays) and validated on an institutional registry of 83 AIS patients who underwent PSF surgery. Performance metrics included MAE, MedAE, MSE, SMAPE, and ICC. Statistical analysis was performed using Python 3.11, with 10,000 bootstrapped samples to estimate 95% CIs for MedAE.

Results
The keypoint R-CNN was trained using "Dataset 16" and validated on 83 AIS patients undergoing PSF. Keypoint R-CNN achieved an MAE of 2.22 (95% CI: 1.06-3.39), MedAE of 1.47 (0.89-3.15), MSE of 9.1, SMAPE of 4.29, and ICC of 0.98, significantly outperforming existing automated methods such as VLTENet and Auto-CA. By comparison, VLTENet achieved a SMAPE of 5.44 on the test subset of the AASCE dataset, which dropped to 13.9 when applied to external clinical data. The superior performance of the R-CNN on external datasets suggests greater generalizability. Notably, the SMAPE of 4.29 in this study outperformed Auto-CA, which had a SMAPE of 5.27, and the MAE of 2.22 was superior to the 2.51 reported by VLTENet.

Conclusion
The keypoint R-CNN demonstrates exceptional accuracy in automating coronal TCA measurements and outperforms existing methods. Its further development, scaling, and adoption could streamline scoliosis screening, surgical planning, and postoperative assessment, improving overall patient outcomes and reducing manual workload.

31. A Novel AI Classifier for Enhanced Spine Radiograph Interpretation

Kellen Mulford, PhD; Julia Todderud, BA; Christina Regan, BS; A. Noelle Larson, MD; *Ahmad Nassr, MD*

Hypothesis
This study aimed to develop AI models that can accurately classify spine radiographs for view, presence or absence of implants, and implant type.

Design
Novel AI image Classifier Development

Introduction
Artificial intelligence applications in healthcare, particularly in clinical research and registry devel-

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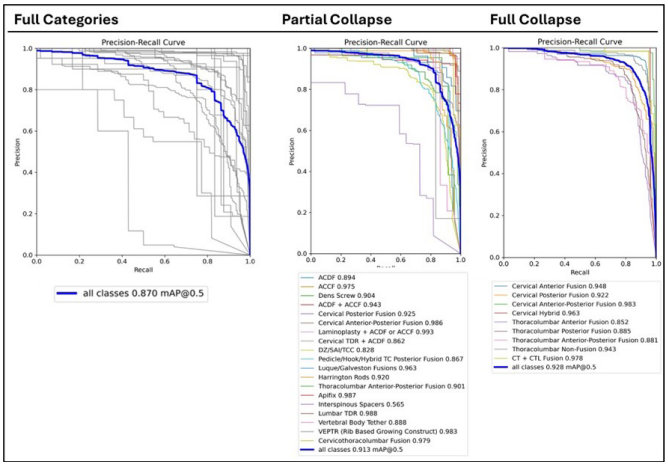
opment, offer incredible advances for efficient and accurate management of patient data. We sought to develop an automated spine radiographic registry using deep-learning pipelines.

Methods
This study utilized our clinical spine registry to develop a series of machine learning models for spine radiograph classification. Patient imaging included unpaired AP/PA and Lateral spine radiographs. A total of 18,386 spine images from 4728 patients were used for model development, with models designed to classify spine imaging by patient positioning, pre- vs. post-operative status, radiograph view, and spine implants. The models were trained using convolutional neural networks via image classification, conformal prediction, and object detection and validated using standard performance metrics (F1 Score, coverage, MAP-50, respectively).

Results
The models demonstrated excellent performance across various classification tasks. For the whole spine vs. whole body classifier, the overall accuracy was 0.99 (N=344 images), with F1 scores of 0.99 for whole spine identification and 0.97 for whole body identification. The bending vs. standing model achieved a perfect F1 score of 1.00 (N=442 images). The pre- vs. post-operative status classifier exhibited an overall performance of 0.98 (N=1010 images), with the highest F1 score of 0.99 for the uninstrumented no-brace category. The view classifier achieved an overall performance of 0.968 (N=1520 images), with conformal prediction improving coverage to 0.980 across the 11 categories. The treatment classifier, identifying spine implants across 23 categories, attained an overall performance ranging from 0.870 to 0.928 with category grouping and full stratification (N=6753 images). The highest performing individual label was Laminoplasty + ACDF or ACCF (MAP-50=0.995) and the lowest performing was Thoracolumbar Posterior Fusion – Hook Constructs (N=14 in test set MAP-50=0.377).

Conclusion
This study presents a novel multilevel AI model for spine radiograph classification, able to accurately curate and annotate a large range of complex radiograph input for use in clinical and research applications.



32. Multimodal Machine Learning Model for Predicting Perioperative Outcomes in Spinal Surgery

Kyle Mani, BS; Thomas Scharfenberger, BS; Samuel Goldman, BS; Emily Kleinbart, BS; Evan Mostafa, MD; Rafael De la Garza Ramos, MD; Mitchell Fourman, MD, MPhil; Ananth S. Eleswarapu, MD

Hypothesis
Incorporating structured electronic health record (EHR) data with unstructured free-text inputs using natural language processing (NLP) will enhance machine learning (ML) predictions of peri-operative outcomes in spinal surgery compared to models using only structured data.

Design
Retrospective cohort study.

Introduction
ML algorithms can analyze large amounts of structured EHR data to predict peri-operative outcomes, but integrating unstructured free-text data via NLP may improve accuracy. This study aims to develop a multi-modal ML model that combines structured data (e.g., patient demographics, comorbidities) with unstructured free-text inputs (e.g., medical history, medications) to predict extended length of stay (LOS), 90-day reoperations, and ICU admissions.

Methods
The study included 1,898 patients who underwent spine surgery from 2018–2023 at four urban academic spine centers. Two extreme gradient boosted (XGBoost) ML models were developed: one using only structured EHR data, and a multi-modal model integrating structured data with free-text inputs processed via the quanteda package in R. NLP-generated numerical vectors were combined with tabular data, and models were trained using 10-fold cross-validation with an 80:20 train-test split. Model performance was assessed using AUC-ROC,

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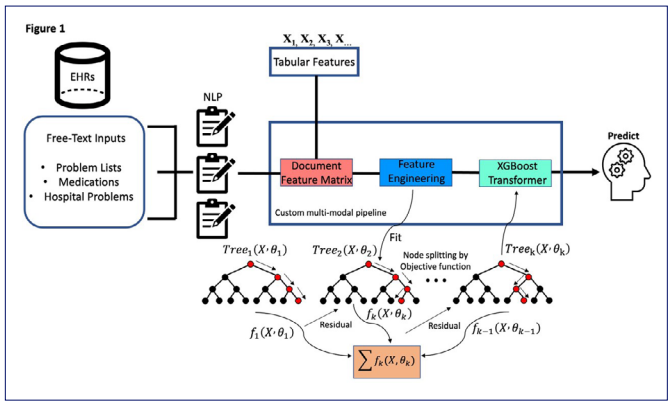
Brier scores, calibration slope, precision, recall, and F1-scores, with explainable AI (XAI) used for feature importance analysis.

Results
Of the 1,898 patients (60.7% female, median age 60, median BMI 30.3), 10.1% had an extended LOS (≥14.4 days). The cohort's median LOS was 4 days, with a 90-day reoperation rate of 10.54%, and ICU admissions of 7.74%. The tabular EHR model had AUC-ROC values of 0.770–0.779, Brier scores of 0.074–0.099, and calibration slopes of 2.279–2.418. Precision and recall were 0.918–0.973 and 0.988–0.994, with F1-scores between 0.954–0.973. The multi-modal model outperformed, with AUC-ROC values of 0.827–0.903, Brier scores of 0.056–0.083, and calibration slopes of 0.755–1.217. Precision ranged from 0.909–0.933, recall from 0.979–0.994, and F1-scores from 0.943–0.962. Key predictors included age, BMI, hemoglobin, and osteomyelitis.

Conclusion
The multi-modal NLP model outperformed the tabular model for all outcomes. Future efforts will integrate additional dimensions like history of present illness, physical exam, and imaging data, with plans for clinical implementation in pre-operative pathways.



Schematic

33. A Novel Multi-Modal Wearable Motion Balance Surveillance Device Enhances Unsupervised Exercise Effects in Adolescent Idiopathic Scoliosis Patients

Chengyin Wang, PhD; *Owen Yuechuan Zhang, MD*; Yiqiao Zhang, MD; Jianguo Zhang, MD; Qianyu Zhuang, MD

Hypothesis
Our novel multi-modal wearable motion balance surveillance device provides dynamic, quantitative and visualized motion monitoring and enhances the exercise effects of adolescent idiopathic scoliosis (AIS) patients.

Design
Medical engineering development and prospective clinical validation

Introduction
Current supervision of therapists and static radiography on core exercise is ineffective in revealing dynamic, quantitative, visualized muscle engagement, posture deviation and imbalance. Therefore, AIS patients need an intelligent wearable motion monitor to ensure satisfied rehabilitation, especially when supervision is inaccessible.

Methods
Surface electromyography (sEMG) signal and spatial positioning information (SPI) were integrated for monitoring. The Rehabilitation Confidence Coefficient (RCC) was set for quantitative assessment. The sEMG and SPI of experienced physical therapists were recorded as standard. 15 AIS patients and 15 healthy individuals were recruited. They firstly finished two core exercises for upper and lower back without supervision, then were asked to learn standard records and refine their exercises.

Results
The two groups had no significant difference in sex. When unsupervised, sEMG peak for the upper back appeared near T7 (standard), T5 (normal) and T4 (AIS) levels. Lower back sEMG peak appeared near L5-S1, L3, and L4 levels, respectively. sEMG amplitude averages were 48.1% and 62.3% for AIS and normal group ($p<0.05$). SPI results showed that posture deviation rate averages were 23.1% and 33.7% ($p=0.037$), respectively. sEMG asymmetry of the convex and concave sides was only found in the AIS group. For the refined exercise, we noticed a significant rise in sEMG amplitude by average 17.5% in the AIS group and 19.2% in the normal group ($p<0.05$). The sEMG asymmetry of the AIS group was lower by 8.7% ($p=0.023$). In addition, SPI result found that the refinement benefited exercise range and stability in both groups. Quantitative analysis showed the normal group had higher RCC values (82.73% vs 63.25%, $p<0.05$), signifying increased completion and adherence to standardized movements.

Conclusion
Our novel multi-modal wearable motion balance surveillance device is effective for dynamic, quantitative and visualized muscle engagement monitoring, posture correction and imbalance detection, which enhances unsupervised core exercise effect of AIS patients.

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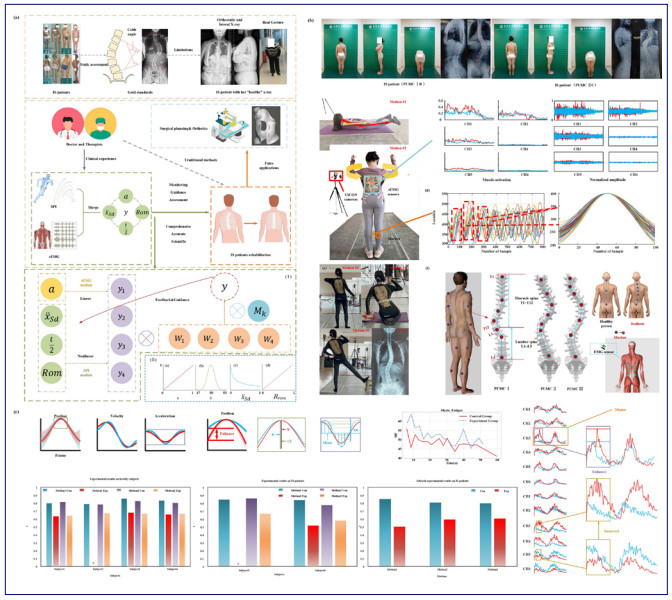

34. Optimization and Validation of an Extreme Gradient Boosting Model to Predict Reoperation Following Surgical Site Infection: Analysis of 96,216 Patients with ACS NSQIP Database

Mert M. Dagli, MD; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip, BA; Kevin Bryan, BA; Connor Wathen, MD; Yohannes Ghenbot, MD; John Arena, MD; Joshua L. Golubovsky, MD; John Shin, MD; Ali Ozturk, MD; William C. Welch, MD; Jang Yoon, MD

Hypothesis
An extreme gradient boosting (XGBoost) model can accurately predict reoperation risk following surgical site infections (SSIs) in lumbar spine surgery, using preoperative and intraoperative variables to achieve high accuracy and sensitivity.

Design
Retrospective Study Design

Introduction
The volume of lumbar spinal surgeries performed in the United States has been rising steadily, and surgical site infections (SSIs) represent a significant postoperative complication. SSIs contribute to patient morbidity and impose a considerable financial burden on healthcare systems due to extended hospital stays, emergency department visits, readmissions, and increased outpatient follow-ups. This study aimed to develop, and internally and externally validate, an artificial intelligence (AI) model using XGBoost to predict reoperation following SSIs in lumbar spine surgery.

Methods
The study followed TRIPOD+AI guidelines and used the ACS NSQIP database to identify lumbar spine surgery patients based on procedure codes. SSIs were classified into superficial, deep incisional, and organ/space types. Predictor variables included SSI types, wound infection, preoperative lab values (albumin, hematocrit, WBC, alkaline phosphatase), ASA classification, functional status, diabetes, age, and race. Weighted XGBoost was selected as the optimal method, and a grid search was conducted for tuning. Model performance was evaluated using accuracy, sensitivity, AUC-ROC, precision-recall, F1-score, and PPV, with bootstrapped 95% CIs. An institutional database was used for external validation, and feature importance analysis was performed.

Results
The study cohort included 96,216 patients who underwent lumbar spinal surgery. The weighted XGBoost model demonstrated an exceptional accuracy of 0.9939, a sensitivity of 0.8000, and an AUC-ROC of 0.9974. Feature analysis revealed that the most important predictors of reoperation following SSIs included wound infection types, preoperative albumin levels, and ASA classification.

Conclusion
This study demonstrated the accuracy and reliability of an AI-based extreme gradient boosting model for predicting reoperation due to SSIs following lumbar spine surgery. The implementation of AI models for SSI prediction enables improved risk stratification and optimized resource allocation.

35. Can a Novel AI-Based Predictive 3D Imaging Software for Idiopathic Scoliosis Obviate the Need for Routine Xrays?

Abdullah AlDuwaisan, FRCS(C), MBChB; Hani Alharbi, MD, FRCS; Joel Maliakkal, BS; Carolina Ricardo, BS; Firoz Miyanji, MD, FRCS(C)

Hypothesis
This study aims to validate the predictions produced by the 3D imaging software, namely the presence of scoliosis and curve severity.

Design
Prospective comparative study

Introduction
Idiopathic Scoliosis (IS) is a three-dimensional (3D) spinal deformity that causes changes in the appearance of the patient's torso.Current practice involves full-length scoliosis x-rays to diagnose scoliosis with interval xrays to follow curve progression.Shortfalls of current care models have prompted the development of a 3D imaging software consisting of a circumferential clinical video to quantify topographic malalignments associated with scoliosis.

Methods
Patients diagnosed with IS were recruited prospectively from a single pediatric spine center. All pa-

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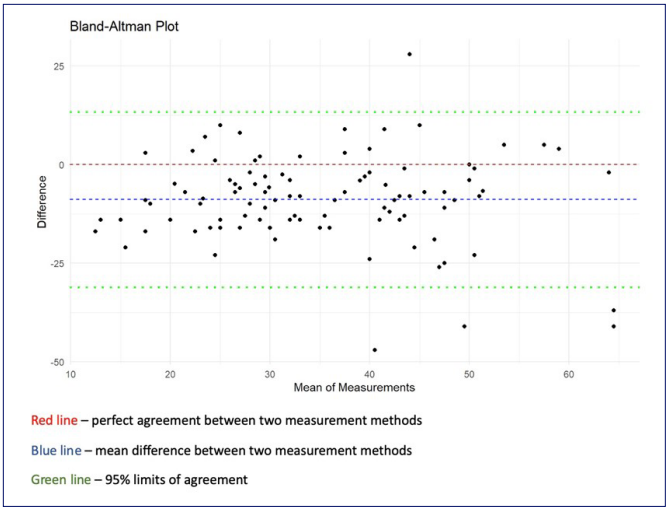
tients had routine scoliosis xrays and in addition two clinical videos were taken using the application(one in standing position, and one in Adam's forward bend). The videos were transformed into 3D models.An algorithm was then used to determine the AI predicted major Cobb angle.Actual major Cobb was measured by a member of the clinical team. Spearman correlation determined correlation between predicted and measured Cobb.Bland-Altman analysis determined agreement between predicted and measured major Cobb.

Results

115 patients (80% females,20% males;mean age 14.6 [SD 2.2]) were recruited.The mean major Cobb for all participants was 39.5° (16-85);72.2% had main thoracic,24.3% had lumbar/thoracolumbar and 3.5% had proximal thoracic curves.18 scans failed to generate predictive models.Mean predicted Cobb was 30.8° (4-63).The imaging software identified the presence of scoliosis in 94.9% of patients,with a positive predictive value of 1. The Spearman correlation coefficient was 0.69, indicating a moderate-strong positive correlation between measured and predicted Cobb. Bland-Altman analysis highlighted a mean difference of -8.86 with a correlation coefficient of 0.519 ($p<0.01$,predicted Cobb was 8.86° lower) indicating moderate agreement.The limits of agreement ranged from -31 and 13.

Conclusion

There is a moderate-strong positive correlation between the AI-predicted and measured Cobb,suggesting 3D imaging software can accurately diagnose scoliosis in majority of cases.There appears to be moderate agreement between predicted and measured Cobb angles.The software may be beneficial for diagnosing scoliosis,obviating the need for screening x-rays.



Predicted vs Measured Cobb

36. Development of a Machine Learning Tool to Improve Intraoperative Neurophysiological Monitoring: Proof of Concept

Varun Arvind, MD, PhD; Omar Taha, BS; Matthew Weintraub, BSE; Anil Mendiratta, MD; *Michael G. Vitale, MD, MPH*

Hypothesis

A Machine Learning Model may be able to autonomously identify anomalies in motor evoked action potentials (MEPs) in patients undergoing spinal deformity correction surgery.

Design

In this pilot study, we retrospectively analyzed IONM data from 16 pediatric patients (< 18 years) with complex spinal deformities, 10 who experienced significant IONM signal changes that resulted in formal alerts from the neurophysiology team, and 6 without neuromonitoring loss.

Introduction

Intraoperative neurophysiological monitoring (IONM) has dramatically improved the safety of spine surgery. The effectiveness of IONM is dependent on the interpretation of data in real-time by highly trained neurologists/neurophysiologists. Machine learning (ML) provides an attractive approach to standardize IONM interpretation and may allow for earlier alerts by identifying subtle patterns of signal change.

Methods

Stable baseline MEPs recorded prior to instrumentation/correction were used to train a ML classifier to learn a patient-specific MEP signature. The model was trained to detect anomalous patterns of patient-specific MEP waveforms. Based on correlation with subsequent formal alerts of IONM changes, we defined a "red flag warning" if the anomaly varied by more than 20%. (Fig. 1). The time at which the first

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detectable adverse change in MEPs was noted by the IONM team was compared to the time at which the red flag warning by the model was raised.

Results
Red flag warnings were identified in all 10 patients with neuromonitoring loss. In the 6 patients without neuromonitoring loss, a red flag warning was issued in 3. Warnings were raised an average of 17.5 minutes (95% CI: -0.75 - 35.75 minutes) before the first detectable change was identified by the IONM team. In 1 case, the warning was identified 12 minutes after the IONM team. In 3 cases, warnings were identified at the same time as the IONM team. In 6 cases, warnings were raised before the IONM team. Overall, there were 10 true positive, 3 true negative, 3 false positive, and 0 false negative cases. Sensitivity of the model was calculated as 1, specificity 0.5, PPV 0.77, and NPV as 1.

Conclusion
The machine learning model identified IONM loss an average of 17.5 minutes earlier than traditional methods. This approach may enhance the early detection of surgical complications. More research on a larger group of patients is necessary to further validate the model.

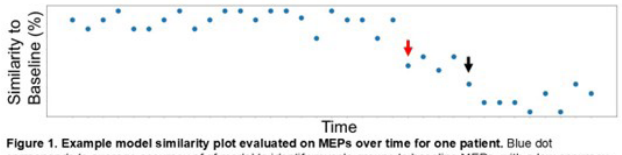

Figure 1. Example model similarity plot evaluated on MEPs over time for one patient. Blue dot corresponds to average accuracy of of model to identify muscle groups to baseline MEPs, with a low accuracy indicating an anomaly. Red arrow marks correspond to red flag warnings, or a a drop greater than 20% in accuracy from the prior MEP. Black arrow is the earliest change noted by the attending neuromonitoring team.

37. Normative Alignment Goals Using Machine Learning Finds the Sweet Spot Between Pseudarthrosis and Proximal Junctional Kyphosis in Adult Spinal Deformity

Sarthak Mohanty, BS; Justin L. Reyes, MS; Josephine R. Coury, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; *Lawrence G. Lenke, MD*

Hypothesis
Machine-learning in asymptomatic volunteers provides improved targets for pelvic incidence minus lumbar lordosis (PI-LL) following adult spinal deformity (ASD) correction

Design
Retrospective with external validation in a single-center cohort

Introduction
Traditional age-adjusted spinopelvic alignment formulas risk under-correction in ASD patients. Leveraging machine learning (ML), this study develops surgical targets by analyzing alignment in asymptomatic volunteers.

Methods
A predictive model was built for PI-LL from 468 asymptomatic adults(80% training, 20% validation) across multiple centers/ethnicities. The eXtreme Gradient Boosting algorithm utilized PI, age, & sex. Fig 1B illustrates alignment targets, stratified by age & PI. To validate targets, we analyzed 458 ASD patients with 2Y follow-up. These patients were classified as under-(UC), adequately-(AC), or over-corrected(OC), based on the model's targets ±5° (Fig 1B). Key outcomes were pseudarthrosis/implant breakage & PJK. Outcomes were analyzed using multivariable regression models, adjusted for significant variables identified in univariate analyses. Data shown as [UC vs AC vs OC,P(ANOVA)].

Results
Mean absolute error between observed & predicted PI-LL were 3.04° & 5.02° for training & validation groups(Fig 1A). In the surgical ASD cohort, 149(32.5%), 159(32.8%), & 150(34.7%) patients were UC, AC, & OC respectively. Differences were observed in instrumented levels(12.31 vs 12.69 vs 13.8,P=0.0028), baseline PI-LL(30.3° vs 22.1° vs 17.8°,P<0.0001), & T1PA(30.9° vs 26.0° vs 23.4°,P<0.0001). Pseudarthrosis rate was 9.82%(45/548), with highest incidence in UC cohort(15.4% vs 8.18% vs 6.0%,P=0.0161). PJK rate was 10.0%(46/458), most prevalent in OC group(19.3% vs 6.04% vs 5.03%,P<0.0001). In an adjusted multivariable model(P<0.0001, AUC=0.76) found that AC(aOR: 0.45,P=0.046), & OC(aOR: 0.41,P=0.044) had lower odds of pseudarthrosis compared to UC patients(Fig 1C). In an adjusted PJK model(AUC=0.687,P<0.0001), AC had lower odds of PJK compared to OC (OR: 0.45,P=0.0034 (Fig 1C). Both models found the current classification supersedes baseline alignment and magnitude correction in association with pseudarthrosis & PJK.

Conclusion
ML PI-LL targets demonstrate a critical balance in deformity correction. Deviation from these benchmarks increases risk of pseudarthrosis when UC and PJK when OC.

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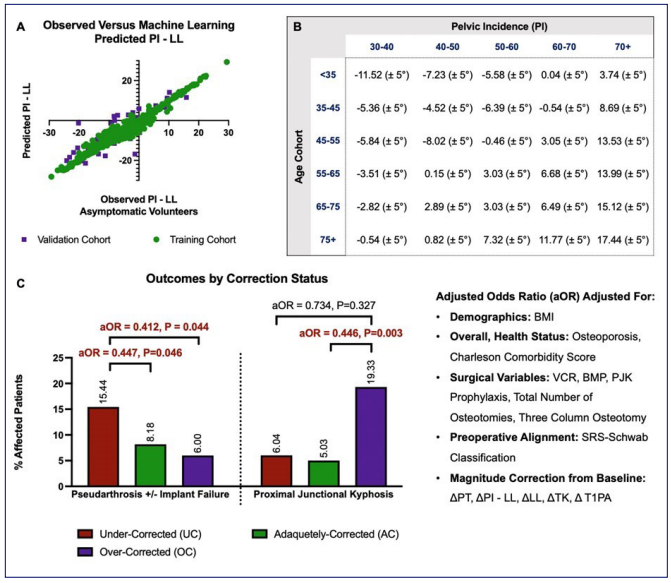

38. Comparative Analysis of Artificial Intelligence and Traditional X-Ray Parameter Measurements in Spinal Surgical Planning

Esteban Quiceno, MD; Mohamed A. Soliman, MD, PhD; Asham Khan; Jacob Greisman, MD; John Pollina, MD; *Jeffrey Mullin, MD*; Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

Hypothesis

Artificial intelligence (AI) can reliably measure spinal alignment parameters in patients with adult spinal deformity, improving efficiency.

Design

Multicenter retrospective study

Introduction

Accurate measurement of spinal parameters is essential for diagnosing and treating spinal disorders. Traditional manual measurement methods are time-consuming and prone to variability. This study aims to assess the accuracy and reliability of artificial intelligence (AI) methods compared to traditional measurements performed by a neurosurgeon trained in spine surgery (Operator 1).

Methods

We conducted a comparative analysis of spinal parameter measurements obtained through an AI model and the same measurements manually taken by a neurosurgeon in 198 patients with adult spinal deformity who underwent full-body X-rays. Parameters examined included thoracic kyphosis, lumbar lordosis, pelvic incidence(PI), sacral slope(SS), pelvic tilt(PT), sagittal vertical axis(SVA), C7 coronal alignment(C7 CSL), thoracic Cobb angle, and lumbar Cobb angle. Data analysis utilized Pearson coefficients, p-values, and interrater reliability.

Results

The results demonstrated a high correlation and significant agreement between measurements obtained through AI and Operator 1. Sacral slope (SS) and pelvic tilt (PT) demonstrated Pearson coefficients of 0.96 and 0.97 (both with p-values<.001) and interrater reliabilities of 0.94 and 0.92, respectively. Sagittal vertical axis (SVA) exhibited a Pearson coefficient of 0.96 (p-value <.001) with an interrater reliability of 0.96. PI-LL and PI had Pearson coefficients of 0.89 and 0.92, respectively (both with p-values<.001) and interrater reliabilities of 0.92 and 0.91. Kyphosis T1-T12 demonstrated a Pearson coefficient of 0.87 (p-value<.001) with an interrater reliability of 0.86. C7 CSL had a lower agreement with a Pearson coefficient of 0.82 (p-value<.001) and an interrater reliability of 0.80. Thoracic and lumbar Cobb angles showed Pearson coefficients of 0.84 (p-value<.001) and interrater reliabilities of 0.85 and 0.81, respectively. The use of AI significantly reduced the time required to obtain spine alignment measurements (p-value<.001)

Conclusion

Artificial intelligence facilitates thoracolumbar spinal parameter measurements, demonstrating accuracy and reliability with good correlation and interrater reliability (≥0.8) in all assessed thoracolumbar parameters.

39. Machine Learning Models Capable of Predicting Spine Surgery Outcomes Using Smartphone Accelerometer Data

Daksh Chauhan, BS; Hasan Ahmad, BS; Ryan Turlip, BA; Harmon Khela, BS; Omkar Anaspure, BS; Kevin Bryan, BA; Robert Subtirelu, BS; Yohannes Ghenbot, MD; Michael Y. Wang, MD; Jang Yoon, MD

Hypothesis

Here, we applied advanced machine learning (ML) techniques alongside patient mobility data to forecast the direction and extent of postoperative functional activity.

Design

Retrospective study design.

Introduction

Degenerative spondylosis and spondylolisthesis can be successfully treated through surgical intervention; however, postoperative complications may emerge for some patients. While patient-reported outcome measures are typically relied upon to track post-intervention recovery, accurately and objectively assessing functional outcomes, mobility, and recovery status is exceedingly important. Recent technological advancements have shed light on to the utility of smartphone mobility data in evaluating functional outcomes after surgery.

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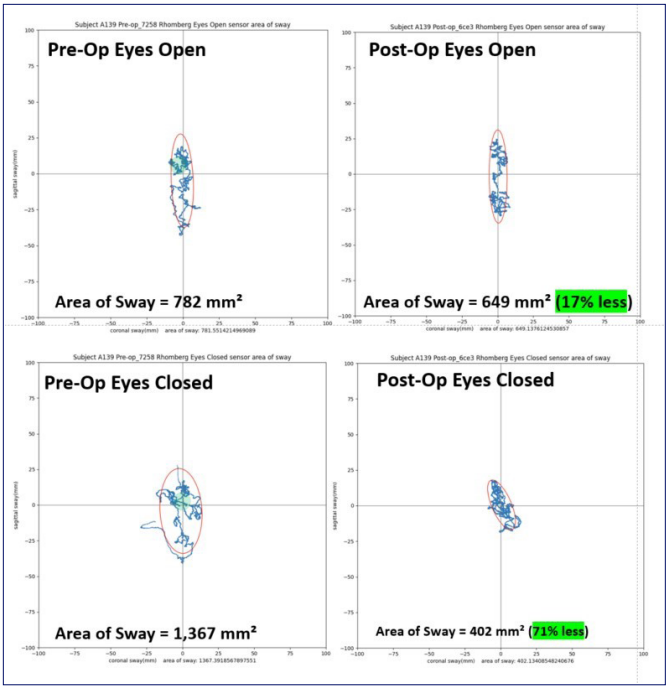
Methods
A retrospective review of 75 patients was conducted in which patient activity data (steps-per-day) was gathered from the Apple Health (Apple Inc., Cupertino, CA) app over a two-year peri-operative period. Inputs into the machine learning algorithm encompassed immediate post-operative patient activity trends, age, and BMI. Three machine learning models (logistic regression, random forest, and extreme gradient boosting) were trained on 80% of the dataset. The effectiveness of these models in predicting the magnitude and duration of greater postoperative mobility was subsequently confirmed using the remaining dataset.

Results
Following the training process, the RF and XGBoost models demonstrated accuracy rates of 86.7% (sensitivity 80%, specificity 90%) and 80% (sensitivity 60%, specificity 90%), respectively, in prognosticating postoperative secondary decline. The LR model achieved an accuracy of 73.3% (sensitivity 50%, specificity 88.8%). Receiving operator characteristic curves indicated areas under the curve of 0.80 for RF, 0.7 for XGBoost, and 0.693 for LR. An analysis of feature importance identified the duration of the immediate post-operative recovery period as a significant predictor of secondary decline in physical activity.

Conclusion
These findings delineate that the RF model exhibiting superior accuracy in predicting the direction and extent of postoperative functional activity compared to the XGBoost and LR models. This highlights the potential of the RF model for clinical outcome charting and predictions. Above all, our study illustrates the efficacy of machine learning models in projecting postoperative outcomes following spine surgery.



40. Impact on Pre- and Post-Fusion Quality of Life of Failed Brace Treatment or Veretebral Body Tethering in Idiopathic Scoliosis

Jeanne Loubeyre, MD; Julie Joncas, RN; Soraya Barchi, BSc; Felix L. Brassard, MD; *Stefan Parent, MD, PhD*

Hypothesis
To evaluate the effect of failure of brace treatment (nighttime / full time) and Vertebral Body Tethering (VBT) on quality of life (QoL) before and after posterior fusion (PSF).

Design
Prospective cohort study in a single pediatric center.

Introduction
In a patient with scoliosis, prolonged use of a brace can affect QoL, especially due to discomfort and psychological impact. VBT is a less invasive treatment than fusion, which can improve mobility, eliminate the need for daily brace use, and often avoid later fusion. However, in the case of failure or curve progression, anxiety and psychological impact may intensify. Surgery can correct the curvature and stabilize the spine, thus improving appearance and posture.

Methods
QoL questionnaires (SRS-22 and SF-12) from 162 patients pre- and post-fusion were analyzed, divided into 4 groups: 22 VBT, 38 full time braces (FB), 26 night time braces (NB), and 76 direct PSF for the control group.

Results
There is no statistically significant difference between the 4 groups in overall pre- or post-operative

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QoL based on the total SRS-22 score (Fig.). Preoperatively, patients with NB had a better self-image compared to other groups ($p<0.05$) but were more impacted in their activities ($p=0.02$). Postoperatively, NB wearers had better mental health than other groups ($p=0.02$). In all 4 groups, there was a significant improvement in self-image between pre- and post-operative assessments. Mental health in NB patients also significantly improved post-operatively. There was a significant improvement in overall post-operative QoL compared to pre-operative scores in the brace groups (FB $p=0.022$; NB $p=0.016$) and the control group ($p<0.05$), but not in the VBT group ($p=0.705$). There was no statistically significant difference between the 4 groups on the SF-12 score, nor within each group between pre- and post-operative assessments.

Conclusion

There is no statistically significant difference in pre- or post-operative QoL between day braces, night braces, or VBT in patients with treatment failure requiring spinal fusion. Surgery improves the QoL in brace-wearing patients but the magnitude of this improvement is not seen in VBT patients undergoing PSF. This potentially relates to the disappointment following failure of the initial procedure.

Fig. SRS-22 total and domains scores before and after surgery

41. Spinal Ultrasound to Quantify In-Brace Correction Before Nighttime Brace Fabrication in Adolescent Idiopathic Scoliosis

Dineke G. van de Fliert, MD; Peter P. Lafranca, MD; Arthur Arets; Indy van Loon; Moyo C. Kruyt, MD, PhD; René M. Castelein, MD, PhD; Tom P. Schlosser, MD, PhD

Hypothesis

In-brace correction of the Providence nighttime brace can be accurately quantified using radiation free, 3D spinal ultrasound before the brace is fabricated.

Design

Prospective cohort study.

Introduction

Initial in-brace curve correction is one of the most important predictors of brace treatment success in adolescent idiopathic scoliosis. After brace fabrication, the in-brace correction is sometimes not perfect and requires further optimization. Ideally, the in-brace correction is optimized prior to fabrication and assessed without using ionizing radiation. This study investigates the application of 3D spinal ultrasound during Providence nighttime brace measurement in prone, corrected position on the measurement board, and tests the relation with the ultimate radiographic curve correction in the brace.

Methods

Twenty-four consecutive adolescent idiopathic scoliosis patients, indicated for a Providence nighttime brace underwent standing full-spine radiographs and 3D spinal ultrasounds. On the measurement board, another 3D spinal ultrasound was obtained in prone, corrected position. Four weeks after brace fitting, supine in-brace radiographs were obtained. Curve angles of the major curves and curve correction were measured on coronal reconstructions of the 3D ultrasound images, as well as on the radiographs. Pearson's correlation coefficient was used to evaluate for linear correlations between the angles and correction of both techniques.

Results

Radiographically, the curve corrected from 30.0°±7.8 (mean±sd) to 8.9°±5.9 in-brace (71%±16). On the spinal ultrasound, the curves corrected from 18.6°±5.8 standing to 5.2°±3.1 on the measurement board in corrected, prone position (72%±15%). The curve angle and relative correction on the measurement board were linearly correlated ($r=0.878$ and $r=0.827$ ($p<0.001$), respectively) to the ultimate in-brace correction.

Conclusion

This study demonstrates that by application of 3D

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spinal ultrasound during brace measurement, live feedback on the expected in-brace curve correction can be obtained. The in-brace correction in the Providence brace can be accurately assessed by the coronal spinal ultrasound angles and this allows for brace optimization before actual brace fabrication, without the need for ionizing radiation.

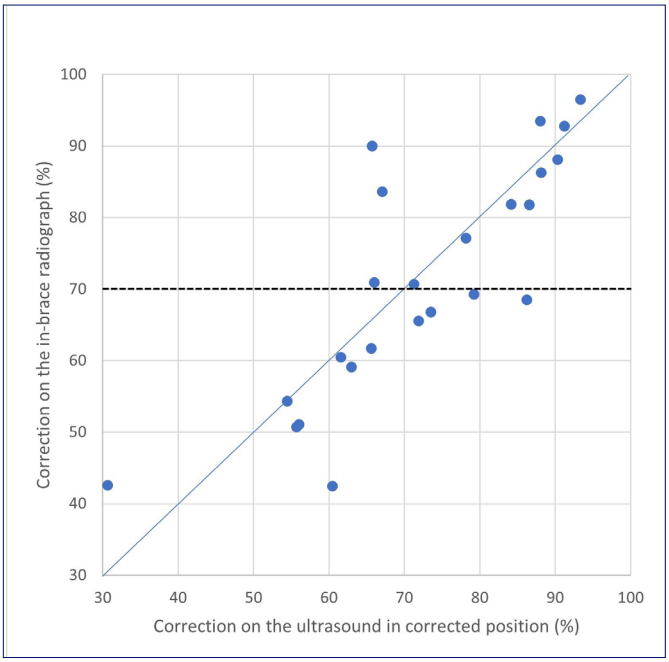

Figure 1: The expected correction percentage of the brace (ultrasound in corrected position) vs. in-brace correction percentage (radiograph).

42. Comparison of In-Brace Curve Correction and Curve Progression Between Night-Time and Full-Time Bracing in Thoracic AIS – A Matched Cohort Study

Martin Heegaard, MD, PhD; Lærke C. Ragborg, MD, PhD; Amy L. McIntosh, MD; Anne-Marie Datcu, BS; Regina Velarde, BS; Martin Gehrchen, MD, PhD; Daniel J. Sucato, MD, MS; Benny T. Dahl, MD, PhD, DMSci; *Megan Johnson, MD*; Soren Ohrt-Nissen, MD, PhD

Hypothesis
We hypothesize that the final curve progression in AIS patients will be lower in NTB due to the higher initial IBC% with this type of brace.

Design
Retrospective Study

Introduction
The rigidity of the thoracic spine has raised concerns regarding the efficacy of night-time bracing (NTB) for thoracic curves in adolescent idiopathic scoliosis (AIS). However, some studies suggest that NTB may yield outcomes comparable to full-time thoracolumbar sacral orthosis (FTB). This study aims to compare the initial in-brace correction percentage (IBC%) and final curve progression between NTB and FTB in AIS patients with thoracic curves.

Methods
In a dual center setting, we retrospectively included skeletally immature AIS patients with thoracic curves measuring 20-45°, treated with either NTB or FTB. Patients with significant compliance issues were excluded (NTB: early brace discontinuation; FTB: <6 hours of daily wear). Propensity-score matching was conducted for gender, Risser stage, age, and curve size at brace initiation. Radiographic parameters were measured at the beginning and end of brace treatment, with in-brace radiographs obtained at brace fitting. A univariate linear regression analysis was used to determine the significance of IBC% on major curve progression.

Results
Among 447 eligible patients, 87 were matched in the NTB group and 134 in the FTB group. Night-time braced patients had significantly higher rates of curve progression (>5° and >50°) compared to FTB patients (60% vs. 33%, p<0.001; 35% vs. 19%, p=0.008). The IBC% was significantly higher in the NTB group compared to the FTB group (59% vs. 37%, p<0.001). In the NTB group, the IBC% did not significantly impact the progression of the major Cobb angle (Coefficient -0.08, 95%CI -0.24;0.08). In contrast, for the FTB group, a 1% increase in IBC% was associated with a 0.22° decrease in major Cobb angle (Coefficient -0.22, 95%CI -0.30;-0.14). Conclusion: The NTB demonstrated higher IBC% but also higher progression rates compared to FTB in AIS patients with thoracic curves. The IBC% did not significantly influence progression in the NTB group. However, in the FTB group, an increase in IBC% was associated with a reduction in major Cobb angle.

Conclusion
The NTB demonstrated higher IBC% but also higher progression rates compared to FTB in AIS patients with thoracic curves. The IBC% did not significantly influence progression in the NTB group. However, in the FTB group, an increase in IBC% was associated with a reduction in major Cobb angle.

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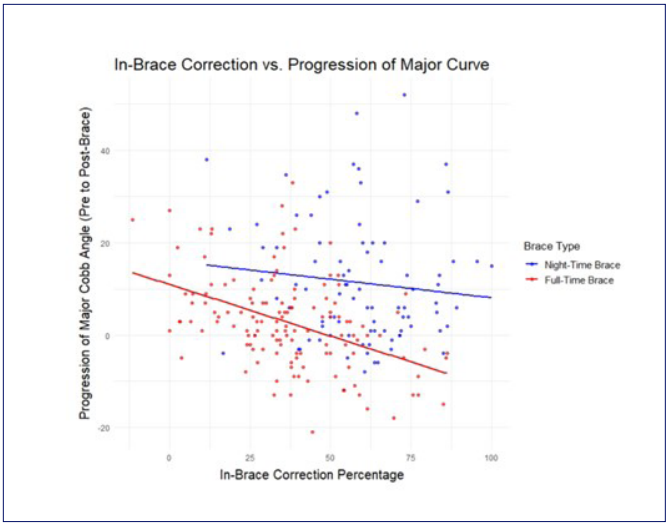


In-Brace Curve Progression Table

43. MRI Generated Synthetic CT in Pediatric Spine Patients

George Michael, BS; Suhas Etigunta, BS; Andy Liu, BS; *David L. Skaggs, MD, MMM*; Meliza Perales, RN, BSN; Cristabelle Alexander, MS; Christopher Watterson, MD; Daniel Hoghougi, MRSO; Norman Gellada, BHS; Kenneth D. Illingworth, MD

Hypothesis
MRI-generated synthetic CT (sCT) is clinically useful in pediatrics, enabling the diagnosis of bony and soft tissue pathologies without radiation exposure and using a single imaging study.

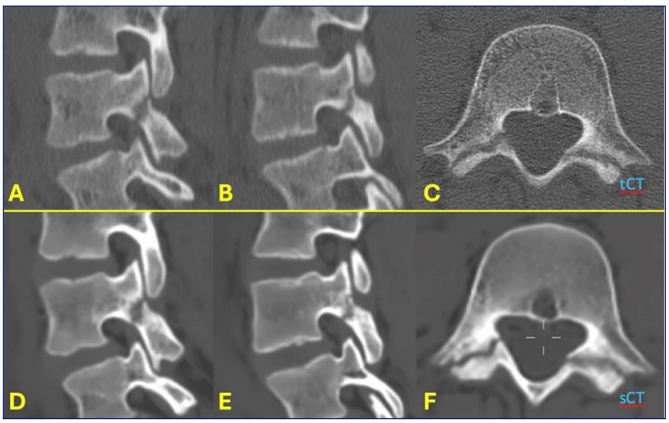
Design
Retrospective cohort.

Introduction
Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are common imaging studies used to evaluate pediatric spine patients. MRI-generated sCT images have demonstrated near equivalence in accuracy when compared to traditional CT (tCT) in cadaveric studies. This recent advancement allows potential visualization of both bony and soft tissue anatomy without harmful ionizing radiation. To date, there are no reports of the use of sCT in the evaluation of pediatric spinal pathologies. This study aimed to evaluate the clinical utility of sCT in managing pediatric and adolescent patients suffering from various spinal conditions.

Methods
Inclusion criteria included any patients receiving a sCT for spinal evaluation from October 2023- September 2024. For any patient having a tCT within 3 months of the sCT, osseous anatomical measurements on coronal, sagittal, and axial sequences were compared.

Results
25 patients underwent sCT of the spine (2 cervical and 23 lumbar). Indications included: rule out congenital cervical anomalies vs. congenital muscular torticollis (2), with both later undergoing bipolar sternocleidomastoid release; spondylolysis (13); spondylolisthesis (2); scoliosis/back pain (4); chronic back pain (4); symptomatic transitional lumbosacral anatomy (4). Seven of the 25 patients had tCT scans within 3 months of the sCT. The findings of the sCT and tCT were identical in 6 of the 7 patients (all spondylosis). In 1 patient, an anterior apophyseal ring anomaly at L5 (slight fragmentation ~1mm) was noted on the tCT but was not as clearly visualized on the sCT. Fifty-four measurements comparing vertebral anatomy on sCT and tCT were performed, of which 87% (n=47) were within 1 mm.

Conclusion
MRI-generated synthetic CT (sCT) is a radiation-free imaging option for evaluating the pediatric spine, offering 3D visualization of bony anatomy that is largely within 1 mm of tCT measurements.



A-C) Traditional CT shows bilateral L4 spondylolysis with fracture gapping. D-F) MRI generated sCT images demonstrates fracture gapping of the L4 spondylolysis with near identical osseous detail as tCT.

44. Understanding Technical Difficulties and Recognized Errors in Pediatric Robotic Spine Surgery

Margaret L. Sullivan, BS; *Grant D. Hogue, MD*; Craig M. Birch, MD; M. T. Hresko, MD; Mark A. Erickson, MD; Roger F. Widmann, MD; Jessica H. Heyer, MD; Kirsten Ross, MD; Robert F. Murphy, MD; Dennis P. Devito, MD; Shanika De Silva, PhD, MS; Daniel J. Hedequist, MD

Hypothesis
Adoption of robotics coupled with navigation(RCN) is not a frictionless process, but technical challenges can be promptly resolved without significant consequences to patient care.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Design
Level I: prospective multicenter surgical outcomes registry

Introduction
RCN in posterior spinal fusion is increasing in prevalence, and literature supports its value for safe and accurate pedicle screw placement. This study presents a multi-institutional analysis of potential technological difficulties in pediatric robotic spine surgery.

Methods
Data collected from a multicenter prospective registry included patient demographics, disease etiology, and clinical and surgical characteristics. The difficulties were categorized as: loss of registration, loss of calibration, inability to perform trajectory, screw malposition, and system malfunction. Generalized estimated equations (GEE) were used to quantify RCN technical difficulties and identify associations with clinical factors and procedural metrics.

Results
553 patients were included in the study(66% female, 61% idiopathic diagnosis, median BMI 21). Median preoperative Cobb angle (scoliosis only) was 60°, with a median of 10 levels fused and 10 robotic screws placed per patient. Intraoperative technical difficulties were encountered in 147 patients (27%). The most frequent were inability to perform trajectory (9%), loss of registration (8%), and loss of system calibration (6%) (Table 1). Of 6739 RCN-placed screws, 31 (0.4%) were malpositioned: all recognized and redirected intraoperatively. Two instances (0.4%) of dural leaks were recorded. Patients with technical difficulties had larger preoperative Cobb angles (median 64° vs. 59°;p=0.009) and underwent fusion of more vertebral levels (median 11 vs. 10;p=0.003). Increased BMI was associated with higher odds of technical difficulties; specifically 173%, 88%, and 44% higher odds of inability to perform trajectory, screw malposition, and loss of calibration, respectively (all p<0.05). Technical difficulties did not significantly affect EBL (p=0.4) or operative time (p=0.06). No returns to the operating room or neurologic deficits resulted from technical difficulties.

Conclusion
Technical difficulties identified here were recognized and resolved intraoperatively, preventing adverse consequences patients. More levels fused, higher BMI, larger Cobb angles, and syndromic diagnoses increased the likelihood of technical difficulties.

Table 1: Raw proportions and GEE-estimated proportions with 95% confidence intervals of each RCN technical difficulty

	Raw Frequency (%)	Estimated Proportion (95% CI)
Robotics and navigation technical difficulty	148 (27%)	26% (15, 41)
Type of robotic technical difficulty		
Loss of calibration	34 (6%)	7% (4, 14)
Loss of registration	42 (8%)	9% (6, 13)
Inability to perform trajectory	50 (9%)	9% (7, 12)
Screw malposition	27 (5%)	6% (3, 13)
Neurodeficit/Dural leak/Visceral injury	2 (0.4%)	0.4% (0.3, 0.4)
System malfunctions	27 (5%)	5% (2, 10)
Other	3 (1%)	0.4% (0.2, 0.8)

[1]Estimated from a GEE model that includes a compound-symmetry correlation structure to account for within-site correlation.

45. Initial Results of Posterior Dynamic Distraction Device in Surgical Treatment for Adolescent Idiopathic Scoliosis

Angela Lu, DNP, FNP-C, RNFA; Madelyn Hill, MPH; *Michael C. Albert, MD*

Hypothesis
We hypothesize that PDDD will demonstrate to be a minimally invasive, fusionless surgical option for treating qualifying AIS patient while preserving flexibility.

Design
Prospective study, non-randomized cohort study

Introduction
The use of posterior dynamic distraction devices (PDDD) is a minimally invasive approach for surgical management of adolescent idiopathic scoliosis (AIS). The PDDD is an internal brace that expands with a ratchet mechanism. The purpose of this study is to report the long-term outcomes of AIS patients treated with PDDD.

Methods
A prospective study on the outcomes of a PDDD was performed. Inclusion criteria included skeletally immature patients that were Lenke 1 or 5 with a Cobb angle between 40-60˚ that reduced to ≤30˚ with side bending and thoracic kyphosis <55˚. Patient demographics, operative details, narcotic use, Cobb angle magnitudes, and complications were reported.

Results
A total of 54 patients were included, with 30 (55.6%) patients having a 2-year follow-up, and 18 (33.3%) with 3-year follow-up. This sample included 43 (79.6%) females and 11 (20.4%) males. There were 35 (64.8%) patients with a Lenke 1 curve and 19 (35.2%) patients with Lenke 5. Average duration of the PDDD procedure was 107.3± 20.4 minutes with an average blood loss of 29.2 ±17.2mL. Narcotics were provided for an average of 3.2±1.6 days. Patients had an average length of stay of 1.0±0.3 days. Preoperatively the major Cobb curve magnitude averaged 45.1˚±5.5˚, 16.5˚±6.9 at immediate postoperatively, 14.9˚±9.6˚

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at 1-year follow-up, 17.9˚±9.5˚ at 2-year, and 21.2˚±9.5˚ at 3-year. Complications included 3 (5.6%) revisions due to device or screw breakage/loosening, 3 (5.6%) converted to fusions due to increased curve magnitudes, and 4 (7.4%) removals that did not show significant rebound of curves. Patients that converted to a fusion had a motor vehicle accident, significant weight gain, and junctional kyphosis.

Conclusion
This study suggests the use of PDDD in treatment of AIS is beneficial in avoiding a spinal fusion, allowing for a minimally invasive surgery, decreased surgical time, minimal blood loss, and decreased length of stay. Cobb angles significantly improved postoperatively and were stable or improved by the 2-and 3-year follow-up. Patients that had the PDDD removed maintained postoperative curve magnitudes. Further studies are required to understand the long-term outcomes of PDDD.

46. Posterior Dynamic Distraction for AIS: Minimum 2-Year Follow Up Results of 80 Consecutive Patients

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Hypothesis
Posterior Dynamic Distraction (PDD) is a viable non-fusion treatment option for AIS with low operative morbidity and low rate of conversion to fusion.

Design
Prospective

Introduction
Non-fusion techniques for the treatment of adolescent idiopathic scoliosis (AIS) have gained popularity. This report describes the minimum 2-year outcomes on 80 consecutive patients treated with Posterior Dynamic Distraction (PDD).

Methods
Demographics, surgical details, reoperations, and radiographic measurements were prospectively collected. Success was defined as a curve ≤30º and no conversion to spinal fusion.

Results
80 patients with a mean follow-up of 37±5 months were evaluated. Mean age at surgery was 15±2 years; 58 (73%) patients were female. 54 (68%) patients had Lenke 1 curves and 26 (33%) patients had Lenke 5 curves. Mean procedure time, blood loss, and hospital length of stay were 111±37 minutes, 42±38 ml, and 1.0±1 day respectively. Lenke 1 patients had correction from 45±7° to 21±11° (54±23%). Lenke 5 patients corrected from 46±8° preoperatively to 19±10° (60±20%). For Lenke 1 patients, mean thoracic kyphosis (TK) changed from 23±11° to 34±11° (p<0.005). Mean lumbar lordosis (LL) changed from 58±11° to 63±18° (p=0.019); however, mean sagittal vertical axis (SVA) did not change significantly (8±37 mm to -13±33 mm; p=0.163). In Lenke 5 patients, mean TK changed from 25±12° to 34±11° (<0.005). Mean LL changed from 61±12° to 56±13° (p=0.008); however, mean SVA did not change significantly (-24±40 mm to -15±28 mm; p=0.234). 25 patients (32%) had or are scheduled for reoperation. Reasons for reoperation included implant or screw breakage (n=11), ratchet malfunction (n=1), screw migration/pull-out (n=3), curve progression (n=4), infection (n=2), junctional kyphosis (n=1) and pain (n=3). Of the 80 participants, two patients converted to posterior spinal fusion (2.5%). 66 (83%) patients, 42 (78%) Lenke 1 patients, and 24 (92%) Lenke 5 patients had successful outcomes with a major curve correction to ≤30° and no conversion to spinal fusion at last follow up.

Conclusion
Scoliosis correction with PDD was successful at 2-year follow-up for 83% of patients, with a 32% reoperation rate, but only a 2.5% rate of spine fusion. This study suggests that PDD is a viable non-fusion option with low operative morbidity for patients with AIS that meet appropriate selection criteria.

Patient Demographics (N=80)	Mean±SD or N(%)
Age	15±2 years
Gender: Female Male	 59 (73%) 21 (27%)
Pre-Op Lenke Type Type 1 Type 5	 54 (68%) 26 (33%)
Operative Findings	
Procedure Time	111±37 min
Blood Loss	42±38 mL
Hospital Length of stay	1 Day

Lenke 1 (n=54)	Preoperative Mean Cobb ±SD	Preoperative Lateral Bend Correction (%)	Last Follow-up Mean Cobb ±SD	Correction at Last Follow-up (%)
Major Curve	45±7°	16±8	21±11°	54±23
Secondary Curve	29±8°	14±9	19±11°	
Lenke 5 (n=26)	Preoperative Mean Cobb ±SD	LB (%Correction)	Last Follow-up Mean Cobb ±SD	
Major Curve	46±8°	12±7	19±10°	60±20
Secondary Curve	28±10°	12±8	18±11°	

Table: PDD Demographics and X-ray Results

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

47. Does an Efficient, Steady, or Dual-Surgeon Approach Produce the Best Outcomes in Pediatric Patients Undergoing Spine Surgery?

Vishal Sarwahi, MD; Effat Rahman, BS; Katherine Eigo, BS; Yungtai Lo, PhD; Jon-Paul P. DiMauro, MD; *Terry D. Amaral, MD*

Hypothesis
An efficient, high-volume, surgeon will have superior outcomes when compared to a steady surgeon or a dual-surgeon approach.

Design
Retrospective study

Introduction
Studies have shown that longer operative times are linked to increased blood loss, higher complication rates, and a greater risk of infection. While a dual-surgeon approach has proven effective in reducing operative times and mitigating these adverse outcomes, there is also a correlation between surgeon volume and results. The purpose of this study was to compare outcomes of an efficient (high-volume) surgeon with a steady surgeon and a dual-surgeon approach.

Methods
Retrospective chart review of 653 patients with adolescent idiopathic scoliosis (AIS) who underwent a posterior spinal fusion in the years 2017-2023 was done. We defined a high-volume surgeon as a surgeon who completed more than 50 cases a year. Clinical, surgical, and radiographic outcomes were collected. Kruskal-Wallis test was used for continuous variables and chi-squared for categorical variables.

Results
375 patients were operated on by the efficient surgeon, 157 were operated on by the steady surgeon, and 121 were operated on by dual-surgeons. There were no demographic differences among the three groups. Anesthesia and surgical times were significantly shorter for the efficient surgeon ($p<0.001$ and $p<0.001$, respectively). LOS and EBL were significantly lower for the efficient surgeon compared to the other two groups ($p=0.04$, $p<0.001$).

Conclusion
Surgeons often reach a steady state in their outcomes. Compared to a dual-surgeon team or a steady surgeon, an efficient high-volume surgeon achieves superior outcomes regarding operating room parameters and length of stay. When these positive outcomes are multiplied by total number of cases, it amounts to major cost benefits and savings to the institution. It is valuable to assess ways in which institutions and surgeons can continue to overcome their steady state. As seen in previous studies as well as this one, high-volume is one factor that can change surgeon's outcome.

48. Intraspinal Anomalies in Presumed AIS Does Not Increase the Risk of Intraoperative Neuromonitoring Changes During Posterior Spinal Fusion

Bill Woodhams, BS; Michael Benvenuti, MD; John T. Anderson, MD; *Kenneth A. Shaw, DO*; Connor J. Mathes, MD

Hypothesis
Do patients with presumed AIS with an intraspinal anomaly have an increased risk for IONM changes during PSF

Design
Retrospective review at a single, tertiary-care pediatric hospital

Introduction
The presence of an intraspinal anomaly (IA) has been previously thought to increases the risk of intraoperative neuromonitoring (IONM) changes during posterior spinal fusion (PSF), but few studies have assessed this dogmatic teaching.

Methods
We review the results of all children with presumed AIS undergoing PSF with a preoperative total spine MRI. The presence of an IA was confirmed by MRI review and the need for subsequent neurosurgical evaluation and/or intervention were recorded and compared against the AIS cohort. Demographic, surgical, and radiographic criteria were collected. The IONM data, including baseline signals and any changes from baseline in sensory or motor signals were compared between the IA and AIS cohorts.

Results
Of the 427 patients meeting inclusion criteria, 33 (7.7%) were found to have an IA: 23 syringomyelia, 14 Chiari I malformation, 4 tethered cord, and 8 cerebellar tonsillar ectopia with 8 total patients undergoing preoperative neurosurgical intervention. The AIS cohort had a significantly higher rate of IONM changes during PSF (AIS:13.7% vs IA:0%; $p=0.023$). IONM changes included 26 sensory potential changes (6.6% of cohort), and 33 motor potential changes (8.4% of cohort), with 5 patients exhibiting both. Risk factors for IONM change included preoperative curve magnitude (68.7°±15.5 vs 60.9°±11.7, P=<.001) and undergoing concomitant posterior column osteotomies (12/40 patients (30%) vs 42/387 patients (10.9%); p=<.001).

Conclusion
The presence of an IA in patients undergoing PSF for scoliosis does not increase the risk of IONM

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

changes. Contrary to traditional thinking, this study demonstrated a significantly greater risk of IONM changes from baseline in patients without intraspinal anomalies. While their presence is not suggested as a protective factor, this evidence supports the safety of corrective surgery in a population found to have these anatomical abnormalities. Further, careful consideration should be given to patients requiring osteotomies during PSF as the risk of IONM changes is significantly increased. Future research evaluating IONM changes of different Lenke spinal cord classifications could also aid in preoperative risk assessment.

49. False Negative Intraoperative Neuromonitoring Alerts during Pediatric Spinal Deformity Surgery: The Dreaded Outcome

Chris Bozorgmehr, BS; Hilton C. Braithwaite IV, BS; *Scott J. Luhmann, MD*

Hypothesis
Multimodal intraoperative neuromonitoring (IONM) with sematosensory evoked potential/transcranial motor evoked potential (SSEP/TcMEP) reduces false negative alerts and postoperative neurological deficits compared to SSEP/DNEP (descending neurogenic evoked potential) in pediatric spinal deformity surgery.

Design
Retrospective Case Series

Introduction
IONM effectively reduces spinal cord dysfunction in pediatric spinal deformity surgery by enabling corrective actions during alerts. A postoperative neurological deficit without an intraoperative alert is a serious complication. This study aims to describe false negative IONMs and the immediate and final outcomes.

Methods
An institutional neuromonitoring database was reviewed (11/1992-4/2024) to identify consecutive patients (0–18 yrs) who underwent pediatric spine deformity surgery. Inclusion criteria were false negative cases defined as having a decline in neurologic function at conclusion of surgery without IONM alerts.

Results
Of 5317 consecutive cases, 16 patients (0.32%) experienced post-surgical neurologic decline without IONM alerts. Mean age 14 years (11-16). Surgeries included 14 posterior spinal fusions and 2 anterior/posterior fusions. Neuromonitoring modalities included SSEPs (n=5), SSEPs and DNEPs (n=10), and SSEPs and TcMEPs (n=1). Preoperatively, five cases had abnormal neurologic status. All 16 experienced postoperative decline: 8 with weakness, 5 with weakness and sensory deficits, 2 with monoplegia, 1 with paraplegia. At final evaluation, 3 fully recovered, 5 partially recovered, 5 had no recovery and 3 were unknown. In spinal cord and nerve root level surgeries with known outcomes, complete recovery occurred 29% and 17%, respectively. At the spinal cord level, 90% used SSEP/DNEP and 10% used SSEP/TcMEPs. At the nerve root level, 17% had full recovery, lower than both the spinal cord group and published literature. Reoperations included: 3 for further decompression, 2 for instrument removal, 2 for revision.

Conclusion
This is the largest series of false negative IONM cases in pediatric spinal deformity surgery, with 16 cases (0.32%) from 5317 surgeries. Only 3 patients (19%) fully recovered, an incidence of 0.06%. With just one false negative using SSEP/TcMEP, these modalities are preferred over SSEP/DNEP to reduce false negatives during spinal surgery.

Table 1: Descriptions and Outcomes of False Negative IONM Events

Procedure	Diagnosis	IONM Modalities	Postoperative Neurologic Result	Final Neurologic Outcome
Deformity PSF/ASF	Syndrome	SSEP and DNEP	Monoplegia LUE; no change elsewhere	Partial Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	No dorsiflexion or plantarflexion R;LE; weakness R hand; paresthesia right hand and foot	Unknown
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	Paraplegia	No Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP and DNEP	Weakness/Paresthesia LUE; no changes elsewhere	Resolved
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	1/5 LLE Dorsiflexion; no changes elsewhere	Partial Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	R Quad Weakness; RLE Paresthesia	Unknown
Deformity PSF	Idiopathic	SSEP and DNEP	Weakness/Paresthesia RLE	Unknown
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	L Quad 0/5	No Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	0/5 motor and sensory R L5 distribution	No Recovery
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	Monoplegia RLE	Partial Recovery
Deformity ASF/PSF	Spondylolisthesis/Spondyloptosis	SSEP only	0/5 L Dorsiflexion	No Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	L Dorsiflexion weakness	Resolved
Deformity PSF	Idiopathic	SSEP and TcMEP	L Foot Drop	Partial Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	R Foot Drop	Partial Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	weak bilateral dorsiflexion, left>right	No Recovery
Deformity PSF	Not Given/Unknown	SSEP and DNEP	L L3 weakness	Resolved

Descriptions and Outcomes of False Negative IONM Events

50. Unilateral Intraoperative Neuromonitoring (IONM) Alerts in Cord Level Surgeries for Severe Spinal Deformities – Etiology and Recovery Patterns - Results from International SDIM Study

Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Colby Oitment, MD, FRCS(C); Stephen J. Lewis, MD, FRCS(C); Lawrence G. Lenke, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; Justin S. Smith, MD, PhD; Nasir Quraishi, MB, ChB, BSc, MRCS, LLM, FRCS, PhD; Yong Qiu, PhD

Hypothesis
Osteotomy is the commonest cause of unilateral IONM alerts in severe spinal deformity surgery.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Design
Prospective international multicentric cohort study

Introduction
Data regarding IONM alerts, the resolution measures & new neurological deficits that occurred in surgery for severe spinal deformities are sparsely available

Methods
20 centers documented the demographics, radiographic findings, and surgical events of patients undergoing deformity surgery with EMG, SSEP, & MEP monitoring, on standardized data collection forms including all IONM alerts, & corrective measures taken. Neurological examination was performed at baseline, immediate post-op, and before discharge

Results
57 (out of 349) patients {average age 21.4 (+/-15.6) years,70.3% females} had IONM alerts. Out of the 37 patients who had unilateral alerts, 75.7% were scoliosis {coronal Cobb 77.6 (+/-24.8) & coronal DAR 11.5 (+/-3.6)} with thoracic apex - T9 (24.3%), T8 (21.6%). 34 patients (91.9%) had an osteotomy, 9 were 3 column. 44 out of 81 alerts were unilateral, 38 with MEP only, and 6 were associated with SSEP. Mean BP during alert was 77.5 (+/-9.4) mm Hg and mean time from skin incision was 213.8 minutes. Osteotomy was the most common surgical event producing the alert (57.9%) followed by screw/rod placement (21.4%). Responses included elevating BP (36.4%), blood transfusion (20.5%), implant removal (18.2%), and steroids (18.2%). A traumatic surgical event was identified in 27 (61.4%) unilateral alerts. Complete unilateral MEP signal loss occurred in 22.7%, >75% loss in 68.2% and >50% loss in 9.1%. By skin closure, MEP signal recovered to near baseline in 68.2% with 81.8% of alerts recovering to at least 50% of baseline. Of the 37 patients that had unilateral MEP losses, de novo neurological deficits were seen immediately in 10 (27%) and 4 (10.8%) at discharge

Conclusion
Unilateral MEP alerts +/- SSEP changes occur most frequently with osteotomies. 27% had immediate postop deficits, reducing to 10.8% at discharge. Appropriate surgical manoeuvres, relieving compressive pathologies, lead to partial or complete reversal of the signal loss. 70% of complete losses resolved to near baseline within 60 minutes, 82.1% of the incomplete losses recovered to at least 50% by skin closure. Recognizing and responding to unilateral MEP alerts was associated with a good outcome.

51. Cured Patients With Early Onset Idiopathic Scoliosis (EOIS) After Serial Casting Are at Risk of Recurrence at Intermediate Follow-up

Rayyan Abid, BA; Abigail E. Manning, BS; Craig M. Birch, MD; *Peter F. Sturm, MD*; Ying Li, MD; Michal Szczodry, MD; Michael P. Glotzbecker, MD; Pediatric Spine Study Group

Hypothesis
Serial casting may serve as an alternative to surgery for patients with EOIS.

Design
A retrospective query of the Pediatric Spine Registry.

Introduction
Serial casting is an effective non-operative technique for EOIS patients. Serial casting limits curve progression while preserving spinal growth, delaying or even eliminating the need for surgery. Some patients with EOIS can be "cured" with curve reduction under 15°. Patients cured with casting are typically braced for approximately 1 year. However, no long-term studies have defined whether "cured" patients maintain a small curve over time or if they are at risk of needing further treatment due to curve progression. We examined if casting patients remained "cured" over time following their treatment.

Methods
We identified 43 patients with EOIS who were treated with serial casting, achieved a curve under 15° and for whom we had a minimum of 2 years of follow-up after completing casting. Failure was defined as an increase >6°, resulting in a Cobb angle >15° at any point during follow-up, requiring cast/brace treatment after cessation of initial cast/brace, or undergoing surgery. Average Cobb angle at the time of cure was 11.1°. A Kaplan Meier survival analysis was used to identify failure rates over time.

Results
Of 43 patients, 13 (30.2%) met our criteria for failure. Mean follow-up time was 4.45 years. 4 patients (9.3%) completed bracing and were later re-braced while 3 patients (7.0%) required surgery. The mean curve magnitude of the patients who failed was 26.3°, with an average increase of 14.9°. At 5.08 years, the probability of successful treatment is 60.5%. Of those who "failed", the median time to failure was 2.45 years. 16 patients (37.2%) were braced for >2 years following casting. Patients with successful treatment were braced for a median of 1.42 years while patients with "failed" treatment had a median brace time of 1 year.

Conclusion
While EOIS patients may be "cured" with serial casting, this may not be sustained. At intermediate follow-up, 30% of "cured" patients had curve progression and 16% required a second treatment. Many patients continue bracing after casting for an extended period of time even after achieving a small curve.

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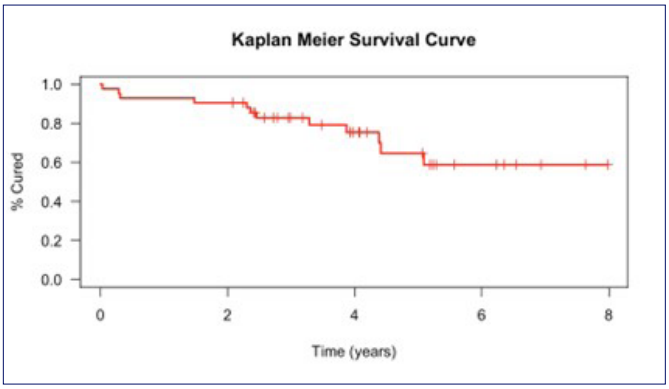
The percentage of "failures" likely will increase with longer follow-up through skeletal maturity, and patients need to be closely monitored after completion of casting/bracing.



52. Outcomes of Traditional Dual Growing Rods (TDGR) with Apical Control Techniques for the Treatment of Early-Onset Scoliosis: Comparison to Patients Treated with TDGR-Only with a Minimum 2-Year Follow-Up After Graduation

Chenkai Li, MD

Hypothesis
TDGR combines with apical control techniques (ACT) could improve curve correction and decrease the incidence of mechanical complications.

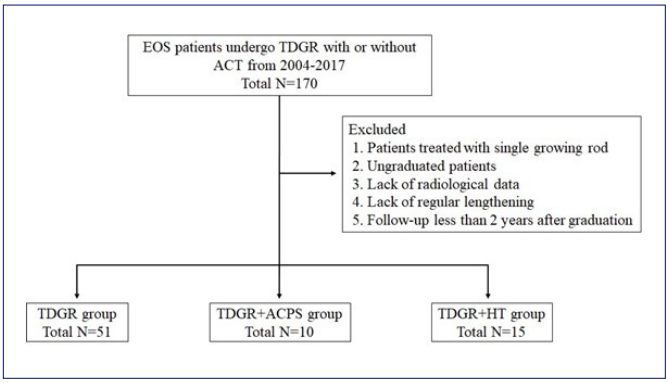
Design
Retrospective study

Introduction
Long-term results for TDGR with ACT are limited. The aim of this study was to retrospectively review and compare the outcomes of patients who graduated from TDGR with or without ACT.

Methods
Patients who were treated by TDGR with or without ACT with a minimum 2-year follow-up after graduation were enrolled. According to the intervention for the apex, patients were further divided into the TDGR group, the TDGR + apical control pedicle screws (ACPS) group (without apical fusion), and the TDGR + hybrid technique (HT) group. Clinical outcomes, radiological parameters, pulmonary function, and complications were compared among the three groups.

Results
A total of 76 patients (51 patients in the TDGR group, 10 patients in the ACPS group, and 15 patients in the HT group) were enrolled. Compared to TDGR, TDGR+ACT achieved better main curve correction, better control of apical vertebral translation and rotation, and lower incidence of complications and revision surgery (P<0.05) while maintaining development of the spine and chest. Although the difference was not significant, patients in the TDGR+ACT group had better pulmonary function at the last follow-up (P>0.05). The percentage of patients receiving final fusion in the TDGR+ACT group was significantly lower than that in the TDGR group (P<0.05).

Conclusion
Compared to TDGR, TDGR+ACT can achieve better curve correction and apical control and comparable clinical outcomes while maintaining the growth of the spine and chest. Patients may derive more benefits from treatment with TDGR+ACT, including a lower incidence of mechanical complications and revision surgery, better pulmonary function, and the avoidance of final fusion.



Patient flow chart

53. Sagittal Spinal Profile in Patients with Lumbosacral Hemivertebrae: Preoperative Status and Postoperative Evolution at more than 7.5 year follow-up

Owen Yuechuan Zhang, MD; Zhuosong Bai, MD; Jianguo Zhang, MD; *Qianyu Zhuang, MD*

Hypothesis
A significant percentage of lumbosacral hemivertebrae (LSHV) patients exhibits preoperative sagittal imbalance. Posterior hemivertebra resection, especially accompanied with anterior column reconstruction (ACR), could effectively improve the sagittal balance.

Design
Retrospective review of prospective database.

Introduction
LSHV present a complex challenge in congenital scoliosis. Previous studies have proved the efficiency of posterior LSHV resection. However, previous studies have primarily focused on coronal balance, neglecting the sagittal alignment which is crucial for spinal function and quality of life score.

Methods
From 2002 to 2022, 58 LSHV patients treated by

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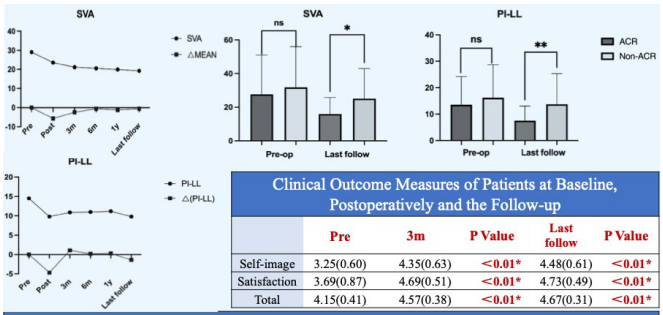
posterior LSHV resection were investigated retrospectively, with a 7.5-year follow-up period (ranging from 2.0 to 19.5 years). Sagittal balance parameters were measured preoperatively and at multiple postoperative time points. Clinical outcomes were assessed using the Scoliosis Research Society questionnaire (SRS-22).

Results
Preoperatively, 60.3% of patients presented with sagittal imbalance (SVA>20mm). Postoperatively, the SVA significantly improved, reaching <20 mm at 1-year follow-up. PI-LL also showed significant improvement at immediate post-op (P=0.012) and last follow-up (P=0.013). ACR was associated with better postoperative global sagittal balance (SVA: P=0.015; PI-LL: P<0.01). The total, self-image, and satisfaction scores of SRS-22 significantly improved postoperatively (all P<0.01).

Conclusion
This study highlights for the first time the prevalence of preoperative sagittal imbalance in LSHV patients, and emphasizes the impact of LSHV resection (particularly when accompanied by ACR), in achieving postoperative sagittal balance and enhancing patients' quality of life during the long-term follow-up.



Clinical Outcome Measures of Patients at Baseline, Postoperatively and the Follow-up

	Pre	3m	P Value	Last follow	P Value
Self-image	3.25(0.60)	4.35(0.63)	<0.01*	4.48(0.61)	<0.01*
Satisfaction	3.69(0.87)	4.69(0.51)	<0.01*	4.73(0.49)	<0.01*
Total	4.15(0.41)	4.57(0.38)	<0.01*	4.67(0.31)	<0.01*

Mean Sagittal Parameters at Baseline, Postoperatively, and at Each Interval Follow-up

	pre	post	P value	3m	P value	6m	P value	1y	P value	last follow	P value
SVA	29.121	23.467	0.168	21.079	0.036*	20.503	0.02*	19.886	0.016*	19.243	<0.01*
PI-LL	14.5	9.8	0.012*	10.9	0.073	11	0.087	11.2	0.113	9.8	0.013*

Sagittal Balance Parameters and SRS-22 Scores of LSHV Patients at Baseline, Postoperatively, and at Each Interval Follow-up

54. One year Safety- and Efficacy correcting Neuromuscular or Syndromic Early Onset Scoliosis with the Spring Distraction System (SDS) or the One Way Self-Expanding Rod (OWSER)

Justin V. Lemans, MD; Casper S. Tabeling, MD; Jeroen Renkens, MD; Hilde W. Stempels; Lotfi Miladi, MD; *René M. Castelein, MD, PhD*; Moyo C. Kruyt, MD, PhD

Hypothesis
The SDS and OWSER perform similarly after one year in terms of efficacy and safety.

Design
Multicenter randomized trial.

Introduction
Current "growth-friendly" implants for treatment of early onset scoliosis (EOS) have limitations that reduce their efficacy and cost-effectiveness. Two systems have been developed that mitigate many of these limitations, the spring distraction system (SDS) and the one way self-expanding rod (OWSER) (Figure 1). The aim of this multicenter study was to compare the 1-year efficacy and -safety of SDS and OWSER in the treatment of neuromuscular or syndromic EOS.

Methods
Non-ambulant, neuromuscular or syndromic EOS patients with progressive curves were included in 3 academic spine centers. Included patients were randomized to treatment with SDS or OWSER and were blinded until after surgery. Outcomes were coronal and sagittal curve correction, spinal growth and the occurrence of (serious) adverse events ((S)AEs) and unplanned returns to the operating room (UPROR). In addition, spinal growth, implant lengthening, and perioperative findings were recorded systematically. Data were collected preoperatively, immediately postoperatively, and at 1, 3, 6 and 12 month follow-up.

Results
Thirty patients were included. Two patients died during follow-up, unrelated to the surgical treatment. Mean age at surgery was 9.0 years, 20/30 patients were male. Mean coronal curve decreased from 74.9° preoperatively, to 37.6° postoperatively and stabilizing at 37.7° after 1 year, with no differences between groups. The T1-T12 segment increased 18 mm/year for SDS and 9 mm/year for OWSER. For the T1-S1 segment, this was 26 mm/year (SDS) and 18 mm/year (OWSER). Although a remarkable difference, this was not significant. Five (S)AEs occurred in the SDS group and 11 (S)AEs in the OWSER group. One (S)AE in the SDS group and 6 in the OWSER group were implant-related. There was 1 UPROR in the SDS group (0.06/patient/year) and there were 5 UPRORs in the OWSER group (0.35/patient/year). The (S)AE rate was 0.25/patient/year for SDS and 0.78/patient/year for OWSER.

Conclusion
The SDS and the OWSER achieved adequate coronal curve correction of 50%, which was maintained at one-year follow-up. Spinal length increase was excellent for both systems. This high SAE rate was substantial and partially reflects the vulnerability of the patient group.

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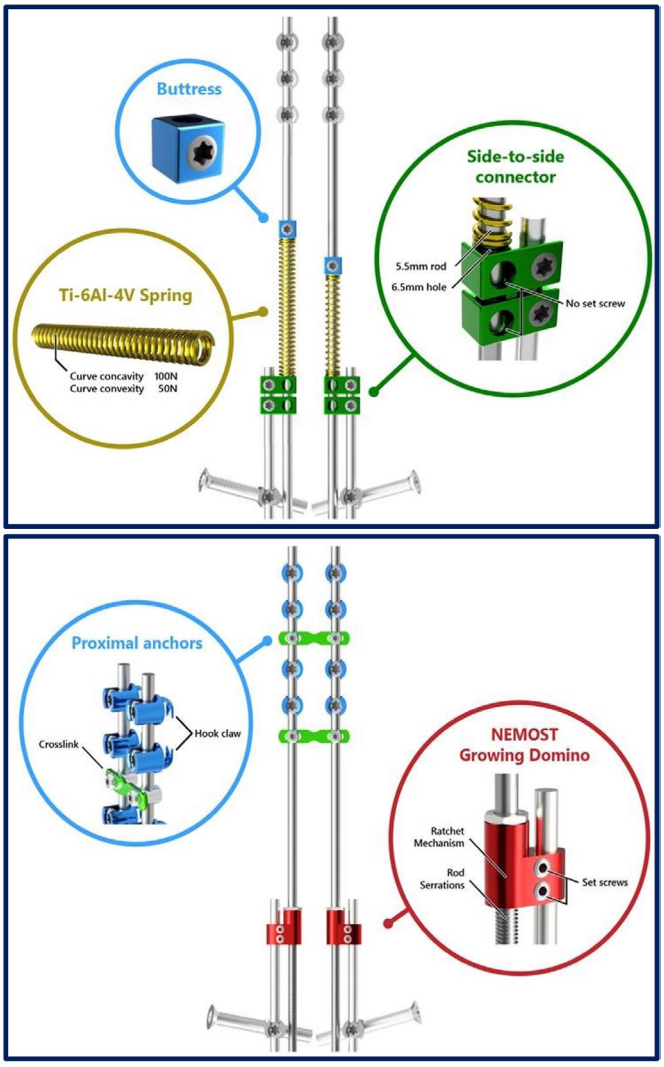

Figure 1. The SDS(above) and the OWSER (below)

55. Designated Spine Anesthesia Teams Improve Perioperative Outcomes for Complex Scoliosis

Neelufar Raja, BS; Arianne Salunga, DO; Talissa Genoroso, MD; Nicole Pham, MPH; Hiba Naz, BS; Amishi Jobanputra, MS; Stephanie Pan, MD; *Kali R. Tileston, MD*; John S. Vorhies, MD

Hypothesis
This is a single center retrospective study performed at a tertiary care children's hospital assessing the effects of a DSAT on surgical and clinical outcomes of pediatric patients with complex scoliosis.

Design
This is a retrospective chart review study

Introduction
In June 2020, our institutional policy changed, assigning only a designated team of anesthesiologists to all spinal deformity surgery. We hypothesized that Designated Spine Anesthesia Teams (DSATs) would demonstrate greater efficiency in caring for complex scoliosis cases.

Methods
All pediatric patients who underwent a spinal fusion between June 2016 to June 2024 with a planned postoperative stay in the intensive care unit (ICU) were included in our retrospective analysis. Our hospital implemented DSATs in June 2020. Therefore all patients between June 2016 were considered pre-DSAT implementation even if our intraoperative team consisted of members who were rolled into the DSAT team.

Results
We identified 214 patients over an eight-year period (94 patients pre-DSAT implementation and 120 patients post-DSAT implementation), the implementation of a DSAT led to significant enhancements in surgical efficiency and perioperative process measures. There was a notable reduction in total anesthesia time, which diminished by an average of 36 minutes (p = 0.01). Additional reductions included the durations between Patient Arrival to PreOp and Anesthesia Ready. Intraoperative management was also affected with the mean allogenic blood transfusion volume in the post-DSAT cohort approximately half that of the pre-DSAT cohort (344cc vs 645cc). Post DSAT patients were more likely to be extubated in the OR (71.4% vs 50.6%) in a subanalysis of GMFCS IV and V patients with fusion to the pelvis, a 72 minute decrease in total anesthesia time was noted (p = 0.004). This cohort of neuromuscular patients were also more likely to be extubated in the OR Post DSAT (61.5% vs 30.8%).Demographics, preoperative radiographic findings and types of procedures performed were similar between the two cohorts. Of note, this intervention did not alter overall length of hospital stay.

Conclusion
DSATs significantly enhance the intraoperative delivery of care for pediatric patients with neuromuscular scoliosis. DSATs cultivate a deeper familiarity with the intraoperative needs of a certain cohort of patients resulting in improved predictability and standardization.

56. Don't Sweat It: Impact of Raising Room Temperature on Patient Temperature During Pediatric Spine Surgery

Lindsay M. Andras, MD; Abigail Padilla, BS; Michael J. Heffernan, MD; Tyler A. Tetreault, MD; Tishya Wren, PhD

Hypothesis
Room temperature has little impact on the rate of change in patient temperature in the presence of the

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forced air warmer.

Design
Prospective Cohort Study

Introduction
There is concern that intraoperative hypothermia leads to increased complication rates (Reynolds, 2008). Emphasis on avoiding intraoperative hypothermia and efforts involving raising the room temperature has been shown to negatively impact surgeon performance (Dunn, 2017), though patient benefit has not been demonstrated.

Methods
Patients undergoing thoracolumbar posterior spinal fusion were prospectively enrolled. In addition to patient demographics and clinical data, room temperature data was acquired using a Fireboard 2 Thermometer (Fireboard Labs, Kansas City MO). Temperature probes were placed: 1) in the open air, 2) the shoulder/upper body under the drapes and 3) the hip/lower body under the forced air warming blanket (Bair Hugger). Data were continuously recorded and analyzed in 5-minute increments. Hypothermia was defined as a body temp < 35.5°Celsius.

Results
There were 956 datapoints at 5-minute increments analyzed from 79.3 hours of collected surgical data. While the air warmer was used, mean temperature around the patient's upper body was 33.6±0.2°C and lower body was 38.6±0.2°C. Average room temperature was 22.5±0.2 °C. Temperature around the patient's upper body was an average of 11.0° greater than the room temperature and around the lower body was a mean of 16.1° greater than the room temperature. Temperature around the upper body did not correlate with room temperature (p= 0.64). Mean patient temperature at the start of the procedure was 35.7°C and 46.2% were hypothermic. Increases in patient temperature once the forced air warmer had reached 100 degrees occurred at an average of 0.012°C /min. The rates of patient temperature changes at varying room temperatures are shown in Table 1.

Conclusion
It appears that room temperature has little impact on the rate of change in patient temperature in the presence of the forced air warmer.

Table 1. Rate of patient temperature change at varying room temperatures.

Group (Temperatures in degrees Fahrenheit)	Rate of Temperature Change (degrees/min)
1 (<70)	0.010
2 (70.1-72.5)	0.013
3 (72.6-75)	0.006
4 (75.1-77.5)	0.012

57. Complications in Halo Gravity Traction: A 40-Year Longitudinal Review

Anne-Marie Datcu, BS; Anna McClung-Booth, BSN; David C. Thornberg, BS; *Jaysson T. Brooks, MD*; Daniel J. Sucato, MD, MS; Karl E. Rathjen; Brandon A. Ramo, MD

Hypothesis
HGT is a well-established and effective method for gradually correcting severe scoliosis. Minor complications related to pin sites are frequent, while neurological complications or those necessitating traction cessation are rare.

Design
IRB approved, single center retrospective chart review.

Introduction
Halo gravity traction(HGT) has been considered a safe, effective method for correction of spinal deformities by gradually correcting deformity and theoretically minimizing risk of postoperative neurologic deficits. However, HGT is not without complications, the purpose of our study was to identify the breakdown and frequency of complications in HGT.

Methods
Review of patients who underwent HGT from 1985 – 2022. Demographics, type of scoliosis, and prior treatment was collected. Duration of HGT, number of episodes in HGT, and complications from HGT were documented.

Results
A total of 335 patients underwent 369 episodes of HGT (range 1-6 episodes), with 26 patients undergoing ≥2 episodes. 89/335 (26%) had prior spine surgery. Mean age was 10.8 years (±4.1 years, range 1.5 - 25.6 years). Major Curve and Kyphosis were 97.8° (±30°, range 14-179°) and 67.6 ° (±31°, range -20-164°). The most common diagnosis undergoing HGT was syndromic (n= 120). Mean length of HGT was 92 days (±212 days, range 3-2380 days), maximum percentage in traction was 47.8%. There were 175 total complications. Neither prior surgery nor curvature size correlated with having a complication. Idiopathic and congenital patients were less likely to experience a complication than neuromuscular or syndromic (p= <.001), and syndromic less than neuromuscular (p= <.001). Patients who experienced a complication were younger, achieved a greater % of total body weight in traction, and spent a greater duration of time in traction. Pin track infection requiring antibiotics was the most common complication (n=58). Only 3 patients had to discontinue HGT due to confirmed neurological changes.

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Conclusion
Our study found that complications from HGT are common; however, a significant number of these are minor and often require intervention but can be addressed without the need to discontinue traction. Patients who are a younger age, achieve more weight in traction, and spend a greater duration of time in traction are more likely to experience a complication. Additionally syndromic and neuromuscular patients are more likely to have a complication.

Group	Complications Absent	Complications Present	p-Value
Idiopathic	21	32	**<.001**
Congenital	20	35	**<.001**
Neuromuscular	53	54	**<.001**
Syndromic	47	73	**<.001**
Idio vs. Cong			0.111
Age in years	12 (±4)	910 (±5)	**0.003**
Days in traction	76 (±170)	118 (±206)	**0.039**
Maximum % weight in traction	45.8 (±15.8)	51 (±18.1)	**0.007**

Complication Type	Number Reported
Pin Track "Infection(s)" - No Treatment	16
Pin Track Infection - Require Antibiotic Treatment	58
Pin Track Infection - Requiring Screw Replacement	10
Pin Track Infection - Requiring Screw Removal	5
Loosening of Pin(s) - Requiring unplanned screw removal w/o replacement	22
Loosening of Pin(s) - Requiring unplanned screw removal w/replacement	27
Fall causing skull fracture/pin motion requiring unplanned halo/screw revision	5
Traction paused for concerns of neuro changes - resumed	5
Traction discontinued because of confirmed neuro changes/deterioration	3
Family Opted to abort traction/treatment plan	2
Traction stopped/aborted because of lack of spinal improvement	1
Aborted Halo due to Intolerance	0
Plan of Care Change	4
Non-Compliance	2
Other	18

HGT Demographics & Complications

58. Transcriptional Profiling of Paravertebral Muscles in Patients with Adolescent Idiopathic Scoliosis Reveals Genes Involved in Satellite Cell Differentiation and Muscle Fiber-Type Specification

Jessica McQuerry, MD; *Stephanie Ihnow, MD*; Darius Ramkhalawan, MS; Gloria Vazquez, BS; Nigel J. Price, MD; Robert Decker, MD; Nadja Makki, PhD

Hypothesis
Expression levels of AIS-associated genes in paravertebral muscle, cartilage, and bone will differ from convex to concave sides and between AIS and control patients.

Design
Prospective

Introduction
The underlying etiology of Adolescent idiopathic scoliosis(AIS) remains unclear. Recent genome-wide association studies(GWAS) and linkage studies have identified several genetic loci associated with AIS.

Methods
Patients undergoing posterior spinal fusion for AIS or patients without scoliosis undergoing spinal surgery (control patients) were prospectively identified and consented for tissue banking of bone, facet joint cartilage and samples of paraspinal muscles from convex and concave side of curvature. Tissues were collected at the time of procedure and transcriptional profiling was performed.

Results
We compared gene expression of paravertebral muscle from AIS patients versus controls, and from the convex vs. concave side of the curve. Several differentially expressed genes relevant to AIS pathogenesis were identified. EGR1 was the most highly upregulated gene, previously shown to promote satellite cell differentiation and differentially binds to an enhancer with an AIS-associated variant. WNT9A, one of the most differentially expressed genes between the convex and concave sides, was shown to attenuate satellite cell differentiation. Myosin heavy-chain 1 and 2 are differentially expressed between patient and control and between convex and concave sides of the curve, indicative of indicative of differences in muscle fiber-type composition. Another gene of interest, SOX6, is upregulated in AIS patients and is essential for proper muscle fiber-type specification. Knockout of SOX6 in zebrafish leads to a curved spine phenotype. We previously identified AIS-associated non-coding variants at the SOX6 locus through genome-wide meta-analysis. By carrying out enhancer assays, we identified a novel enhancer, carrying an AIS-associated SNP that elevates enhancer activity.

Conclusion
Our study highlights changes in gene expression and regulatory pathways in AIS. Linking these changes to AIS-associated genetic variants provides a foundation for mechanistic studies into AIS pathogenesis, which is crucial for its early diagnosis, prevention, and treatment.

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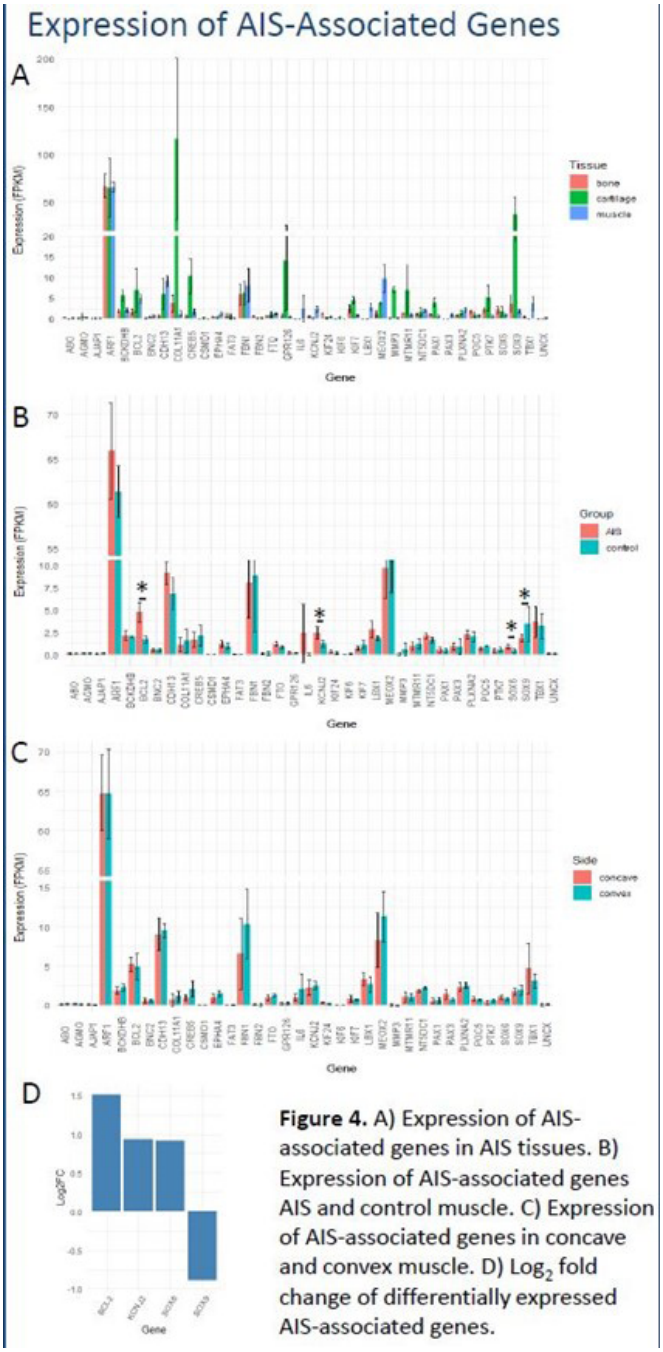

Figure 4. A) Expression of AIS-associated genes in AIS tissues. B) Expression of AIS-associated genes AIS and control muscle. C) Expression of AIS-associated genes in concave and convex muscle. D) Log_2 fold change of differentially expressed AIS-associated genes.

59. Dystrophinopathy in Paravertebral Muscle of Adolescent Idiopathic Scoliosis: A Prospective Cohort Study

Junyu Li, MD; Danfeng Zheng, MD; Zekun Li, MD; Jiaxi Li, MD; Zexi Yang, MD; Xiang Zhang, MD; Yingshuang Zhang, MD; Miao Yu, MD

Hypothesis

AIS is commonly associated with paraspinal muscle pathology based on previous studies, but the patients did not show typical symptoms of decreased limb muscle strength and respiratory muscle function limitation. So AIS may be a particular kind of core myopathy, and we infer that the pathological changes of paravertebral muscles are involved in the development and evolution of AIS, especially the proteins therein.

Design

A Prospective Cohort Study

Introduction

AIS's mechanism remains unknown.Based on the hypothesis that the onset and clinical progression of AIS may be associated with certain neuromuscular diseases, we used pathological methods to further analyze paraspinal muscle changes in AIS patients and introduced immunohistochemical antibody markers used in neuromuscular disease diagnosis through routine morphology. And we are particularly interested in the Dystrophin protein.

Methods

A total of 40 patients with AIS, 20 patients with Congenital Scoliosis (CS) and 20 patients with Spinal Degenerative Disease (SDD) have been enrolled so far. All patients underwent open posterior surgery in our hospital, and paravertebral muscle (multifidus muscle) biopsy was performed during the operation. Many indexes describing muscle were included in this study, especially dystrophin staining. The above pathological results were compared among AIS, CS and SDD groups. The correlation between Cobb Angle and Nash-Moe classification and the above pathological findings was analyzed in AIS patients.

Results

There were significant deletions of dystrophin-1 ($P<0.001$), dystrophin-2 ($P<0.001$) and dystrophin-3 ($P<0.001$) in AIS group compared with both CS group and SDD group. The higher the Nash-Moe classification in the AIS group, the more significant the loss of dystrophin-2 ($P=0.042$) in the convex paraspinal muscles. In addition, there was a negative correlation between the dystrophin-1 and 2 on the concave side of AIS group and Cobb Angle, and there was a significant correlation between dystrophin-2 and Cobb Angle ($P=0.011$).

Conclusion

Dystrophin protein deficiency in the paraspinal muscles plays a significant role in the formation and progression of AIS. The severity of scoliosis in AIS patients is correlated with the extent of dystrophin loss in the paravertebral muscles. Therefore, dystrophin dysfunction may be relevant to the occurrence and development of AIS.

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PODIUM PRESENTATION ABSTRACTS

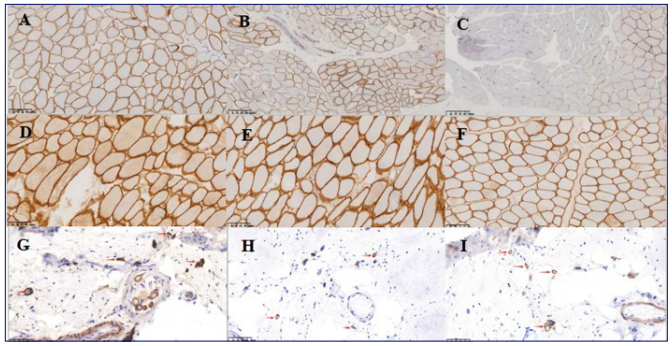

Figure of AIS(A-C), CS(D-F) and SDD (G-I) groups

60. Evaluation of a Novel Bone Graft with Sclerostin Inhibiting Small Molecule in Sheep Lumbar Interbody Fusion

Debra Ellies, PhD; F S. Kimball, PhD; Harold Aberman, PhD; Steven Peckham, PhD; Douglas C. Fredericks, BS; *Sigurd H. Berven, MD*

Hypothesis
Sclerostin inhibition accelerates healing

Design
See method

Introduction
The small molecule sclerostin inhibitor, OSF-1, is being developed as a novel bone graft substitute with mechanism of action different from other bone grafts with decoupling of bone formation from resorption. Large animal feasibility studies were designed to show initial efficacy of OSF-1 and identify formulations for further development in IDE-enabling studies.

Methods
Study protocols were IACUC approved. Sheep underwent two-level transforaminal lumbar interbody fusion (L2-3 and L3-4) with posterior instrumentation. PEEK spacers (17x10x6 mm) were filled with 0.4 cc of graft. In the first study (N=5 sheep), levels received either 1.5 mg/cc OSF-1 on a collagen carrier containing hydroxyapatite/β−tricalcium phosphate granules and bioactive glass (OSF-1/HA:TCP:BA) or carrier alone. Animals were euthanized at 8 (N=2), 12 (N=1) and 16 weeks (N=2). In a second study, OSF-1/HA:TCP:BA was compared to two different collagen carriers with TCP as the ceramic component (OSF-1/TCP:BA-1 and OSF-1/TCP:BA-2). Theses carriers differed in the bioactive glass incorporation method. Fusion was determined by µCT assessment of bridging bone. Morphometry was based on µCT. Non-decalcified histology was used for evaluation of new bone formation and fusion.

Results
In the initial study, OSF-1/HA:TCP:BA levels were graded as partially fused at 8 weeks and fused at 12 and 16 weeks by µCT. None of the carrier control levels were fused at any time point. Morphometry showed a 2.5x increase in bone for OSF-1/HA:TCP:BA compared to control at 8 weeks. Histology was consistent with radiographic results - OSF-1 treated levels were near fusion at 8 weeks with complete fusion at other time points. Control levels had bone at the endplates with a fibrous tissue preventing fusion. In the second study, all of the levels treated with OSF-1/TCP:BA were fused at 16 weeks, while 1 of 2 OSF-1/HA:TCP:BA levels was fused based on reconstructed CT and µCT images. The TCP:BA carrier was almost fully resorbed by 16 weeks.

Conclusion
OSF-1 on a collagen ceramic carrier matrix shows promise in a clinically relevant large animal lumbar interbody fusion model. Carrier screening studies showed consistent fusion within 16 weeks for TCP formulations. With the formulation identified, OSF-1 is ready for IDE-enabling biocompatibility and pivotal large animal dosing and efficacy studies.

61. Dental Composite Offers Comparable or Greater Pullout and Shear Strength to Lateral Mass Screw Fixation in a Human Cadaveric Model

Javier Castro, MD; *James Mok, MD*; Karl Bruckman, MD; Calvin Chan, MS; Anna Karnowska, PhD; Harsh Wadhwa, MD; Olivia Okoli, BS; Jayme Koltsov, PhD; Serena S. Hu, MD

Hypothesis
Dental composite offers greater pullout and shear strength to lateral mass screws in a cadaveric model.

Design
Biomechanical study

Introduction
Lateral mass screw fixation is the common method of fixation for instrumented posterior fusion of the subaxial cervical spine. While screws have established efficacy, dental composite applied to the bony surface may be a promising alternative, offering potential advantages such as ease of application, size, and avoidance of screw loosening, malposition, or fracture.

Methods
20 human cadaveric subaxial cervical vertebrae were collected and prepared for biomechanical testing. In each vertebra, one side underwent lateral mass screw fixation and the contralateral side underwent composite fixation. On the screw side, a 12x3.5 mm lateral mass screw was inserted using standard free hand technique. For the dental composite side, the lamina were treated with etching acid solution and dental bonding agent over a 10mm diameter area

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before an orthodontic bracket was attached using dental composite. 9 randomly chosen specimens were subjected to an axial load to failure (pull-out) test, where load was perpendicular to the vertebral surface. The remaining specimens were subjected to cyclical testing where load was applied cranially (shear) relative to each vertebrae and gradually increased until failure occurred. Statistical analysis was performed with significance level set at p<.05.

Results
Under axial load (pull-out), the dental composite group (203.4 ± 43.4N) showed significantly higher ultimate load than the screw group (127.7 ± 21.2N) (p<0.001). The predominant failure mode under axial load was the composite cleanly pulling off the cortical bone surface whereas the screw pulled through the cancellous and cortical bone. In cyclical testing, the ultimate shear load between lateral mass screws (173.6 ± 65.5N) and composite materials (163.7 ± 48.4N) in human cadaveric bone was not significantly different (p=0.7). The predominant failure mechanism in both fixation methods under shear was fracture distant from the fixation site, indicating robust fixation integrity despite material differences.

Conclusion
Dental composite has similar shear strength and greater pullout strength compared to lateral mass screws. Composite fixation may serve as viable alternatives to traditional lateral mass screws in specific clinical scenarios.

62. A Classification System to Assess Cervical Spine Alignment and Guide Surgical Treatment for Adult Cervical Deformity: A Multi-Ethnic Alignment Normative Study (MEANS)

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Hypothesis
Cervical Sagittal Alignment (CSA) is widely varied in an asymptomatic population and correlates with T1 slope (T1S)

Design
Retrospective Cohort Study

Introduction
Determining normative cervical spine alignment is crucial for guiding corrective surgery in spinal deformities. Prior studies correlate T1S-CSA >17 (cervical mismatch) as a threshold for defining deformity. This study assesses cervical mismatch (CM) rate and predictability of a CSA formula (CSA = T1S - 16.5°) in an asymptomatic adult cohort and propose a new CSA classification system.

Methods
468 asymptomatic adults (18-80 years) from 5 countries (USA, France, Japan, Singapore, Tunisia) formed the Multi-Ethnic Alignment Normative Study (MEANS). T1S and CSA (C2C7°) were measured; CM prevalence (T1S-CSA > 17) was recorded. Positive values are kyphotic, and negative values are lordotic. MEANS cohort data was used for linear regression to derive a new predictive formula for comparison. A classification system was then developed using the new predictive formula and cSVA. Modifiers were added for segmental subaxial sagittal cervical alignment (SCA). CSA was evaluated based on its comparison to predicted. Thresholds were set based on the average+2SD in the MEANS cohort for cSVA, and T1S. The threshold for SCA was based on the segment with the highest mean+2SD.

Results
Mean CSA was -0.42 (12.67)°,T1S was 23.0 (7.86), cSVA was 19.08 (9.75), and the highest mean SCA was 3.22(4.77) which was of segment C4/C5. T1S-CSA was 22.58 (9.39) with an interquartile range of 9.5 - 35.7. Of all subjects, 71.4% exhibited CM > 17°. Linear regression yielded CSA= -1.085(T1S) +24.52 (R2=0.45, p<.0001) which was simplified to CSA = 24.5 - T1S. This MEANS-derived formula predicted CSA within 5° in 38.9% vs. 35% with an MAE of 7.64 vs. 8.99 when compared to a previous CM formula. 97% of the data was captured by Types 1A-B of the classification system, with the rest being captured by Types 2-4. Only 1% surpassed threshold for segmental kyphosis. Overall, age, CSA, OC2-CL, cSVA, T1S, and TK were statistically different amongst the groups (p<.01), without significant differences in lumbar or pelvic parameters.

Conclusion
There was a high prevalence of CM > 17°, suggesting that the previous definition of cervical deformity needs to be reassessed. A new classification for cervical alignment was thus developed.

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Type	Definition	Description	cSVA
Type 1A	Neutral or Kyphotic Alignment	Neutral or Kyphotic CSA (Measured CSA more kyphotic than Predicted CSA); CSA > 25 – T1S.	cSVA<40
Type 1B	Lordotic Cervical Alignment	Lordotic CSA (Measured CSA more lordotic than Predicted CSA); CSA ≤ 25- T1S	cSVA<40
Type 2	Primary Cervical Malalignment	T1S < 40°	cSVA ≥40
Type 3	Primary Thoracolumbar Malalignment	T1S ≥ 40°, Lordotic CSA (CSA ≤ 25- T1S)	cSVA ≥ 40
Type 4	Combined Thoracolumbar and Cervical Malalignment	T1S ≥ 40°, Neutral or Kyphotic CSA (CSA > 25 – T1S)	cSVA ≥ 40
Modifiers:	Segmental cervical sagittal alignment (sCSA)		
N (Neutral)	Any subaxial cervical segment with kyphosis < 13°		
K (Kyphosis)	Any subaxial cervical segment with kyphosis ≥ 13°		
Note: *+ve = kyphosis, -ve= lordosis*			

63. The Extraordinary Changes of Herniated Intervertebral Disc After LAMP for Cervical Spondylotic Myelopathy Associated with Disc Herniation

Xuhong Xue, MD, PhD; Sheng Zhao, MD

Hypothesis
Retrospective study for prospective database

Design
To investigate the immediate change of herniated intervertebral disc after posterior cervical laminoplasty (LAMP)

Introduction
Cervical laminoplasty can indirectly decompression for spinal cord by expanding spinal canal volume, which achieves good clinical outcome.At present, few studies have reported that the spontaneous regression of the cevical herniated discs in the long-term follow-up. However, immediate disc changes after LAMP have not been reported.

Methods
From October 2020 to September 2022, the data of all patients with cervical spondylotic myelopathy with disc herniation who underwent LAMP was prospectively collected. All patients underwent CT scan, MRI and X-ray of cervical spine before surgery, and X-ray and MRI within 3 days,1 month,3 months,6 months and 1 year after surgery. The multi-point area and two-dimensional distance method were used to measure the changes of the herniated disc in preoperative, postoperative and final follow-up. The incidence and percentage of regression of the herniated disc were calculated. Paired T test was used to analyze the difference between pre- and post-operation. Pearson analysis was used to analyze the correlation between radiographic parameters of cervical spine and the changes of herniated disc.

Results
Forty-five patients met the inclusion criteria were included.A total of 150 herniated discs were measured. Respectively,the incidence of disc regression was 67.33%(101/150) and 69.33%(104/150) by area and distance measurement method. The overall regression rate immediately after surgery was 20.35%-29.82%, with the largest change in C5/6, followed by C6/7, C4/5 and C3/4.With the extension of follow-up, the regression ratio increased significantly. There was a positive correlation between the changes of C4/5 disc herniation and the changes of C4/5 sagittal diameter (r=0.371, p=0.018), The dural sac would gradually increase and the protrusion of the intervertebral disc would gradually decrease over time.

Conclusion
In patients with cervical spondylotic myelopathy and disc herniation, different degrees of disc regression will occur immediately after LAMP. In the long-term follow-up, the immediate regression of the herniated disc is stable. Along with time, the degree and proportion of regression of the herniated disc will further increase.

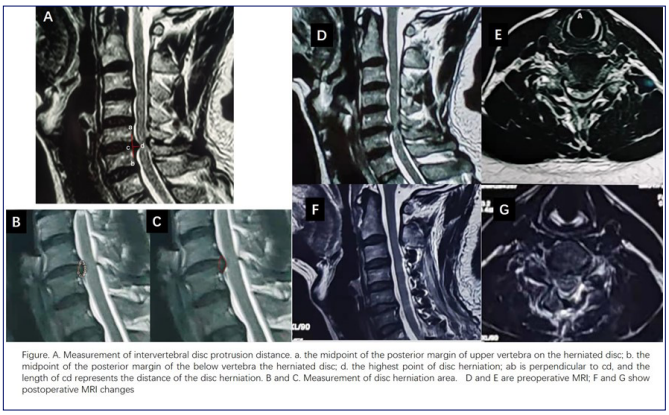

Figure. A. Measurement of intervertebral disc protrusion distance. a. the midpoint of the posterior margin of upper vertebra on the herniated disc; b. the midpoint of the posterior margin of the below vertebra the herniated disc; d. the highest point of disc herniation; ab is perpendicular to cd, and the length of cd represents the distance of the disc herniation. B and C. Measurement of disc herniation area. D and E are preoperative MRI; F and G show postoperative MRI changes

Changes of cervical herniation disc

64. Radiographic Fusion Rates in Anterior Cervical Discectomy and Fusion: Analysis of FDA IDE Trials

Elyette M. Lugo, BS; K. Daniel Riew, MD; Samuel K. Cho, MD; *Amit Jain, MD, MBA*; AO Spine Knowledge Forum Degenerative

Hypothesis
There is large variability in fusion assessment methods for ACDF in FDA IDE trials.

Design
Systematic Review

Introduction
Anterior cervical discectomy and fusion (ACDF) is a widely performed procedure for treating cervical spine disorders. Achieving successful radiographic fusion is critical or long-term stability and symptom

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relief. However, the literature reports a wide discrepancy in fusion rates following ACDF, underscoring the need for a more reliable estimate. This study aims to provide a comprehensive assessment of radiographic fusion criteria and reported rates using data from FDA Investigational Device Exemption (IDE) clinical trials.

Methods
A systematic review following PRISMA guidelines was conducted to identify FDA IDE clinical trials that evaluated radiographic fusion after ACDF. Eligible studies included adult patients undergoing 1- or 2-level ACDF, utilized FDA-approved devices, and reported radiographic fusion outcomes. Data extracted included patient demographics, surgical details, radiographic fusion criteria, and follow-up intervals. Statistical analysis was performed using unpaired t-tests with significance set at $p \leq 0.05$.

Results
Eleven FDA IDE clinical trials with 1,926 patients (84.8% undergoing 1-level ACDF and 15.2% undergoing 2-level ACDF) were included. Fusion was assessed using various criteria, including the presence of bridging bone on radiographs, radiolucency in <%50 of graft-vertebra, and variable motion criteria (angular and translational) on radiographs. The mean age was 45 years for 1-level ACDF patients and 47 years for 2-level patients. At 24 months, the weighted mean fusion rate for 1-level ACDF was 91%, increasing to 97% at 84 months. For 2-level ACDF, fusion rates ranged from 81% at 24 months to 92% at 84 months. Statistically significant differences were noted between 1-level and 2-level ACDF fusion rates at 24 and 84 months ($p<0.01$). None of the studies routinely used CT scans or validated criteria of ≤1mm translational motion on flexion/extension radiographs.

Conclusion
This study provides a comprehensive analysis of radiographic fusion rates following ACDF, highlighting the variability in reported outcomes due to differing fusion assessment criteria. Many FDA IDE trials relied on poor indicators, such as high angular and translational motion, sugseting over-estimation of fusion rates and underscoring the need for standardized, more accurate assessments.

65. Does Intra-operative Methylprednisolone Improve Outcomes of Surgery for Degenerative Cervical Myelopathy? - A Prospective Randomized Study

Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; *Kushal R. Gohil, MBBS, MS, DNB*

Hypothesis
Administration of fixed-dose intravenous steroid(Methylprednisolone) intraoperatively would reduce neuroinflammation and enhance functional and radiological outcomes in decompressive surgeries for DCM.

Design
Randomized controlled trial

Introduction
Degenerative cervical myelopathy(DCM) is a leading cause of spinal cord dysfunction in adults, often requiring surgical intervention. The role of intra-operative methylprednisolone(MP) in enhancing surgical outcomes remains unclear. Objective was to evaluate the efficacy of intra-operative MP in improving clinical and radiological outcomes in patients undergoing surgery for DCM.

Methods
This prospective, randomized controlled trial included 65 patients with DCM, allocated into MP (n=33) and control (n=32) groups. MP was administered intra-operatively, and outcomes were assessed using the Modified Japanese Orthopedic Association (mJOA) score, mJOA recovery rate (mJOA RR), Nurick grade, Nurick recovery rate (NRR), and Chen grading on MRI. Statistical analysis included independent t-tests and Mann-Whitney U tests, with effect sizes (Cohen's d) and 95% confidence intervals (CI) reported for primary and secondary outcomes.

Results
The MP group showed greater improvement in mJOA scores at 24 months with an effect size of 0.51 (95% CI: 0.14 to 0.88), though the difference was not statistically significant ($p=0.107$). The mJOA RR at 3 months showed a moderate effect size of 0.55 (95% CI: 0.17 to 0.93). Nurick grade improvements were observed, with effect sizes of -0.42 (95% CI: -0.80 to -0.04) at 1 month and -0.36 (95% CI: -0.74 to 0.02) at 3 months. For radiological outcomes, the MP group demonstrated a significant improvement in Chen grading at 24 months with an effect size of -0.71 (95% CI: -1.09 to -0.33, $p=0.038$). Complication rates were comparable between both groups, emphasizing the safety of MP administration.

Conclusion
Intra-operative administration of MP may provide moderate improvements in functional and radiological outcomes in DCM surgery, as indicated by effect sizes, despite some outcomes not reaching statistical significance. The findings suggest potential neuroprotective benefits of MP, but further large-scale, multicenter trials are needed to validate these results and optimize dosing strategies.

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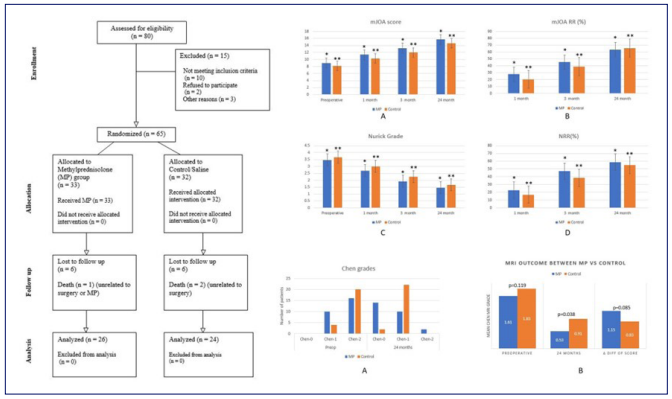


CONSORT(Consolidated Standards of Reporting Trials)diagram-flow of study participants through various stages of this RCT.

66. Transarticular Atlantooccipital and Condylar Screw Fixation for Occipital Cervical Stabilization in Pediatric Patients: Case Series with at Least 1 Year Follow Up

David F. Bauer, MD, MPH

Hypothesis
Occipital condyle screws and transarticular C1 lateral mass to Occipital Condyle screws are safe and effective in pediatric patients.

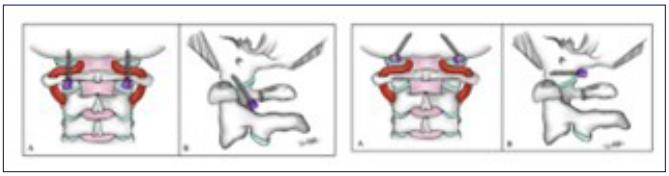
Design
Retrospective review of prospective institutional database

Introduction
Surgical fixation for occipitocervical instability or deformity can be challenging due to limitations in occipital instrumentation that include prominent hardware, limited fixation points on the occiput, and risk of intracranial injury. Occipital instrumentation is particularly difficult in pediatric patients with thinner skull osteology and smaller bony surface area. Transarticular atlantooccipital and occipital condyle screw placement are newer techniques that have been described as alternative strategies for occipitocervical fixation. Cadaveric studies have demonstrated the feasibility and biomechanical equivalence to traditional plating systems for both techniques, however their clinical application has been limited. We present the largest case series of pediatric patients who underwent either transarticular atlantooccipital or direct occipital condyle screw fixation for the treatment of occipital cervical instability.

Methods
We reviewed our institutional database for patients undergoing occipital condyle or transarticular atlantoocciipital screw fixation between June 2021 and May 2023. Three patients underwent transarticular atlantooccipital screw fixation and three patients underwent direct occipital condyle screw fixation. Clinical presentation, complications, fusion rates, and postoperative outcomes were reviewed.

Results
Age range was 2 to 20 years old. Occipitocervical instability was secondary to congenital skeletal dysplasia and neuromuscular scoliosis. Presenting symptoms included dysphagia, dysphonia, headaches, and neck pain. All patients underwent instrumentation guided by spine navigation. There were no intra- or postoperative complications and all patients demonstrated evidence of fusion 3 months after surgery, demonstrating an excellent fusion rate with low morbidity.

Conclusion
Transarticular atlantooccipital and direct occipital condyle screw fixation are alternative techniques to occipital plate fixation. Using spine navigation, these techniques can be performed safely in pediatric patients and provide adequate fixation for successful arthrodesis.



Occipital condyle and transarticular atlantal occipital fixation

67. Cervical Disc Replacement versus Anterior Cervical Discectomy and Fusion in Patients with Preoperative Cervical Myelopathy

George Abdelmalek, MD; *Harjot Uppal, MD*; Neil Patel, MD; Daniel Coban, MD; Stuart Changoor, MD; Nikhil Sahai, MD; Kumar Sinha, MD; Ki S. Hwang, MD; Arash Emami, MD

Hypothesis
We hypothesize that CDA will result in superior PROMs compared to ACDF in patients with CSM while maintaining similar complication rates between the two procedures.

Design
Retrospective cohort study

Introduction
Cervical spondylotic myelopathy (CSM) is a progressive condition characterized by spinal cord compression secondary to degenerative disc disease. While anterior cervical discectomy and fusion (ACDF) have long been considered the standard surgical treatment for CSM, loss of motion segments after this procedure may lead to sequelae, including adjacent segment disease (ASD) and pseudarthrosis, fur-

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ther propagating loss of function and the potential requirement for revision procedures. More recently, cervical disc arthroplasty (CDA) has been introduced as a motion-preserving alternative to ACDF in CSM. This study aimed to compare ACDF to CDA in patients with preoperative CSM.

Methods
A retrospective review at a single institution was performed of all patients who underwent either one or two-level ACDF or CDA with a minimum follow-up of two years. Myelopathic severity was determined using the Nurick classification. Demographics, perioperative data, and complication rates were compared between the two cohorts of patients. Patient-reported outcome measures were assessed using VAS-neck, VAS-arm, and NDI scores.

Results
110 patients were included in the final analysis; 55 underwent ACDF, and 55 underwent CDA. No significant differences were observed in demographics or perioperative data. Overall complication rates were similar between the two cohorts (p=0.167). Rates of dysphagia (p=1.00), dysphonia (p=0.157), infection (p=1.00), hardware failure (p=0.154), spontaneous fusion (p=0.308), heterotopic ossification (p= 0.132), pseudoarthrosis (p=0.154), and ASD (p=0.315) were similar between the two groups. Furthermore, revision rates were similar between the two groups (p=0.315). No significant differences were observed in postoperative Nurick scores between the two cohorts (p=0.410). PROM improvements were greater in the CDA cohort (p< 0.001).

Conclusion
ACDF and CDA had statistically similar complication rates and improvements in myelopathic symptoms. However, patients who underwent CDA had superior PROMs compared to those who had undergone ACDF.

68. The Role of Occiptocervical Lordsis in Assessing Upper Cervical Alignment and its Associations with Sagittal Spinal Parameters: A Multi-Ethnic Alignment Normative Study

Roy Miller, MD; Justin L. Reyes, MS; Alexandra Dionne, BS; Josephine R. Coury, MD; Fthimnir Hassan, MPH; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Michael Kelly, MD; Lawrence G. Lenke, MD; *Zeeshan M. Sardar, MD*

Hypothesis
Occipitocervical lordosis is varied in an asymptomatic cohort and correlates with the T1 Slope (T1S) and T1S-CSA cervical mismatch (CM).

Design
Retrospective Cohort Study

Introduction
Determining normative cervical spine alignment is crucial for guiding corrective surgery in spinal deformities and is commonly evaluated using C2-C7 cervical sagittal angle (CSA). Occipitocervical alignment is imperative to maintain horizontal gaze, sagittal balance, and quality of life. Therefore, this study seeks to evaluate upper cervical alignment using occipitocervical lordosis (OC2) and its relationship to CM.

Methods
468 asymptomatic adults (18-80 years) from 5 countries (USA, France, Japan, Singapore, Tunisia) formed the Multi-Ethnic Alignment Normative Study (MEANS). OC2 was measured and MEANS cohort data was used to conduct a correlation analysis with other sagittal spinal parameters. Mean OC2 was compared between different demographic groups.

Results
Mean OC2 was -18.13 (8.5), CL was -0.42 (12.67), and cSVA was 19.03 (9.76). While a statistically significant difference amongst ethnic groups was found (p=.02) the mean difference was below 5 degrees which may not be clinically significant. No statistically significant differences were found between mean OC2 of different sex or BMI. OC2 demonstrated moderate negative correlations with CSA (r= -0.46) and cSVA (r= -0.43), indicating that a more lordotic OC2 was associated with less lordosis between CSA and a more posterior cSVA. OC2 also demonstrated a negative correlation with T1S-CSA (r= -0.57), indicating that more lordotic OC2 is associated with a higher cervical mismatch.

Conclusion
This normative cohort demonstrates the interplay between changes in OC2 and CSA, cSVA, and the T1 slope. An increased OC2 lordosis suggests a higher T1S-CSA mismatch. In the context of deformity correction requiring occipitocervical fusion, our findings emphasize the significance of evaluating upper cervical alignment in preoperative planning and the potential downstream effects changes of OC2 may have on alignment.

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Table 1: Correlation matrix of OC2 and sagittal alignment parameters

Parameter	OC2-CL (R)
Age	-0.09
BMI	-0.10
C2C7 (SRS sign)	**-0.46******
cSagittal Vertical Axis (mm)	**-0.43******
C7 Slope Angle (°)	0.03
CL/C7S Ratio	-0.10
T1S-CL	**-0.57******
T1 Slope Angle (°)	0.06
T1T12(°)	0.09
T4T12(°)	0.08
TK Max (°)	**0.10***
T4 Pelvic Angle (°)	-0.04
L1L5(°) SRS Sign	-0.01
LL Max SRS Sign	-0.09
L1S1(°)	0.05
L1S1 SRS Sign	-0.05
L1 Pelvic Angle (°)	-0.03
Pelvic Incidence (°)	0.01
Pelvic Tilt (°)	0.00
Sacral Slope (°)	0.01
PI-LL	-0.05

*p-value<.05, ****p-value<.0001

70. A Retrospective Single-Center Review of the Performance of Polymer-Embedded Biphasic Calcium Phosphate Bone Graft With Submicron Needle-Shaped Topography Used Standalone in Transforaminal Lumbar Interbody Fusion

Justin Davis, MD; Brian Everist, MD; Casey Butrico, PhD; Katherine Sage, MS, DO, FAOAO, FAAOS

Hypothesis

We hypothesized that a novel polymer-embedded biphasic calcium phosphate bone graft with a submicron needle-shaped topography (BCP<μm) used standalone would result in a high fusion rate and improved patient-reported outcomes.

Design

A single-center, single-arm retrospective evaluation of 20 patients who received TLIFs with standalone BCP<μm was initiated to evaluate fusion.

Introduction

Iliac crest bone graft (ICBG) is the gold standard graft material for spinal fusion procedures to treat degenerative disc disease (DDD). Limitations in the availability of autograft and morbidity associated with an additional harvest procedure led to the development of synthetic bone grafts. BCP<μm was developed to provide traction for pro-healing M2 macrophages. M2 macrophages stimulate stem cells to form new bone throughout the graft, promoting predictable fusion.

Methods

Patients were evaluated with computed tomography (CT) scans, X-rays, and patient-centered outcome questionnaires at 12 months post-operative. X-rays and CT scans were interpreted by an independent physician blinded to the clinical status of the patients. Interbody fusion was evaluated based on the BSF Interbody Fusion Classification, with Grade 1 characterized as "not fused" and Grades 2 and 3 characterized as "fused".

Results

Of the 20 subjects (11 female, 9 male), the average age of participants was 67.2, and the average BMI was 32.30. Six participants (30%) underwent previous lumbar surgery, 7 (35%) had diabetes, and 11 (55%) were former or current smokers. Thirty-six total levels were fused. Seventeen subjects had only interbody fusions, and 3 patients had interbody and posterolateral fusions. An average of 2.0 cc of BCP<μm was grafted per level in the interbody space. At 12 months post-operative, 34/36 (94.4%) levels were deemed fused, and 2/36 (5.6%) levels were not fused. There were three adverse events reported that were not associated with the bone graft. The change in average VAS score was 2.5/10 (25%), and all patients who reported pre-operative leg and back pain reported an improvement at 12 months.

Conclusion

BCP<μm demonstrated high fusion rates at 12 months post-operative in a challenging patient population. TLIF fusion was accompanied by improvements in VAS pain scores as well as post-operative back and leg pain improvement.

71. Localization of Low Back Pain Source by S1R PET/MRI

Ethan Schonfeld, MS, BS; Ghani Haider, MD; Neelan J. Marianayagam, MD, PhD; Kelly Yoo, MD, PhD; Gordon Li, MD; Sandip Biswal, MD; Anand Veeravagu, MD

Hypothesis

The novel Sigma-1 Receptor (S1R) PET/MRI can localize low back pain generators, and reduce FBSS from improved patient and target selection.

Design

Prospective study

Introduction

Surgical intervention for low back pain (LBP) results in Failed Back Surgery Syndrome (FBSS) in an estimated 40% of cases. 80-90% of standard diagnostic exams fail to identify the nociceptive source of LBP, leading to non-specific therapy, FBSS, and long-term opioid prescription. Standard imaging often

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finds false positives or no findings at all. Sigma–1 Receptors (S1R) have been strongly implicated in nociception, offering the opportunity to localize LBP using a novel S1R radioligand. However, it is unknown whether S1R is expressed in human LBP pain generator tissue.

Methods
Patients presenting with LBP to a single fellowship trained complex spine neurosurgeon at a large academic center were treated according to standard of care. All patients (N=11) underwent a staged Anterior Lumbar Interbody Fusion (ALIF) and posterior fusion. Excised intervertebral disc samples, resected according to standard of care, were immunostained for S1R and evaluated by a board-certified pathologist. Pain relief was clinically assessed after at least two months and a year post-operatively. 6 LBP patients pre-operatively received the S1R PET/MRI.

Results
20 intervertebral disc tissue samples were collected from 11 patients. S1R staining was positive in 10 of 11 patients, in cartilaginous disc (9/11), and in collagenous disc material (9/11). All patients reported a significant improvement or resolution of their back pain at the 3-month post-operative time interval. S1R staining was noted for patients with or without pre-operative lumbar radiculopathy. Patients with S1R staining in both cartilaginous and collagenous tissue at all surgical levels were correlated with worsened pre-operative pain profiles and improved post-operative pain outcomes. S1R PET/MRI signal was abnormally elevated in a variety of tissues (e.g.: spinal nerve, facet joints, spinal canal, paraspinal muscles), and strongly correlated with MRI and pain profile.

Conclusion
The current study provides in vivo evidence that S1R is expressed in local pain generators in human LBP. Degree of staining, disc tissue type stained, and levels positively stained may be established in future work as markers of pathology severity and pain resolution prediction. We offer preliminary in vivo evidence that S1R PET/MRI identifies nociceptive LBP generators.

72. Efficacy of Ultrasound Guided Bilateral Erector Spinae Block with Conventional Anesthesia Care Vs General Anesthesia In Patients Undergoing Single Level Transforaminal lumbar Interbody Fusion Surgery (TLIF): Double blinded Prospective Randomized control study

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Hypothesis
ESPB technique reduces the requirement of post op analgesia and also early mobilization.

Design
Double blinded Prospective Randomized control study

Introduction
Postoperative pain management in spinal fusion surgery is challenging and usually includes administration of extensive amounts of opioid which has adverse effects leading to a longer hospital stay. Inadequate pain control increases cardiac and respiratory complications, delays mobilization, increases the length of hospital stay and may increase the risk of developing a chronic pain syndrome. Novel interfacial plane blocks such as the erector spinae plane (ESP) block, can provide regional analgesia without producing much interference in spinal cord function and are therefore suitable for spinal surgery pain management. ESP block was first described in 2016. Using ultrasound, local anesthetic is injected below the erector spinae muscle group. This causes a sensory blockade over the Antero and dorsolateral side by blocking ventral and dorsal rami of the spinal nerves.

Methods
500 patients over a period of two years were enrolled for the study, out of patients were randomized into two groups control and test based on simple randomized method from 2021 June to 2022 June. All the patients in the study underwent single level TLIF surgery

Results
Pertinent demographic and operated data of 500 patients were analyzed, compared to the control group ESPB patients showed significant reduction in intra op bleeding, maintain low heart rate and normal blood pressures, saturation of opioid consumption significantly 6 hours after the surgery with significant mean value, $p< 0.0001$, and lowered the pain score (0-10) at various points at rest or during mobilization for 24-48 hours after the surgery. ESPB reduced the intra-op bleeding. ESPB decreased the post operative complications relating to opioids like nausea and vomiting; $P<0.001$ also reducing the length of hospital mean of 1 ± 0.5 days; $P<0.001$.

Conclusion
ESP Block in our study in a single center proved to be very effective in reducing intra-op bleeding and reducing the postop opioids consumption, early pain free mobilization and pod 0 discharge in patients undergoing TLIF surgery compared to the control group.

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PODIUM PRESENTATION ABSTRACTS

73. The Impact of Open Lumbar Posterolateral Instrumentation and Fusion versus Minimally-Invasive Techniques: A Propensity-Matched Post-Hoc Analysis of a Randomized Controlled Trial

Eric Zhao, BS; *Robert Cecere, BS;* Gregory Kazarian, MD; Arsen Omurzakov, BS; Tomoyuki Asada, MD; Tejas Subramanian, BS; Izzet Akosman, BS; Nishtha Singh, BS; Annika Bay, MD; Kasra Araghi, BS; Olivia Tuma, BS; Atahan Durbas, MD; Adin Ehrlich, BS; Sereen Halayqeh, MD; Tarek Harhash, BS; Adrian Lui, MD; Andrea Pezzi, MD; Sheeraz Qureshi, MD; Sravisht Iyer, MD

Hypothesis

MIS leads to decreased postoperative pain and opioid use and increased early ambulation, but higher doses of intraoperative radiation.

Design

Post-hoc Retrospective Analysis of RCT

Introduction

While comparisons of minimally-invasive (MIS) versus open fusions exist, few studies have looked at primary MIS versus open 1- and 2-level lumbar fusions where MIS includes anterior, lateral, posterior, and combined approaches. Limited data on early postoperative opioid use, pain, and ambulation exist using this novel definition of MIS.

Methods

This was a propensity-matched post-hoc analysis of a randomized controlled trial of patients undergoing primary one and two-level lumbar fusions. Preoperative and postoperative patient-reported outcomes (PROMs) including numeric pain rating scale (NPRS), brief pain index (BPI), Oswestry disability index (ODI), and PROMs minimal clinically important difference (MCID) were assessed, along with perioperative data (opioid use [morphine milligram equivalents, MME], operative time, estimated blood loss [EBL], hospital length of stay [LOS], ambulation distance, urinary retention, and radiation exposure).

Results

After matching, 90 patients (30 MIS, 60 open) were included. There were no significant differences in postoperative day (POD)1 and POD3 NPRS and BPI. MIS cohort showed greater oral opioid use, lesser intravenous opioid use, lower total MME POD0 - POD2, lower EBL, shorter operative time, shorter LOS, greater ambulation distance POD0 through POD1, and greater radiation exposure. There were no differences in urinary retention or preoperative ODI, but MIS had a lower 2-year postoperative ODI.

Conclusion

One- and two- level MIS lumbar fusion has several advantages over open fusion, including lower EBL, shorter LOS, less opioid use, and greater immediate postoperative ambulation. These benefits come at the cost of greater radiation exposure.

Acute Postoperative Opioid Use and Perioperative Data After Two-to-One Propensity Matching

	MIS (n = 30)	Open (n = 60)	p-value
PCA duration, d (mean ± sd)	1.2 ± 0.7	1.4 ± 0.6	0.382
PCA total, mg (mean ± sd)	3.68 ± 2.61	4.50 ± 5.31	0.922
PCA POD0	1.33 ± 1.87	1.40 ±1.31	0.248
PCA POD1	0.65 ± 1.00	2.28 ± 2.83	**0.019**
PCA POD2	NA	NA	NA
Oral Hydromorphone (n/total n [%])	0/17 (0.0)	5/41 (12.2)	0.308
PO Oxy total, mg (mean ± sd)	74.6 ± 86.9	154.9 ± 193.4	0.202
PO Oxy POD0	19.4 ± 13.3	9.7 ± 13.0	**0.005**
PO Oxy POD1	22.1 ± 19.3	35.6 ± 30.8	0.189
PO Oxy POD2	34.4 ± 30.8	35.9 ± 38.0	0.659
Received Additional Opioid During Hospital Stay (n/total n [%])	10/17 (58.8)	8/40 (20.0)	**0.006**
Total MME POD0 through POD2	125.3 ± 101.4	223.0 ± 187.9	**0.027**
Length of Stay, d (mean ± sd)	2.0 ± 1.4	3.5 ± 2.0	**< 0.001**
Discharge POD0 (n [%])	1 (3.3)	0 (0.0)	0.333
Discharge POD1 (n [%])	11 (36.7)	2 (3.3)	**<0.001**
Discharge POD2 (n [%])	13 (43.3)	18 (30.0)	0.244
Discharge ≥ POD3 (n [%])	5 (16.7)	40 (66.7)	**<0.001**
Operative Time, m (mean ± sd)	173.2 ± 89.5	213.0 ± 76.4	**0.016**
EBL, mL (mean ± sd)	149.0 ± 164.0	549.3 ± 452.0	**< 0.001**
Early ambulation, ft (mean ± sd)			
POD0	9.1 ± 23.0	2.9 ± 19.4	**0.011**
POD1	149.2 ± 107.8	100.0 ± 115.1	**0.022**
POD0 through POD1	158.3 ± 112.8	102.9 ± 121.0	**0.009**
Urine Retention (n [%])	2 (6.7)	3 (5.0)	1.000
Radiation, mGy (mean ± sd)	54.3 ± 34.6	25.2 ± 53.9	**< 0.001**

PCA = Patient Controlled Anesthetic (hydromorphone); PO Oxy = oral oxycodone; POD = postoperative day; d = days; mg = milligrams; sd = standard deviation; mGy = milligray. Significant p-values are bolded.

74. Five Years Follow up after MIS TLIF vs MIS Decompression for Grade 1 Spondylolisthesis: Is There any Difference in Outcomes?

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Hypothesis

As minimally invasive surgery (MIS) spares muscular

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and midline osseoligamentous structures, MIS may hypothetically mitigate the superiority observed for open fusion versus open decompression alone for grade 1 degenerative lumbar spondylolisthesis.

Design
Analysis of prospectively collected multi-center cohort.

Introduction
Here, we compare 5-year outcomes of MIS transforaminal lumbar interbody fusion (TLIF) versus MIS decompression alone.

Methods
We analyzed patients who underwent single-segment MIS TLIF or MIS tubular decompression for grade 1 degenerative lumbar spondylolisthesis from the prospective QOD spondylolisthesis cohort. Univariate and multivariable analyses compared outcomes including Oswestry Disability Index (ODI), numeric rating scale (NRS) back pain (NRS-BP), NRS leg pain (NRS-LP), EuroQol-5D (EQ-5D), North American Spine Society (NASS) satisfaction score, and cumulative related reoperation rate.

Results
Overall, 143 underwent MIS surgery: 72 (50.3%) TLIF and 71 (49.7%) decompression. The MIS TLIF cohort was younger (62.1±10.5 vs 72.3±9.6 years), had lower rates of diabetes (9.7% vs 22.5%), was more likely to ambulate independently (88.9% vs 85.9%), use private insurance (65.3% vs 26.8%), be employed preoperatively (54.2% vs 23.9%), and had higher baseline NRS-BP (6.9±2.6 vs 5.6±3.2) ($p<0.05$). Otherwise, the cohorts were similar for baseline characteristics. MIS TLIF had more blood loss (108.8±85.0 vs. 33.0±63.2 ml), longer operative times (228.2±110.7 vs. 101.8±48.0 mins), and longer hospitalization lengths (2.9±1.8 vs. 0.7±1.2 days) ($p<0.001$). Five years postoperatively, both cohorts had significant mean improvements in ODI, NRS-LP, NRS-BP, and EQ-5D ($p<0.05$). MIS TLIF demonstrated significantly larger reductions in NRS-BP (-4.0±3.5 vs. -2.2±3.4) and higher rates of satisfaction (NASS 1 or 2: 81.4% vs. 57.6%) ($p<0.05$) but similar ODI, NRS-LP, NRS-BP, and EQ-5D ($p>0.05$). MCID rates for ODI, NRS-LP, NRS-BP, and EQ-5D were equivalent between the cohorts ($p>0.05$). MIS TLIF had a significantly lower reoperation rate (5.6% vs 15.5%, $p=0.001$). Multivariate analyses did not identify fusion as a significant predictor of ODI, NRS-LP, NRS-BP, and EQ-5D.

Conclusion
While both MIS TLIF and MIS decompression are associated with clinical benefits in well-selected patients, our 5-year results demonstrate that MIS TLIF is associated with fewer reoperations and higher patient satisfaction.

Table 1: Patient-reported outcomes for patients undergoing MIS for grade 1 lumbar spondylolisthesis at 5 years follow-up.

Variable	MIS TLIF (N=70)**	MIS Decompression (N=66)**	p-value
ODI			
Raw Score, mean ± std	19.8 ± 18.8	20.2 ± 17.5	0.911
Change from Baseline, mean ± std	-25.7 ± 21.1	-20.8 ± 20.8	0.215
MCID Rate (%)	47 (73.4%)	31 (58.5%)	0.088
NRS Back Pain			
Raw Score, mean ± std	2.8 ± 2.9	3.6 ± 2.8	0.193
Change from Baseline, mean ± std	-4.0 ± 3.5	-2.2 ± 3.4	**0.014**
MCID Rate (%)	49 (75.4%)	21 (56.8%)	0.051
NRS Leg Pain			
Raw Score, mean ± std	1.9 ± 2.8	2.1 ± 2.5	0.723
Change from Baseline, mean ± std	-4.2 ± 3.5	-3.9 ± 3.0	0.728
MCID Rate (%)	45 (69.2%)	27 (73.0%)	0.69
EQ5D			
Raw Score, mean ± std	0.76 ± 0.25	0.76 ± 0.2	0.873
Change from Baseline, mean ± std	0.18 ± 0.27	0.15 ± 0.28	0.584
MCID Rate (%)	29 (45.3%)	17 (45.9%)	0.951
NASS Satisfaction (%)			0.041
1	45 (64.3%)	34 (51.5%)	
2	12 (17.1%)	4 (6.1%)	
3	5 (7.1%)	3 (4.5%)	
4	3 (4.3%)	10 (15.2%)	

** Excluded 2 deceased patients from MIS TLIF cohort and 5 deceased patients from MIS Decompression cohort.

Abbreviations: ODI, Oswestry Disability Index; MCID, Minimal clinically important differences; NRS, Numerical Rating Scale; NASS, North American Spine Society Patient Satisfaction Index

Patient reported outcomes for patients undergoing MIS for grade 1 lumbar spondylolisthesis at 5 years Follow-up

75. Optimizing Lateral Lumbar Interbody Fusion: Is Expandable Technology Worth It?

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Hypothesis
Expandable technology use in Lateral Lumbar Interbody Fusion (LLIF) allows for better radiographic outcomes and less perioperative complications.

Design
Single center retrospective cohort study

Introduction
Use of expandable technology for interbody fusion is tailored to improve ease of insertion and provide better restoration of disk height and segmental lordosis to improve perioperative outcomes. Outside what has already been published, there are few studies that assess the use of expandable cage in LLIF.

Methods
We assessed one-year outcomes in patients undergoing LLIF with use of either an expandable or static cage. DH was measured as the mean of anterior, middle, and posterior heights across levels where an LLIF cage was placed. Evidence of cage subsidence was evaluated by 1-year radiographic imaging. Logistic regression was performed to control for significant baseline factors between groups.

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Results
89 patients were included (21 EXP, 68 NE). No differences were observed in baseline demographics nor surgical characteristics. EBL was found to be significantly greater in the EXP group (710 vs. 375 ml, p=0.027). Postoperatively between EXP and NE patients, there were no differences in complications (33.3% vs. 28.4%) nor 90 day-readmissions (14.3% vs.13.6%) (p>0.05). There were no significant differences in notable 1-year outcomes, including rates of recurrent radiculopathy and cage subsidence. The EXP group had greater DH at baseline (p<0.05). There was no statistically difference in the change from baseline to one year in DH, SL, and LL, between groups, however the NE group showed more loss of SL 1 year from surgery. When controlling for preoperative DH, EXP patients demonstrated significantly larger disk height restoration (OR=1.57, CI 1.12-2.05, p=0.007), with less deterioration of LL at 1 year from surgery compared to NE (OR= 1.01, CI 1.001-1.21, p=0.049). However, EXP were found to have significant greater odds of requiring revision surgery up to 1 year (OR= 16.78, CI 1.47-191.08; p=0.023).

Conclusion
Use of an expandable cage for LLIF procedure contributed to increased disc height and less loss of lumbar lordosis at 1 year compared to with use of a static cage. Use of an expandable cage was associated with a significantly higher rate of revision at 1 year. Longer term follow-up is critical to better understand more of the clinical impact of each type of interbody device used for LLIF procedure.

Figure 1: Outcomes Between Patients With Expandable and Static Cage Placement in LLIF

		Expandable (N=21)	Static (N=68)	p-value
Demographics	Age	65.76±7.93	63.24±9.69	0.230
	Gender (%F)	61.90%	64.70%	0.801
	BMI	31.74±6.19	30.40±6.48	0.405
	Current Smoker	0.00%	8.80%	0.329
	ASA	2.52±0.51	2.53±0.53	0.966
Surgical Characteristics	Levels Fused	4.10±2.64	3.05±2.48	0.103
	LLIF cages placed	1.57±0.60	1.46±0.63	0.461
	Hyperlordotic Cage?	4.80%	2.90%	0.559
	L1/L2	33.30%	16.20%	0.119
	L2/L3	61.90%	52.90%	0.617
	L3/L4	47.60%	47.10%	1.000
	L4/L5	19.00%	27.90%	0.571
Perioperative Outcomes	EBL (ml)	710.48±720.87	374.82±556.66	**0.027**
	Length of Stay (days)	5.40±3.19	4.29±2.24	0.077
	Post Op Complication	7(33.3%)	19(28.4%)	0.785
	Cardiac	1(4.8%)	7(10.4%)	0.674
	Pulmonary	2(9.5%)	6(9.0%)	1.000
	Neurological Deficit	1(4.8%)	2(3.0%)	0.563
	Ileus	1(4.8%)	4(6.0%)	1.000
	Urinary	2(9.5%)	5(7.5%)	0.670
	90 Day Readmission	3(14.3%)	9(13.6%)	1.000
1 Year Outcomes	Recurrent Radiculopathy at 1 yr	5(26.3%)	23(35.4%)	0.584
	Subsidence at 1 Yr	3(17.6%)	12(20.7%)	1.000
	Return to OR Within 1 Yr	3(14.3%)	3(4.5%)	0.149
	Psuedoarthrosis	1 (4.8%)	0 (0.0%)	0.236
	Mechanical Failure	2(6.5%)	0 (0.0%)	0.054
	Adjacent Segment Disease	1 (4.8%)	2 (2.9%)	0.559

Figure 2: Radiographic Analysis Between Expandable and Static Cage Placement in LLIF

	Expandable (N=21)	Static (N=68)	p-value
Number of Cages	33	99	
Baseline Average Disk Height (mm)	6.71±2.94	5.35±2.07	**0.030**
Δ Average Disk Height Post Op (mm)	5.40±2.55	4.30±2.38	0.095
Δ Average Disk Height Post Op to 1 Year (mm)	-1.04±1.86	-0.44±1.39	0.163
Baseline Average Segmental Lordosis °	7.85±5.43	6.35±4.58	0.299
Δ Average Segmental Lordosis Post Op °	2.30±3.65	3.37±4.83	0.446
Δ Average Segmental Lordosis Post Op to 1 Year °	0.31±2.99	-1.97±4.26	0.058
Baseline Lumbar Lordosis °	51.24±11.88	43.40±15.53	0.087
Δ Lumbar Lordosis Post Op °	2.75±11.16	3.47±9.66	0.812
Δ Lumbar Lordosis Post Op to 1 Year °	2.07±6.36	-1.32±7.92	0.147

76. Long-Term Reoperation Rates After Single-Level Lumbar Discectomy: A Nationwide Cohort Study

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Hypothesis
Reoperation rates following single-level lumbar discectomy are greater following revision compared to index surgery

Design
Retrospective cohort

Introduction
Lumbar discectomy is commonly performed to treat radiculopathy due to disc herniation. Reoperation rates are debated, with reports ranging from 5-24%. This study aims to evaluate reoperation rates following single-level lumbar discectomy, analyze type of reoperation performed, and identify risk factors for reoperation.

Methods
A retrospective analysis was conducted using the PearlDiver national insurance claims database. Pa-

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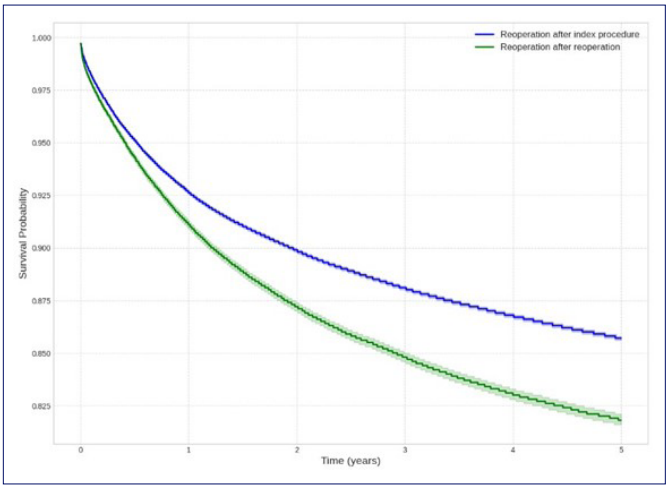
tients aged 18+ who underwent single-level lumbar discectomy with minimum five years follow-up were included. Patients with concurrent procedures and less than five-years follow-up were excluded. The primary outcome was reoperation rate, and secondary analysis evaluated reoperation rates and procedure type following re-exploration discectomy. Kaplan-Meier survival analysis assessed time to reoperation, and Cox models were used to identify factors associated with reoperation.

Results
308,979 patients were included. 5-year reoperation rate following index discectomy was 14.4%. Of patients who underwent reoperation within 5 years, 42.5% underwent fusion, 33.6% any decompression, and 38.2% re-exploration discectomy. Incidence of reoperation discectomy (n=67,098) over 10 years was about 21.7%. 5-year reoperation rate following revision was 18.2%, and 68% of subsequent surgeries were fusions. Kaplan-Meier curves showed faster decline in survival probability within the first year following both index discectomy and re-exploration discectomy. Cox regression identified obesity (HR 1.1429) and higher Elixhauser Comorbidity Index (HR 1.0685) as significant predictors of reoperation.

Conclusion
This study found a 14.4% 5-year reoperation rate following lumbar discectomy, and a higher rate (18.2%) after re-exploration. Over a 10-year period, about 21.7% of patients who underwent primary discectomy required reoperation. These findings suggest nearly one-fifth of patients will require reoperation and highlight the need for appropriate patient counseling. Fusion procedures were more common after revision surgery. Further research is needed to determine efficacy of fusion versus non-fusion techniques for recurrent lumbar disc herniation.



Kaplan-Meier Survival Curve for Reoperation following index procedure vs revision

77. MRI Signal Intensity in Lumbar Disc Herniation Correlates with Failure of Nonoperative Treatment

Jonathan H. Garfinkel, MD; Nicholas Taylor, BA; Mihir Tandon, BA; Kelley E. Banagan, MD

Hypothesis
In patients with a first-time acute lumbar disc herniation, diminished T2 and/or STIR signal intensity within the disc herniation will correlate with failure of initial nonoperative treatment.

Design
Single-center, retrospective observational study

Introduction
Lumbar disc herniation (LDH) is a common pathology, particularly in working-age patients (i.e. 18-65 years old). In most cases, initial management is nonoperative, with surgery reserved for patients with persistent symptoms after 6-8 weeks. It is challenging to predict which patients will fail nonoperative treatment. MRI signal characteristics have not previously been analyzed as a predictor of nonoperative treatment outcome.

Methods
Patients were identified in the electronic medical record by ICD-10 code and visit type and screened for inclusion/exclusion by chart review. Clinical data and MR Images were retrospectively reviewed. On T2 sagittal and axial and STIR sagittal sequences, mean signal intensity was measured in regions of interest (ROIs) encompassing the disc herniation, truncated at the posterior border of the vertebral body, and normalized against the intensity of CSF. Reliability analysis was performed using intraclass correlation. Analysis of the relationship between signal intensity and the primary outcome (surgery within 1 year) was performed using Spearman's Correlation and multivariate logistic regression.

Results
Inter-rater reliability was acceptable for all measures. There was no statistically significant correlation between signal intensity and the primary outcome in the sample population as a whole. However, in the working-age subgroup (89/96 patients) there were negative, statistically significant correlations for the primary outcome with (T2 sagittal : CSF) (ρ=-0.243, p=0.022) and (T2 sagittal : CSF) / (STIR sagittal : CSF) (ρ=-0.224, p=0.035). The correlation of the primary outcome with (T2 sagittal : CSF) signal remained significant in multivariate logistic regression.

Conclusion
A correlation does exist between signal characteristics in a lumbar disc herniation and failure of nonoperative treatment in working-age patients. Further

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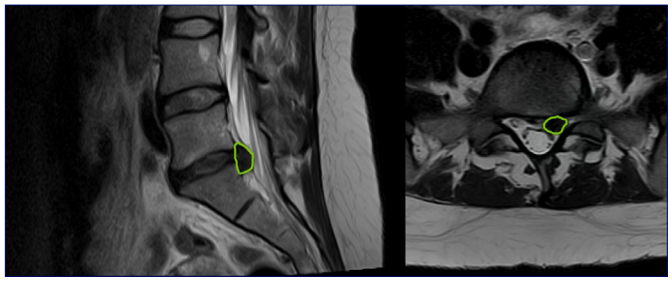
studies are needed prospectively, in larger populations to better quantify this relationship. This is a promising area for future application of artificial intelligence and computer vision to enable rapid analysis of signal characteristics across multiple MRI slices.



Example of ROI selection in a LDH

78. Endoscopic Lumbar Decompression in Obese vs. Non-Obese Patients: Comparable Outcomes Across BMI

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Hypothesis
This study investigated whether obesity affects postoperative outcomes following endoscopic lumbar decompression surgery.

Design
Retrospective study design.

Introduction
Discectomy is one of the most common procedures performed endoscopically, with evidence supporting comparable decompression outcomes to open procedures. However, the impact of obesity on outcomes in endoscopic spine surgery remains relatively underexplored.

Methods
This retrospective study analyzed 110 consecutive patients who underwent transforaminal or interlaminar endoscopic lumbar decompression by a single surgeon between 2019 and 2023 at a multi-hospital academic center. Patients were stratified by body mass index (BMI), with 39 classified as obese (BMI > 30 kg/m^2) and 71 as non-obese (BMI ≤ 30 kg/m^2). Primary outcomes included postoperative patient-reported outcomes (PROs) such as Visual Analog Scale (VAS), PROMIS Physical Function (PF), PROMIS Pain Interference (PI), and PROMIS Depression, as well as EQ5D. Secondary outcomes were intraoperative complications (e.g., CSF leaks, nerve injury, wound infection), length of stay (LOS), and reoperation rates. Propensity-scored stabilized inverse probability weighting (PS-SIPTW) was used to balance baseline characteristics between groups, and p-values were adjusted for multiplicity using the Benjamini-Hochberg correction.

Results
Among the 110 patients, no significant differences were observed in postoperative PROs between obese and non-obese cohorts across all metrics, including VAS, PROMIS PI, PROMIS PF, PROMIS Depression, and EQ5D (all adjusted p-values > 0.05). The mean length of stay was 0.50 ± 1.34 days for obese patients and 0.60 ± 1.58 days for non-obese patients (MD -0.1 days, 95% CI -0.7 to 0.5 days, p = 0.730). Total surgical time also did not differ significantly between the two groups. There were no significant differences in intraoperative complications, including CSF leaks, nerve injury, or wound infection, nor were there significant differences in reoperation rates.

Conclusion
This study found no significant differences in postoperative patient-reported outcomes, complications, or reoperation rates between obese and non-obese patients following endoscopic lumbar decompression. These results suggest that obesity does not negatively impact outcomes in endoscopic spine surgery, and endoscopy may help mitigate surgical risks associated with obesity.

79. Does Hip Osteoarthritis Increase Risk for Revision Surgery for Adjacent Segment Disease after Multilevel Lumbar Fusion?

Akil Paturi, MD; Alexandra Yiachos, BS; Kingsley Ogelle, BS; Juan Rodriguez-Rivera, BS; Constance Maglaras, PhD; *Themistocles S. Protopsaltis, MD*; Tina Raman, MD

Hypothesis
Patients with hip osteoarthritis (OA), without total hip replacement, may face higher revision surgery rates for adjacent segment disease (ASD) following multilevel lumbar fusion.

Design
Retrospective single-center cohort study.

Introduction
Multilevel lumbar fusion can increase mechanical stress on adjacent segments and joints, including the hips. In patients with hip OA, without total hip replacement, it is unclear whether the stiffened hip joint exacerbates forces on adjacent mobile segments. This study evaluates the revision rates for ASD in patients with and without hip OA following multilevel lumbar fusion.

Methods
Patients 18 years or older who underwent multilevel

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lumbar fusion between 2007 and 2023 were retrospectively reviewed. Patients were grouped based on the presence or absence of hip OA, with those with total hip replacement excluded. Demographic data, OA subtypes, surgical techniques, and postoperative outcomes were analyzed. Statistical analyses, including logistic regression, T-tests, and ANOVA, were conducted to assess revision surgery for ASD within a 2-year follow-up.

Results

Of the 5,807 patients, 5,647 did not have hip OA, while 160 had hip OA. Revision surgery for ASD was significantly higher in the hip OA group (18.8%) compared to the non-OA group (7.7%), p<0.001. Hip OA patients were older (66.16 vs. 58.97 years, p<0.001), had a higher BMI (30.34 vs. 29.47, p=0.008), and higher CCI scores (3.46 vs. 2.41, p<0.001), indicating increased comorbidities. Hip OA patients experienced higher rates of intraoperative complications, including significant blood loss (>2 liters), (1.9% vs. 0.4%, p=0.003), neuromonitoring abnormalities (8.8% vs. 4.2%, p=0.005), and postoperative complications (31.9% vs. 20.4%, p<0.001), along with greater incidences of mechanical complications and return to the OR within 30 days (5.6% vs. 2.9%, p=0.04).

Conclusion

Patients with hip OA face significantly higher rates of revision surgery for ASD at 2-year follow-up after multilevel lumbar fusion compared to patients without hip OA. Older age, higher BMI, and greater comorbidities further increase this risk. These findings should guide preoperative discussions between patients and surgeons regarding potential perioperative risks following multilevel lumbar fusion.

Table 1. Patients with no Hip OA versus patients with Hip OA

			No Hip OA(n=5647)	Hip OA (n=160)	p-value
		Revision for Adjacent Segment Disease	**434(7.7%)**	**30 (18.8%)**	**<.001**
Demographics		**Age**	**58.97 ± 13.798**	**66.16 ± 9.289**	**<.001**
		Gender (% Female)	2940(47.9%)	70(43.8%)	.296
		BMI	**29.47 ± 6.28**	**30.34 ± 6.06**	**.008**
		Smoker (% Non-Smoker)	519(90.8%)	15 (9.4%)	.937
		ASA	**2.44 ± 2.09**	**3.03 ± 3.46**	**.001**
		CCI	**2.41 ± 2.07**	**3.46 ± 1.91**	**<.001**
		Levels Fused	2.09 ± 2.127	2.26 ± 1.26	.305
Surgical Characteristics		Operative Time (min)	265.6 ± 121.7	277.1 ± 117.8	.42
		EBL (mL)	418.06 ± 641.03	449.58 ± 621.26	.539
		LOS (days)	6 ± 38.95	9.85 ± 43.75	.219
Complications	Intra-Operative	Any Intraoperative Complication	294(5.2%)	13(8.1%)	.104
		Mass Blood Loss (≥2L)	**21(0.4%)**	**3(1.9%)**	**.003**
		Neuromonitoring	**235(4.2%)**	**14(8.8%)**	**.005**
		Durotomy	227(4%)	10(6.3%)	.16
	Post-Operative	Any Post-Operative Complication	1150 (20.4%)	51 (31.9%)	<.001
		Cardiac	312(5.5%)	14(8.8%)	.081
		Neuro	228(4%)	11(6.9%)	.075
		DVT/PE	65(1.2%)	3(1.9%)	.401
		Pulmonary	155(2.7%)	1(0.6%)	.102
		Airway Edema	2(0.0%)	0(0.0%)	.812
		Ileus	163(2.9%)	3(1.9%)	.449
		Urinary	296(5.2%)	9(5.6%)	.83
		Deep Infection	53(0.9%)	2(1.3%)	.688
		Superficial Infection	44(0.8%)	3(1.9%)	.127
		Death	4(0.1%)	0(0.0%)	.736
		Mechanical	64(1.1%)	5(3.1%)	.022
		Return to OR within 30 days	**161(2.9%)**	**9(5.6%)**	**.04**
		Return to OR within 90 days	487(8.3%)	17(8.1%)	.94

80. Management of Giant Calcified Thoracic Disc Herniation Causing Severe Canal Stenosis and Myelopathy using Partial Vertebrectomy: Clinical and Radiological Outcomes of a Novel Posterior-only Technique

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Hypothesis

Posterior-only partial vertebrectomy(PV) will provide complete spinal cord decompression, prevent iatrogenic neurological deficit and avoid anterior surgery for the management of giant calcified thoracic disc herniation(GCTD) causing severe canal stenosis with myelopathy.

Design

Retrospective

Introduction

GCTD causing severe canal stenosis and myelopathy is a rare condition which can lead to significant neurological deficit. Traditionally, anterior decompression through a thoracotomy has been performed for surgical management. The posterior-only approach eliminates anterior thoracotomy and avoids related morbidity. This study aims to evaluate the safety and efficacy of PV performed with posterior-only approach for GCTD with myelopathy

Methods

Pts who underwent PV for GCTD with min 2 yrs f/up were included. Following instrumentation, wide laminectomy and facet resection, ipsilateral pedicle was

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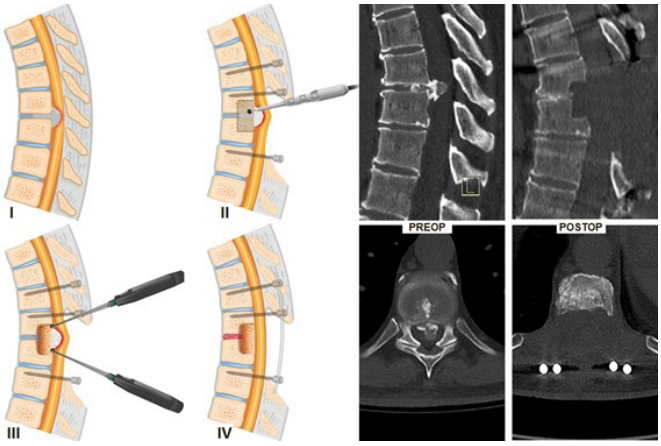
resected. PV was carried cranially using high-speed drill until an adequate space was created underneath CTD. Finally, CTD is cautiously dissected from dura and resected en-block using a reverse curette. According to the size and location of CTD, PV was done bilaterally. Preop axial CT scans were used to measure spinal canal occupation ratio. Neurological evaluation was done using mJOA scale.

Results
21(4M,17F)pts with mean age 47(27-85)yrs and f/up was 62(28-168)m. GCTD was located mid-thoracic(T5-T8) in 5 pts and lower thoracic(T9-T12) in 16 pts. Canal compromise was central in 13 pts and paracentral in 8 pts. Preop spinal canal occupation ratio was mean 43.3%(18-64).Post CT scans showed complete decompression and removal of CTD in all pts. Dural tear(3pts-14%) was the most common complication. All of the 14 (66%) pts who had preop neurological deficit showed improvement postop. 5 of them fully recovered neurologically. Preop mean mJOA score improved from 12.7 to 16.8. None of the pts developed new-onset neurological deficit postop.

Conclusion
Posterior-only PV was a safe and effective method that provides a circumferential(360°) decompression of the spinal cord in pts with CTD causing severe canal stenosis and myelopathy. This technique eliminates the anterior surgery and related complications. All pts showed significant neurological improvement (mJOA 12.7 to 16.8) and none of the pts had new iatrogenic deficit postop.



81. Risk Factors for Post-Operative Cognitive Dysfunction Following Multilevel Lumbar Spinal Fusion

Mladen Djurasovic, MD; Steven D. Glassman, MD; Jeffrey L. Gum, MD; Morgan Brown, MS; Christy L. Daniels, MS; Colleen Mahoney, BS; Benjamin Kostic, BS; Leah Y. Carreon, MD; *Justin Mathew, MD*

Hypothesis
Post-Operative Cognitive Dysfunction (POCD) following lumbar fusion is a multifactorial process and includes preoperative and intraoperative factors.

Design
Retrospective observational cohort

Introduction
POCD is a serious, common and under-recognized complication in elderly patients undergoing surgery. Risk factors for POCD vary in the literature and include preoperative as well as intraoperative factors. This study examines risk factors for POCD following multilevel lumbar fusion

Methods
A retrospective cohort of 566 thoracolumbar fusion cases with a minimum of 4 surgical levels were identified. Chart review was performed for occurrence of POCD and known risk factors for POCD. Anesthetic and surgical data included OR time, fluid volume, blood loss, blood product replacement and use of vasopressors. Arterial line based mean arterial pressure (MAP) data was collected at 1-minute intervals and cumulative duration of MAP<65mmHg was recorded.

Results
Overall, 70 out of 566 patients (12.4%) experienced POCD described most commonly as Encephalopathy (57, 81%), Delirium (8, 11%), Hallucinations (3, 4%) and Altered Mental Status (2, 3%). Univariate analysis of preoperative demographic and comorbidity risk factors are illustrated in Table 1. Patients who developed POCD were older (68.7yrs vs 59.6yrs, p<0.001), had a worse ASA scores (2.9 vs 2.7, p=0.004), more obesity related comorbidities with a higher BMI (32.0 vs 30.0, p=.007), a higher incidence of diabetes (31% vs 16%, p=.002), and sleep apnea (47% vs 28%, p=0.002). Intraoperatively patients who experienced POCD had greater fluid shifts and hemodynamic instability as shown in Table 2 in terms of blood loss (800cc vs 660cc, p=0.047), blood transfusion (350cc vs 201cc, p=0.014), minutes of intraoperative hypotension (11.6 vs 6.4, p=0.043) and vasopressor use (10604mcg vs 6823mcg, p=0.029).

Conclusion
Post-Operative Cognitive Dysfunction is associated with age, preoperative comorbidities and greater intraoperative hemodynamic instability. These factors present targets for optimization prior to surgery to lower the incidence of Post-Operative Cognitive Dysfunction.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Table 1	Post-Operative Cognitive Dysfunction		
	No	Yes	
Total	496	70	
Age	59.64 (15.83)	68.68 (9.05)	<.001
BMI	29.8 (6.43)	31.95 (5.94)	0.007
ASA	2.73 (0.55)	2.91 (0.40)	0.004
Diabetes	81 (16%)	22 (31%)	0.002
Lung disease	152 (31%)	29 (41%)	0.076
Heart disease	100 (20%)	19 (27%)	0.209
Liver disease	9 (2%)	4 (6%)	0.065
Alcohol Use	83 (17%)	9 (13%)	0.491
Sleep Apnea	138 (28%)	33 (47%)	0.002
CPAP	74 (15%)	17 (24%)	0.053
Hearing Impairment	60 (12%)	11 (16%)	0.439
Vision Impairment	252 (51%)	38 (54%)	0.611
Mobility			0.101
Independent	319 (64%)	35 (50%)	
Cane	73 (15%)	11 (16%)	
Walker	63 (13%)	15 (21%)	
Wheelchair	35 (7%)	7 (10%)	
Benzodiazepines	78 (16%)	14 (20%)	0.387
Anticholinergics	35 (7%)	8 (11%)	0.224
Antipsychotics	39 (8%)	9 (13%)	0.169
Tricyclic Antidepressants	84 (17%)	12 (17%)	1.000
Antihistamines	144 (29%)	26 (37%)	0.210
Sedating Antihistamine	45 (9%)	12 (17%)	0.051
Smoking			0.172
Never	271 (55%)	30 (43%)	
Former	38 (8%)	6 (9%)	
Current	187 (38%)	34 (49%)	
PreOp Albumin	4.16 (0.40)	4.07 (0.40)	0.077
HbGA1C	5.92 (0.89)	6.13 (1.03)	0.253

Table 2	Post-Operative Cognitive Dysfunction		
	No	Yes	
Number of Levels	9.77 (2.94)	10.24 (3.78)	0.351
Surgical Time	400.77 (97.05)	434.73 (127.59)	0.047
Estimated Blood Loss	659.88 (499.80)	800.5 (553.29)	0.047
Intra-operative			
pRBC transfused	200.63 (307.32)	349.51 (479.40)	0.014
CellSaver infused	201.61 (216.94)	266.67 (267.81)	0.055
Crystalloids	2166.37 (977.43)	2593.65 (1322.33)	0.011
Colloids	565.22 (410.94)	513.68 (342.18)	0.254
Norepinephrine Equivalents	6822.62 (8886.03)	10603.74 (13824.03)	0.029
MAP <65mmHg minutes	6.35 (8.37)	11.57 (16.40)	0.043
Postop pRBC transfused	87.68 (243.78)	181.74 (338.04)	0.027
Length of Stay	4.83 (2.72)	8.48 (5.80)	<.001

82. Radiographic Predictors of Functional and Pain Outcomes in Scheuermann's Kyphosis: A ROC-Based Minimal Clinically Important Difference (MCID) Analysis

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Hypothesis

More stringent corrections in radiographic parameters, particularly in Pelvic Incidence-Lumbar Lordosis (PI-LL) mismatch and Thoracic Kyphosis (TK), would be predictive of significant improvements in patient-reported outcomes, while parameters such as LL and T1 Pelvic Angle (TPA) might have weaker associations with clinical improvements.

Design

Retrospective study

Introduction

Evaluate the clinical significance of key radiographic parameters in Scheuermann's Kyphosis (SK) correction by calculating the Minimal Clinically Important Difference (MCID). The analysis sought to determine the radiographic thresholds that best predict patient-reported improvements in function and pain, based on Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores at 2 years postoperative follow up.

Methods

A retrospective analysis of 40 patients (mean age of 19.7 years) who underwent surgical correction for SK was conducted.

Results

PI-LL mismatch and TK were the strongest predictors of patient-reported improvements. For PI-LL mismatch, the ROC-based MCID threshold was 6.0°, more stringent than the commonly accepted threshold of ≤10° in the literature. The final PI-LL mismatch values ranged from -7.0° to 8.0° in the cohort. The AUC for PI-LL mismatch was 0.68 for ODI, indicating that it was a fair predictor of functional improvement. In contrast, its AUC for VAS was 0.54, suggesting it had poor predictive value for pain relief. TK demonstrated a significant association with pain relief, with an ROC-based MCID threshold of 0.40° and an AUC of 0.69 for VAS, making it a fair predictor of pain improvement. However, its predictive value for functional improvement was limited. LL and TPA showed limited predictive power for both pain and function, despite being important for sagittal balance.

Conclusion

PI-LL mismatch and TK were the most clinically significant predictors of improvement in patients undergoing surgical correction for SK. Stricter corrections in PI-LL mismatch and TK were associated with better PROs. In contrast, LL and TPA, while essential for sagittal alignment, were poor predictors of meaningful clinical improvements. These findings suggest that surgical planning for SK should prioritize achieving tighter corrections in PI-LL mismatch and TK to maximize patient outcomes.

83. Surgery for Scheuermann's Kyphosis (SK) Normalizes Lumbar Lordosis but not Cervical Alignment when Compared to Asymptomatic Adults

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Hypothesis

Sagittal alignment in SK will regress towards the norm following surgical intervention.

Design

Retrospective Review

Introduction

SK is a deformity identified by rigid thoracic hyperkyphosis; surgical indications include severe kyphosis

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and pain. This study will examine the radiographic differences between SK and normative patients matched on pelvic parameters to investigate the divergence of SK patients before and after surgery.

Methods

The HARMS Study Group database consisted of 97 SK patients with surgical intervention from 2006 to 2011; we included only patients with available pelvic data. The prospectively enrolled multi-ethnic alignment normative study (MEANS) database consisted of 467 total patients; those age <40 were included for comparison with the young HARMS cohort. A 1:1 optimal propensity score match (PSM) was conducted to control for preoperative pelvic incidence (PI) and pelvic tilt (PT) between SK and MEANS patients [SMD: 0.1997, variance ratio: 1.6998]. Wilcoxon rank sum tests and McNemar's tests were utilized for significance.

Results

Of 53 HARMS and 254 MEANS patients, PSM generated 53 matched pairs. By design, PI and PT did not differ between preoperative SK (preSK) and MEANS. Thoracic kyphosis (TK, T1-T12) in preSK was significantly higher than MEANS. Preoperative cervical sagittal angle (CSA, C2-C7) and T1 slope (T1S) were greater in preSK than MEANS. All preSK lumbar measures, including lumbar lordosis (LL, L1-S1), proximal LL (pLL, L1-L4), and distal LL (dLL, L4-S1) were higher than MEANS. At 2-year follow-up after surgery, TK remained significantly higher in the postoperative SK cohort (postSK) compared with MEANS. CSA and T1S also remained greater in postSK than MEANS. In contrast, all postSK lumbar parameters including LL, pLL, and dLL normalized and did not differ from MEANS.

Conclusion

In comparison with a young MEANS cohort matched on PI and PT, the preoperative parameters from cervical to lumbar spine in SK were significantly different, reflecting compensation for extreme TK. Following surgical intervention, SK TK remained significantly higher than MEANS. Compensatory cervical and thoracic parameters regressed but remained significantly different whereas postoperative lumbar parameters normalized and did not differ from asymptomatic patients, suggesting that TK correction may not require complete return to the norm to relieve lumbar hyperlordosis.

HARMS SK vs MEANS normative comparison			*p-value*	*Notes*
Study population	**HARMS**	**MEANS**		
Population description	**Scheuermann's kyphosis**	**normative sample**		
Cohort name	**preSK**	**MEANS**		
Timepoint	**preoperative**	**baseline**		
Total n	53	53		
Baseline demographics				
Age (years) [mean±SD]	15.9 (±1.8)	28.9 (±6.2)	*<0.00001	
Sex [n,%]			0.742	
Male	36 (67.9%)	20 (37.7%)		
Female	17 (32.1%)	33 (62.3%)		
BMI (kg/m^2) [mean±SD]	26.7 (±7.2)	24.9 (±5.5)	0.395	preSK n=49; MEANS n=38
Radiographic parameters (°) [mean±SD]				
Cervical sagittal angle (CSA; C2-C7)	-18.1 (±10.9)	2.7 (12.3)	*<0.00001	preSK n=19; MEANS n=53
T1 vertebral slope (T1S)	37.7 (±9.2)	22.0 (±6.9)	*<0.00001	preSK n=45; MEANS n=53
Thoracic kyphosis (TK; T1-T12)	74.1 (±12.4)	41.6 (±9.1)	*<0.00001	preSK n=45; MEANS n=53
Distal thoracic kyphosis (dTK; T4-T12)	73.5 (±12.6)	34.7 (±8.1)	*<0.00001	preSK n=48; MEANS n=53
Lumbar lordosis (LL; L1-S1)	-69.6 (±14.5)	-52.8 (±10.8)	*<0.00001	preSK n=49; MEANS n=53
Proximal lumbar lordosis (pLL; L1-L4)	-25.5 (±11.3)	-15.6 (±8.0)	*<0.00001	preSK n=49; MEANS n=53
Distal lumbar lordosis (dLL; L4-S1)	-44.1 (±10.6)	-37.1 (±6.4)	*0.0002	preSK n=49; MEANS n=53
Pelvic incidence (PI)	40.2 (±11.6)	41.8 (±9.9)	0.366	preSK n=53; MEANS n=53
Pelvic tilt (PT)	6.7 (±7.3)	6.3 (±6.3)	0.587	preSK n=53; MEANS n=53
Sacral slope (SS)	33.4 (±9.6)	35.4 (±8.3)	0.220	preSK n=53; MEANS n=53
Cohort name	**postSK**	**MEANS**		
Timepoint	**2-year postoperative**	**baseline**		
Total n	53	53		
Baseline demographics				
Age (years) [mean±SD]	18.5 (±1.8)	28.9 (±6.2)	*<0.00001	
BMI (kg/m^2) [mean±SD]	27.4 (±7.5)	24.9 (±5.5)	0.167	postSK n=44; MEANS n=38
Radiographic parameters (°) [mean±SD]				
Cervical sagittal angle (CSA; C2-C7)	-8.0 (±16.3)	2.7 (12.3)	*0.0009	postSK n=21; MEANS n=53
T1 vertebral slope (T1S)	34.1 (±9.9)	22.0 (±6.9)	*<0.00001	postSK n=45; MEANS n=53
Thoracic kyphosis (TK; T1-T12)	56.5 (±13.5)	41.6 (±9.1)	*<0.00001	postSK n=45; MEANS n=53
Distal thoracic kyphosis (dTK; T4-T12)	44.4 (±11.4)	34.7 (±8.1)	*<0.00001	postSK n=48; MEANS n=53
Lumbar lordosis (LL; L1-S1)	-53.3(±13.5)	-52.8 (±10.8)	0.930	postSK n=48; MEANS n=53
Proximal lumbar lordosis (pLL; L1-L4)	-16.6 (±10.6)	-15.6 (±8.0)	0.603	postSK n=48; MEANS n=53
Distal lumbar lordosis (dLL; L4-S1)	-36.7 (±10.0)	-37.1 (±6.4)	0.780	postSK n=48; MEANS n=53
Pelvic incidence (PI)	43.2 (±11.0)	41.8 (±9.9)	0.578	postSK n=53; MEANS n=53
Pelvic tilt (PT)	7.9 (±7.7)	6.3 (±6.3)	0.189	postSK n=53; MEANS n=53
Sacral slope (SS)	35.5 (±10.0)	35.4 (±8.3)	0.884	postSK n=53; MEANS n=53

84. A Novel 3D Coupler for Automated Correction of Spinal Deformities: In Vitro Precision and Functionality Testing

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Hypothesis

A novel Coupler delivers precise digitized multidirectional motions capable of 3D correction of vertebral deviations.

Design

In vitro experimental testing.

Introduction

Deviation of a vertebra in any of the 6 degrees of freedom can cause significant clinical consequences. Spinal deformities are mostly multi-axial; inability to achieve true segmental 3D correction is a long-felt not yet solved problem. Precision surgery and patient-specific realignment are evolving technologies with the promise of improved outcome. The current surgical pathways, using solid rods, lack the accuracy and predictability to match these developments. Digitization and automation help in achieving the required high precision goals and in enabling technological advancements.

Methods

We designed, manufactured, and tested a calibrated high-fidelity metal prototype of a Multi-axial Coupler with a bipartite jointed body and 2 end effector arms/rods, incorporating multiple self-locking uniaxial "Robotic" joints (revolute and linear). The device can be operated using an automated motorized screwdriver or a robot; and is designed to correct

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3 rotational deviations and to restore disc height. Knowing the input/output ratio for each joint mechanism, rotation of the screw head (input) generates a calculated corresponding magnitude of motion at its end effector arm (output). We tested each joint for targeted rotation of 5°, 10°, 15° or translation of 3, 6, 9 mm. Using CT based 3D printed wire-embedded Vertebral Models, the device's ability to manipulate the vertebra in coronal, axial, and sagittal rotation and cephalic-caudal translation was tested and verified with fluoroscopy. The proof-of-concept functionality test was repeated with unilateral and bilateral device configurations.

Results

In all tested motions, the Coupler accurately and repeatedly delivered the predicted targeted motions. The device could mobilize the 2 vertebrae relative to each other in Sagittal and Coronal Angulation, Axial Rotation, and Cephalic-Caudal Translation. Unilateral device configuration produced a more harmonious motion of the vertebrae.

Conclusion

The novel 3D Coupler can deliver precise and predictable multi-directional targeted motions. The device can manipulate the vertebra in 4 out of 6 degrees of freedom. More functional and biomechanical testing are required before clinical trials.

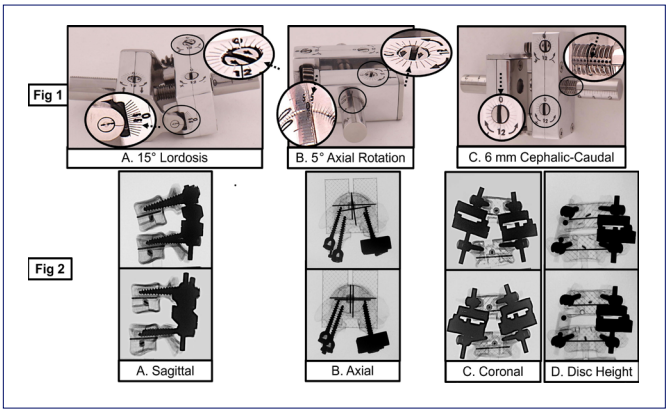

Fig 1 Precision Test. Fig 2 Proof-of-concept Functionality Test.

85. Increased Cell Saver to Blood Loss Ratio is Associated with a Higher Risk of Pulmonary Embolism After Adult Spinal Deformity Surgery

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Hypothesis

Increased cell saver (CS) transfusion to estimated blood loss (EBL) is a driver in the development of postoperative pulmonary embolisms (PE).

Design

Prospective, multicenter cohort of ASD pts w/ ≥1 criteria: PI-LL≥25°, TPA≥30°, SVA≥15cm, thoracic scoliosis≥70°, thoracolumbar scoliosis ≥50°, global coronal malalignment≥7cm, and/or undergoing 3CO.

Introduction

Reports have shown that CS processing introduces fragile RBCs with sub-lethal injuries to its recipients. CS:EBL ≥0.33 is shown to be associated with higher rates of 30D readmissions. We aim to analyze the effect of this ratio on cardiopulmonary (CP) and renal complications.

Methods

Pts were dichotomized based on whether CS:EBL ≥0.33 or < 0.33. Pts were excluded if they had no CS transfused. Key outcomes included renal and CP-related medical complications. Pt characteristics, preop labs, operative data, and radiographic parameters were compared using appropriate statistical tests. A conceptual multivariable logistic regression model was built to assess risk factors associated with the primary outcome.

Results

406 pts were included in this analysis with 10.6% (N=43) and 89.4% (N=363) pts having CS:EBL ≥0.33 and < 0.33, respectively. The ≥0.33 pts were older (66.2±12.2yrs vs 58.9±16.4, p=0.0007), experienced less EBL intraop (1048.3±852.2cc vs 1695.6±1295.3cc, p<0.0001), less instrumented levels(TIL) (12.2±3.3 vs 14.1±3.6, p=0.0001), less PCOs performed (72.1% vs 86.8%, p=0.0103) and less major coronal cobb correction (-17.0±14.6 vs -22.7±16.7, p=0.0373). Despite comparable transfusion rates, ≥0.33 pts has lesser pRBC, FFP, and Platelet units transfused intraop- (p<0.05). No significant differences were observed among overall CP and renal complications. However when stratifying CP complications by type, ≥0.33 pts experienced a greater rate of PE (9.3% vs 1.4%, p=0.0093). A multivariable logistic regression model adjusting for the significant differences between the two groups discerned CS:EBL ≥0.33 to be an independent risk factor for the development of PE, confer-

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ring an OR of 6.57 (1.75-24.66) with excellent model diagnostics (AUC=0.92).

Conclusion

Pts with a CS:EBL ratio ≥0.33 have a 6.57x greater risk of developing a pulmonary embolisms early postop independent of EBL and transfusions administered. The findings support re-evaluation of CS use in this patient population based on perceived benefits.

Logistics regression model to discern effect of CS:EBL on development of pulmonary embolisms in the early postoperative period

Characteristic	Unadjusted Regression [OR (95% CI)]	p-value	Adjusted Regression [OR (95% CI)]	p-value
Age	1.06 (0.99 – 1.13)	0.0968	1.01 (0.96 – 1.05)	0.7819
EBL	1.00 (1.00 – 1.00)	0.4761	1.00 (1.00 – 1.00)	0.9557
CS:EBL ≥ 0.33	7.34 (1.89 – 28.49)	**0.0039**	6.57 (1.75 – 24.66)	**0.0053**
PCO Performed	0.13 (0.03 – 0.49)	**0.0028**	0.32 (0.10 – 1.08)	0.0655
TIV	0.89 (0.74 – 1.08)	0.2298	1.00 (0.86 – 1.17)	0.9461
Colloids Transfused	1.00 (1.00 – 1.00)	0.7967	1.00 (1.00 – 1.00)	0.9687
PRBC Units Transfused	1.12 (0.86 – 1.46)	0.3862	1.39 (0.93 – 2.08)	0.1100
Platelet Units Transfused	1.11 (0.53 – 2.35)	0.7802	1.18 (0.55 – 2.53)	0.6799
FFP Units Transfused	0.90 (0.53 – 1.54)	0.7123	0.75 (0.55 – 2.53)	0.2989
Δ Max Coronal Cobb	1.13 (1.05 – 1.22)	**0.0018**	1.04 (1.00 – 1.09)	0.0658

AUC=0.92, Model p=0.0031, Hosmer and Lemeshow Goodness-of-Fit Test p-value = 0.7264

86. Topical Tranexamic in Adult Spinal Deformity Surgery (TTADS): A Double-Blinded, Placebo Controlled Randomized Controlled Trial ‡

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Hypothesis

Topical tranexamic acid (tTXA) may decrease perioperative blood loss, blood transfusion requirements, and drain output in surgical correction of adult spinal deformity (ASD).

Design

Double-blinded randomized controlled trial (RCT) (NCT03553186).

Introduction

IV TXA has been utilized to diminish blood loss in multiple orthopedic subspecialties, including spine surgery. ASD surgery often results in significant blood loss, necessitating blood transfusions and often leading to greater morbidity and length of stay. The addition of tTXA to IV TXA to further reduce blood loss is understudied.

Methods

A double-blinded RCT was performed comparing the use of intraoperative tTXA to Placebo. An a priori power analysis was performed showing a sample size of 44 pts/arm for a total of 88 to achieve 80% β to detect a reduction in postoperative drain output with α 0.05. Block randomization was performed prior to enrollment. Patients were randomized to tTXA (200cc NS with 5g TXA 100mg/ml (50cc)) or Placebo (250cc NS). The primary outcome was drain output. Secondary outcomes included reinfused cell volume, drain output and blood transfusion volumes at <24 hours, 24-48hrs, 48-72hrs, and >72hrs. Inclusion criteria were: age 18-80, diagnosis of ASD, and surgical correction of ≥ 5 level posterior fusion with instrumentation to the pelvis. Exclusion criteria were: medical contraindications to TXA, intraoperative dural tear, or history of an adverse reaction to TXA. All patients received IV TXA loading (20mg/kg) and maintenance (20mg/kg) doses of 5mg/ml. tTXA was applied after instrumentation and osteotomies and left for ≥ 5min. Univariate and multivariate analyses were performed to assess for the impact of tTXA versus Placebo.

Results

A total of 97 patients were enrolled, 51 in the tTXA group and 46 in the Placebo group. Baseline demographics were similar in terms of age, BMI, gender, and CCI. There were no significant differences in surgical details between groups. There were no differences in intraoperative blood loss, intraoperative transfusion volume, reinfused cell volume, blood transfusion volume at any time point, or drain output at any timepoint in univariate analyses (p>0.05 for all) (Table 1). No significant differences were seen on multivariate analysis.

Conclusion

In ASD surgery, the addition of topical TXA did not have a significant impact on blood loss, transfusion volume, or drain output.

	Mean Placebo	Mean tTXA	Mean Difference	p-Value	95% CI, Lower Bound	95% CI, Upper Bound
Age	62.8	65.4	8.4	0.186	-6.5	1.3
Gender	0.3	0.3	0.5	0.978	-0.2	0.2
BMI	29.2	26.6	5.8	0.416	-3.6	8.7
Age-Based CCI	1.8	2.1	0.9	0.241	-0.6	0.2
Age and Comorbidity-Based CCI	2.7	2.7	1.6	0.820	-0.6	0.8
Preoperative Anticoagulation Use (Yes vs. No; proportion)	0.1	0.0	0.1	0.129	0.0	0.2
Prior Spine Surgery? (Yes vs. No; proportion)	0.6	0.5	0.5	0.312	-0.1	0.3
Prior Fusion? (Yes vs. No; proportion)	0.5	0.3	0.5	0.186	-0.1	0.3
Number of Levels Fused	9.5	10.3	3.1	0.250	-2.0	0.5
Number of Levels Overlapping Prior Fusion	5.0	6.1	5.0	0.298	-3.1	1.0
Procedure Total Time (Minutes)	259.7	280.4	77.7	0.213	-53.3	12.0
Number of Rods Used	3.6	3.4	2.6	0.779	-0.9	1.2
Number of Screws Used	19.2	20.1	7.0	0.545	-3.8	2.0
Number of Cages Used	0.3	0.4	0.6	0.739	-0.3	0.2
Posterior Column Osteotomy (Yes vs. No; proportion)	0.7	0.7	0.5	0.697	-0.2	0.2
Pedicle Subtraction Osteotomy (Yes vs. No; proportion)	0.2	0.2	0.4	0.572	-0.1	0.2
Vertebral Column Resection (Yes vs. No; proportion)	0.0	0.0	0.1	0.930	-0.1	0.1
Number of Posterior Column Osteotomies	2.8	2.6	2.2	0.651	-0.8	1.3
Number of Pedicle Subtraction Osteotomies	0.2	0.2	0.4	0.572	-0.1	0.2
Number of Vertebral Column Resections	0.0	0.0	0.1	0.930	-0.1	0.1
Interbody Fusion Performed?	0.3	0.3	0.5	0.877	-0.2	0.2
Number of TLIF Cages	0.4	0.4	0.6	0.984	-0.3	0.3
Anesthesia Total time	348.4	372.3	96.1	0.209	-61.4	13.6
Total IV of TXA given (mg)	1963.4	2005.3	762.7	0.795	-360.5	276.7
Blood Transfusion <24hrs	319.3	246.3	246.3	0.273	-68.7	238.2
Blood Transfusion 24-48hrs	198.0	269.8	269.8	0.728	-130.9	186.1
Blood Transfusion 48-72hrs	132.0	227.9	227.9	0.879	-157.3	183.3
Blood Transfusion >72hrs	80.0	150.3	150.3	0.462	-65.5	142.2
Blood Transfusion Total	729.3	344.4	344.4	0.220	-101.2	428.7
Drain Output <24hrs	664.5	905.0	905.0	0.541	-375.4	198.3
Drain Output 24-48hrs	407.1	881.9	881.9	0.782	-322.2	243.4
Drain Output 48-72hrs	180.1	265.3	265.3	0.963	-100.9	105.7
Drain Output >72hrs	353.3	319.8	319.8	0.074	-21.9	468.5
Drain Output Total	1605.0	2055.6	2055.6	0.795	-646.8	842.4
Estimated Intraoperative Blood Loss	864.4	612.5	612.5	0.634	-364.2	222.9
Reinfused Blood Cells	256.0	306.3	306.3	0.275	-214.8	61.9
Intraop pRBC Transfusion (Yes vs. No; intraoperative proportion)	0.2	0.5	0.5	0.265	-0.3	0.1
Total Volume Intraop pRBC Transfusion	105.6	307.5	307.5	0.371	-169.0	63.6

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

87. Pre-Operative GLP-1 Agonists Reduce Postoperative Length of Stay in Spinal Surgery

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Hypothesis
Preoperative glucagon-like peptide-1 receptor agonist (GLP-1 RA) utilization will reduce post-operative complications in patients undergoing spinal surgery.

Design
Retrospective cohort study using a propensity-score matched analysis

Introduction
GLP-1 RAs have demonstrated benefits in reducing complications following total knee and hip arthroplasty. However, their impact on spinal surgery outcomes remains largely underexplored. This study aims to assess the effect of GLP-1 RA use on post-operative outcomes in spinal surgery patients.

Methods
A 1:2 propensity score-matched algorithm was applied, matching patients on variables including age, sex, BMI, procedure type, and comorbidities (diabetes, hypertension, hyperlipidemia, heart disease, kidney disease, smoking status, depression, and anxiety), along with the use of insulin, metformin, sulfonylureas, and SGLT-2 inhibitors. The primary outcome measures were post-operative length of stay (LOS), operating room time, 90-day reoperation rate, 90-day readmission rate, and non-routine discharge rate. Standardized mean differences (SMDs) were calculated for covariates to evaluate matching quality. Multivariate logistic regression was used for binary outcomes, and the Mann-Whitney U test was applied for continuous outcomes.

Results
The matched cohort included 873 patients (291 in the GLP-1 RA group and 582 controls). The most common procedure was anterior cervical discectomy and fusion (n = 195, 22.3%). The GLP-1 RA group was 61.9% female, with a mean age of 61.5 years (SD = 9.1) and a mean BMI of 33.7 kg/m² (SD = 6.1). Only 8% of eligible patients in the database were prescribed GLP-1 RAs, lower than the national average. SMD values averaged 1.62%, indicating excellent matching. GLP-1 RA use was associated with a significant reduction in post-operative LOS (GLP-1 RA: 5.9 days vs. Control: 7.2 days, linear coefficient: -1.33 days, 95% CI: -2.44 to -0.23, p = 0.018), particularly in lumbar fusion and posterior cervical fusion procedures. No significant differences were observed in operating room time, 90-day reoperation rate, 90-day readmission rate, or non-routine discharge rate.

Conclusion
GLP-1 RA use before spinal surgery significantly reduced post-operative LOS in a racially heterogenous single-institution cohort. Future research should explore the effects of GLP-1 RAs in spinal surgery using prospective, multi-institutional cohorts to validate these findings.

Supplemental Table 1: Comparison of Continuous Perioperative Metrics Between GLP-1 RA Users and Propensity-Matched Controls Across Procedural Sub-Cohorts

Sub-cohort	Outcome Variable	GLP-1 RA median [IQR]	No GLP-1 RA median [IQR]	P Value
ACDF + ACCF	LOS	2.0 [1-4.75]	2.0 [1-6]	0.322
	OPR Minutes	229.5 [176.5-331.8]	242.5 [193.3-317.8]	0.671
Lumbar Laminectomy	LOS	2.0 [1-4.75]	3.0 [1-9]	0.222
	OPR Minutes	161.5 [109-247]	195 [138.5-260.5]	**0.036****
Lumbar Fusion	LOS	4.0 [3-5.25]	4.0 [3-7]	**0.008****
	OPR Minutes	339.5 [226.8-446]	362 [256.5-478.5]	0.191
Posterior Cervical Fusion	LOS	6.0 [4-8]	8.0 [5-13.8]	**0.044****
	OPR Minutes	390.0 [305-450]	398.5 [297.5-462.8]	0.685
All Other Procedures	LOS	11.5 [5.25-16.8]	9.0 [5-19]	0.884
	OPR Minutes	319.0 [167.5-464]	286 [190-481]	0.960

*ACDF = Anterior Cervical Discectomy & Fusion; ACCF = Anterior Cervical Corpectomy & Fusion; CI = Confidence Intervals; GLP-1 RA = Glucagon-like Peptide-1 Receptor Agonist; LOS = Length of Stay; OPR = Operating Room
Mann-Whitney U Test conducted **Demonstrates significant statistical difference, p< 0.05

Outcome by procedure

88. Utilizing Thoracic Kyphosis Normative Data to Identify Abnormal Spinal Alignments in Adult Spinal Deformity Surgery: Implications for the Definition of Proximal Junctional Kyphosis (PJK)

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Hypothesis
Analyzing segmental kyphosis in asymptomatic subjects challenges the definition of PJK

Design
Retrospective analysis of prospective registry

Introduction
Understanding segmental thoracic kyphosis can guide thoracic alignment correction and help redefine proximal junctional kyphosis (PJK), which traditionally uses a universal 10° kyphosis measure at any spinal segment.

Methods
This study includes 193 healthy volunteers and 980 adult spinal deformity (ASD) patients with a 2-year FU after surgery. For both cohorts, TK was classified as hypo (<30°), hyper (>70°), or normal and then divided

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

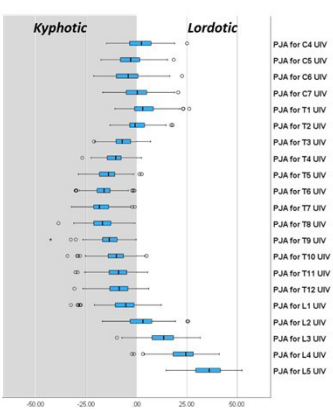
into: T1-T5 (upperTK), T5-T10 (middleTK), and T10-L1 (lowerTK). Based on the normative alignments of global, regional, and segmental TK, the rate of patients with abnormal proximal junctional alignment at 2 years (defined as 2 SD away from normative values) was compared to Glattes' PJK criteria.

Results

Mean TK in asymptomatic volunteers was -48.9°±13.4; its main contribution was middleTK (53.8%), with upper and lower contributing 26.3% and 12.7%. TK segmental normative values (from each vertebra to 2 vertebrae above) are provided in the figure. Pre-op, 38.8% of ASD had hypo-TK, and 2.8% had hyper-TK. Hypokyphosis mainly occurred in middleTK, with significantly lower segmental kyphosis values than normo-TK patients (p<0.001). ASD correction increased TK (-16.9°±12.5, p<0.001), with postop TK distribution showing a slight increase in lowerTK (17.9% vs. 19.8%, p<0.001). Using normative segmental kyphosis data, only 24.2% of ASD patients had abnormal segmental kyphosis post-op, while 40.5% met Glattes' PJK definition (p<0.0001). This discrepancy occurred regardless of UIV location in the thoracic spine. Glattes criteria failed to identify 7% of patients with abnormal segmental alignment at the junction, all with UIV in the lumbar spine.

Conclusion

The mid-thoracic spine primarily drives thoracic kyphosis in adults. This study proposes normative segmental TK values that can serve as alignment targets for TK. Our current definition of PJK does not account for the normal thoracic morphology and should factor in UIV vertebral level. In this study, 16% of PJK identified by the Glattes criteria had a junctional alignment similar to those of healthy subjects, thus calling into question the clinical implications of some cases of traditionally defined PJK.



Description on Healthy Volunteer

PJK vs Abnormal segment in ASD

	N	PJK Rate (Glattes)	Abnormal PJA	P-value
C4	2	0%	0%	-
C5	3	0%	33%	-
C6	0	-	-	-
C7	1	0%	0%	-
T1	8	38%	38%	0.018
T2	68	21%	22%	0.000
T3	119	48%	31%	0.000
T4	165	45%	24%	0.000
T5	40	48%	40%	0.051
T6	9	22%	11%	0.222
T7	2	50%	0%	-
T8	8	63%	13%	1.000
T9	47	49%	34%	0.000
T10	251	52%	23%	0.000
T11	98	49%	19%	0.000
T12	17	47%	18%	0.082
L1	41	15%	17%	0.000
L2	45	11%	20%	0.000
L3	29	7%	24%	0.052
L4	17	0%	6%	-
L5	10	0%	20%	-

89. Disparities in Presentation and Outcomes of Symptomatic Proximal Junctional Kyphosis Based on Over and Under Correction in Adult Spinal Deformity Corrections

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Hypothesis

The presentation of proximal junctional kyphosis (PJK) varies in over and under-corrected.

Design

Retrospective cohort.

Introduction

Proximal junctional kyphosis (PJK) is prevalent after adult spinal deformity (ASD) surgery. The assessment of over and under-correction in age-adjusted alignment on PJK remains to be elucidated.

Methods

ASD patients fused from at least L1 and proximal to sacrum with 2Y data were included. Radiographic PJK (radPJK) was defined by Lafage et al. criteria: >22° change from baseline in PJA & PJA >28°. RadPJK and reoperation for PJK (reopPJK) were evaluated by summation of the Sagittal Age-Adjusted Alignment Score (SAAS) components (TPA, PT, PI-LL). SAAS score was matched (M) if between -1 and 1, under (U) if <-1, and overcorrected (O) if >1. Score was adjusted by one point for each 20-year deviation from target. Greater SAAS mismatch was evaluated by 1 and 2 standard deviations (SD) from the mean postoperative SAAS score.

Results

1065 patients met inclusion (mean age 65, 68% F, 28kg/m2, CCI 1.1, Frailty 3.3). O had earlier onset of radPJK and reopPJK relative to those U (p<.05). Multivariable analysis depicted increased O to have a progressively higher likelihood of radPJK, with O having 1.8x higher odds of radPJK and 5x higher

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

odds of reopPJK compared to U (all p<.05). Increasing age and frailty in O were significant factors increasing the likelihood of reopPJK, whereas lower PI was for U. Table 1. SAAS score of >2 (0.3 SD) and >5 (1.1 SD) increased the likelihood of radPJK and reopPJK respectively, while U to <-6 was for reopPJK. In those requiring reopPJK, U had worse ODI, SRS22r pain, appearance, and satisfaction at the time of occurrence (p<.05). Reoperation improved HRQLs, however to a lesser extent for those mismatched in SAAS. U had a lower MCID rate at 2Y for ODI, SRS22r activity, pain, appearance, and satisfaction (p<.05). PJK prophylaxis affected HRQLs to a greater extent in O relative to U, with 1.5x higher rate of reaching MCID (p<.05).

Conclusion

Under-correction required greater malalignment based on age-adjusted targets, than overcorrection for the development of symptomatic PJK. Those overcorrected were more likely to have earlier and more severe PJK requiring reoperation, while those under-corrected presented with worse disability.

Table 1. Patient Factors

radPJF				
Overcorrected		**OR**	**CI**	**p-value**
	Age	1.054	1.015-1.094	.006
	F Gender	2.697	1.067-6.821	.036
	Preop PI-LL	.970	.951-.989	.002
	ISSG-Invasiveness	1.017	1.007-1.026	<.001
	PJK Prophylaxis	.425	.231-.781	.006
Matched				
	Preop SVA	1.013	1.005-1.022	.002
	Postop PT SAAS Score	.333	.119-.932	.036
Under-corrected				
	Preop PT	1.104	1.035-1.178	.003
	Postop PI-LL SAAS Score	2.128	1.013-4.472	.046
reopPJK				
Overcorrected		**OR**	**CI**	**p-value**
	Age	1.072	1.004-1.145	.036
	Preop T1PA	.947	.901-.994	.027
	Frailty	1.386	1.018-1.886	.038
	Postop PI-LL SAAS Score	2.037	1.176-3.530	.011
	Postop PT SAAS Score	.387	.231-.649	<.001
	PJK Prophylaxis	.156	.025-.964	.046
Matched				
	Frailty	1.502	1.001-2.254	.050
	Postop PI-LL Score	3.320	1.243-8.389	.016
Under-corrected				
	PI	.932	.880-.988	.019

Table 1: Patient Factors

90. Predicting Proximal Junctional Kyphosis after Surgical Correction and Fusion from Lower Thoracic Spine to Pelvis in Degenerative Scoliosis: Is there a Role of Thoracic Flexibility

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Hypothesis

Our study hypothesis that thoracic lordosis was a protective factor for PJK. Among the patients with thoracic kyphosis, higher preoperative T1PA and rigid thoracic curve are independent risk factors for PJK.

Design

Retrospective study

Introduction

Thoracic lordosis and thoracic flexibility were reportedly associated with thoracic spinal sagittal alignment and development of proximal junctional

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

kyphosis (PJK) in degenerative scoliosis (DS) patients who underwent corrective and fusion surgery

Methods
DS patients who underwent long-segment fusion from the lower thoracic spine to the pelvis with the second sacral alar-iliac (S2AI) from January 2015 to January 2020 were retrospectively reviewed. According to the magnitude of thoracic kyphosis (TK), patients were stratified into the Lordosis group (TK<0°) and the Kyphosis group (TK≥0°). Patients were further divided into flexible (standing TK — supine TK≥10°, F-group) and rigid (standing TK — supine TK<10°, R-group) based on the change of TK in standing and supine position. Demographic data including age, sex, body mass index (BMI), bone mineral density (BMD), and sagittal alignment parameters were collected. Univariate analysis and multivariate logistic regression were used to identify the risk factors for PJK.

Results
A total of 102 patients aged 64.8±4.1 years old were included in the present study. PJK was observed in 31/102 (30.4%) patients, and the incidence of PJK was significantly higher in the Kyphosis group than in the Lordosis group (37.8% vs. 10.7%, P=0.008). In the Kyphosis group, a subgroup analysis showed a higher odd of PJK in rigid group than in the flexible group (50.0% vs. 20.0%, P=0.009). Patients with PJK had lower BMD (-2.3±0.9 vs. -1.6±1.0, P=0.007) and higher preoperative T1PA (35.1±9.4 vs. 27.7±9.9, P=0.002) than patients without PJK. The multifactorial logistic regression analysis showed that larger preoperative T1PA (P=0.034) and rigid TK (P=0.041) were independent risk factors for PJK.

Conclusion
Thoracic lordosis is a protective factor for PJK following corrective surgery for degenerative scoliosis. In patients with kyphotic thoracic spine, decreased thoracic flexibility and increased preoperative T1PA are associated with the development of PJK.

91. Pre-contoured Rods in Deformity Surgery: Is the Juice Worth the Squeeze?

Gautham Prabhakar, MD; Yusef Jordan, MD; *Gregory M. Mundis Jr., MD*

Hypothesis
Surgeon specific rods are able to more reliably obtain target alignment goals compared to intraoperatively bent rods

Design
Retrospective cohort

Introduction
Achieving optimal alignment targets in deformity surgery requires thorough preoperative planning. Patient specific instrumentation has evolved in the recent years. Careful planning software can assist the surgeon in obtaining the ideal alignment parameters for successful outcome. This can then be translated into surgeon specific pre-contoured rods which could offer some benefits in the operative setting.

Methods
A retrospective review of patients who were treated with UNiD rods were identified from a single surgeon. A 1:1 match was performed using an existing deformity database in patients who underwent intraoperative bending. All patients had either a 3 or 6 month postoperative radiograph. Pelvic parameters were captured from the preoperative, alignment planning, and postoperative radiographs. The rods were prefabricated based on the software assisted surgical plan.

Results
43 patients who were treated with UNiD rods were identified. 23 patients met inclusion criteria, and 23 patients were matched by PI, age, and gender. Mean PI was 59 and 60 for the UNiD and pre bent groups, respectively. L1PA goal accuracy (within 5 degrees) was 87% in the pre-contoured and 74% in the intra-op bent rod group (p=0.46). There was a statistically significant difference in T4PA goal accuracy which was 74% and 43.5% in the pre-contoured and bent rod groups, respectively (p=.036).

Conclusion
While L1PA target attainment was similar between the two cohorts, patients treated with UNiD rods demonstrated significantly improved T4PA goal achievement. Pre-contoured rods may offer several benefits including decreased operative time, reduced surgeon mental and physical fatigue, and less notching/weakening of the rod. Future studies are needed to identify potential benefits including cost analysis of pre-contoured rods in deformity surgery

92. Age-Adjusted Alignment Goals Inadequately Represent Asymptomatic Adults and are Prone to Undercorrection

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Hypothesis
Age-adjusted alignment formulas inadequately reflect alignment in asymptomatic adults.

Design
Retrospective cohort

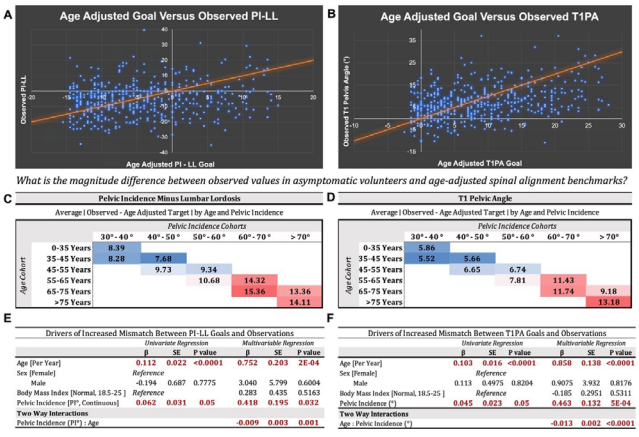
Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Introduction
Recent literature emphasizes age-adjusted alignment objectives in deformity correction, advocating for less aggressive adjustments in older patients. However, applicability of these age-adjusted alignment formulas remains unverified in asymptomatic adults.

Methods
468 asymptomatic adult volunteers with biplanar spinal imaging were included in this multi-ethnic, multi-center cohort. The primary endpoint, mean absolute error(MAE), quantified the absolute discrepancy between observed and age-adjusted targets for Pelvic Incidence-Lumbar Lordosis(PI-LL) and T1 Pelvic Angle(T1PA). These targets were derived as follows: for PI-LL,[(Age-55)/2 +3]; for T1PA,[(Age-55)/2 +16]. Univariate and multivariable logistic regressions assessed the relationship between the actual-to-target alignment deviation and demographic/radiographic factors. The multivariable model adjusted for age, BMI, sex, and pelvic incidence(PI) and incorporated two-way interactions among these variables. Data are shown as[β Estimate(Std Error, P Value)].

Results
Figure 1A and 1B show comparative plots of observed and target values for PI-LL and T1PA, respectively. The MAE for PI-LL was 9.41°. Older age groups exhibited greater deviations: 55–65 years[4.11(1.1, 0.0002)], 65–75 years[5.9(1.42, <0.0001)], and >75 years[5.71(2.28, 0.0124)]. A significant correlation between PI and MAE was observed, with higher errors in PI ranges 60-70[6.3(1.2, <0.0001)] and >70[5.29(1.47, 0.0003)]. Multivariable analysis(Figure 1E) identified increased age[0.75(0.2, 0.0002)] and PI[0.42(0.19, 0.0323)] as independent predictors of larger discrepancies, alongside a significant age x PI interaction[-0.01(0.003, 0.0012)]. The greatest absolute error(>13°) was in participants >55 years with PI >60°(Figure 1C). For T1PA, the MAE was 6.77°, with similar predictors to PI-LL in both univariate and multivariable models. In the latter(Figure 1F), older age[0.86(0.14, <0.0001)] and higher PI[0.46(0.13, 0.0005)], with a significant age x PI interaction[-0.01(0.002, <0.0001)], significantly influenced the error magnitude.

Conclusion
Age-adjusted alignment formulas do not accurately represent asymptomatic adults. Age-adjusted targets, premised on symptomatic adults, risk under correction in older patients needing reconstructive surgery.



93. Gait Analysis of Patients with Suboptimal Clinical Outcomes Following Deformity Correction in Adult Spinal Deformity

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Gil Han, MD; Cheol-Hyun Jung, MD; *Hong-Sik Park, MD*; Woo-Jae Jang, MD

Hypothesis
The persistence of midfoot strike gait (MFS) in patients following deformity correction in adult spinal deformity (ASD) leads to suboptimal clinical outcomes, despite favorable radiographic outcomes.

Design
A retrospective study

Introduction
MFS is a distinct preoperative gait pattern observed in ASD patients, wherein the process of load transfer from heel to the midfoot following heel strike, is dramatically shortened. Despite ideal deformity correction, MFS appears to persist in certain patients. Accordingly, this study aimed to analyze the gait patterns of ASD patients and assess the clinical significance of persistent MFS after surgery.

Methods
176 patients (mean age 70.1 years) who achieved optimal sagittal balance following deformity correction were analyzed. Treadmill-based gait analyses, including center-of-pressure trajectory and three-foot-zone analysis, were conducted preoperatively and postoperatively. Based on postoperative gait pattern, patients were classified into MFS-negative (MN) (n=115) and MFS-positive (MP) groups (n=61), and comparative analyses were performed. Gait patterns of both groups were also compared to those of the normal control group (n=72).

Results
All gait parameters, excluding step time, stride time, and cadence, showed less difference between MN

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

group and the control group, than between MP group and the control group (p<0.05). MN group showed a similar time change in heel-to-forefoot (%) to that of the control group after surgery (p=0.013), and the maximum pressure difference between heel and midfoot was significantly larger in the MN group than in the MP group (p=0.001). There was a significantly higher likelihood of patients with persistent MFS to direct their gaze at the floor while walking (odds ratio 10.95). At the last follow-up, MN group showed a significant improvement in clinical outcomes, including VAS score for back pain, ODI, and SF-36 scale (p<0.05).

Conclusion

Despite achieving optimal sagittal balance in ASD, persistent MFS may lead to suboptimal clinical outcomes, which could result in ongoing pain and restrictions in daily activities. In the setting of ASD surgery, when radiographic outcomes are favorable but clinical results are not, examinations of gait patterns – notably the persistent MFS – as well as investigations behind a tendency for the downward gaze while walking, are warranted.

TABLE. Comparison postoperative gait and radiographic parameters between MN and MP groups†

Variables	Control (N=72)	MN group (n=115)	MP group (n=61)	*p* value
Post PI-LL (°)		-17.9 ± 10.4	-14.8 ± 11.7	0.080
Post SVA (mm)		-20.4 ± 33.6	-16.4 ± 33.1	0.445
Gait parameters				
step length (cm)	44.2 ± 15.4	27.0. ± 9.3	21.0 ± 8.5	<0.05*
stride length (cm)	88.3 ± 30.8	53.9 ± 18.6	42.0 ± 17.1	<0.05*
stance phase (%)	65.1 ± 8.3	69.7 ± 3.7	72.5 ± 4.4	<0.05*
swing phase (%)	33.6 ± 5.0	30.3 ± 3.7	27.5 ± 4.4	<0.05*
double stance phase (%)	31.9 ± 7.1	39.4 ± 7.3	45.0 ± 8.7	<0.05*
Butterfly parameters (Center of pressure analysis)				
length of gait line (mm)	257.3 ± 67.0	222.5 ± 40.6	195.9 ± 46.9	<0.05*
single limb support line (mm)	130.1 ± 50.3	73.9 ± 32.9	52.7 ± 25.7	<0.05*
lateral variability (mm)	11.0 ± 17.9	16.8 ± 9.2	20.8 ± 8.1	0.005*
Force and pressure				
time change heel to forefoot (%)	34.9 ± 11.8	34.1 ± 13.0	28.1 ± 15.4	0.006*
maximum heel pressure (N/cm²)	18.6 ± 6.1	15.0 ± 4.7	12.8 ± 3.7	0.002*

† Data are presented as mean ± standard deviation.

** Statistically significant (p < 0.05)*

Post indicates postoperative; PI, pelvic incidence; LL, lumbar lordosis; SVA, sagittal vertical axis

Postoperative gait and radiographic parameters

94. Analysis of Bone Mineral Density of Lumbar Vertebrae after Sagittal Correction in Adult Spinal Deformity Using Computed Tomography Imaging

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Gil Han, MD; Cheol-Hyun Jung, MD; Hong-Sik Park, MD; *Woo-Jae Jang, MD*

Hypothesis

The bone mineral density (BMD) of lumbar vertebrae decreases after deformity correction in patients with adult spinal deformity (ASD).

Design

A retrospective study

Introduction

Dual-energy X-ray absorptiometry is widely used in BMD measurement, yet it poses inherent limitations for patients who have received long level spinal instrumentation. Accordingly, methods for evaluating vertebral bone quality using CT imaging through attenuation (Hounsfield unit, HU) have been introduced, but postoperative studies of their use in the setting of ASD surgery are lacking.

Methods

156 ASD patients (mean age 71.6 years) who underwent long-segment fixation through lateral lumbar interbody fusion and posterior column osteotomy were analyzed. The HU of each vertebral body from L1-4 was measured using mid-vertebral body sagittal reconstruction CT images following deformity correction, at 1-year and 2-years postoperatively. Changes in HU over time were examined. In addition, the HU and spinopelvic parameters were analyzed and compared between groups with and without accessory rod (AR) fixation.

Results

The HU of all four lumbar vertebrae decreased significantly with increasing follow-up duration. The HU of the vertebrae decreased in both groups, 1-year postoperatively. At both 1-year and 2-years postoperatively, the HU at L1,3,4 decreased at a greater extent in patients who received AR fixation, than in those who did not. Also, the ratio in reduction of HU at L3,4 was greater in patients with AR fixation than in those without. In correlation analysis, the amount of decrease in HU and the ratio in reduction of HU was determined to be greater with larger values for postoperative lumbosacral junctional angle, lower distribution index, sacral slope, and preoperative T-score.

Conclusion

Our results suggest that a greater stress-shielding effect from AR fixation may lead to a reduction in vertebral bone density. Also, when lower lumbar lordosis is corrected to a larger extent, the apex of lumbar lordosis is established further distally and the shear force becomes more concentrated, which could result in stress-shielding over a broader area of lumbar spine. Therefore, we must aim to achieve a solid fusion mass by ensuring preservation of the posterior fusion bed and explore different ways to integrate ARs to the construct in ASD surgery.

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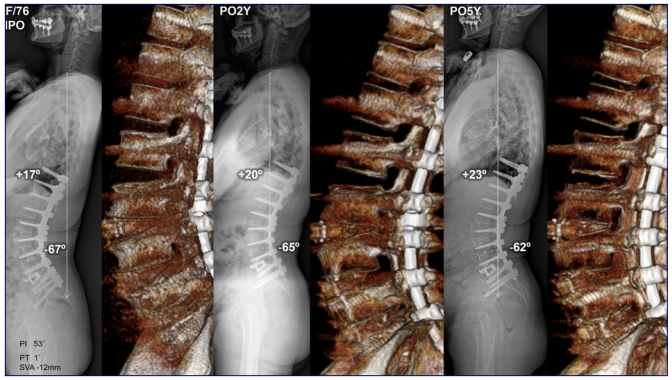


Decrease in bone density, despite optimal sagittal balance

95. Neurocognitive Changes Following Adult Spinal Deformity Surgery: A Prospective Study with 12-Month Follow-Up

Tej D. Azad, MD; John F. Burke, MD, PhD; Justin K. Scheer, MD; Terry Nguyen, BS; Jaemin Kim, BS; Vedat Deviren, MD; Christopher P. Ames, MD

Hypothesis
Adult spinal deformity (ASD) surgery is

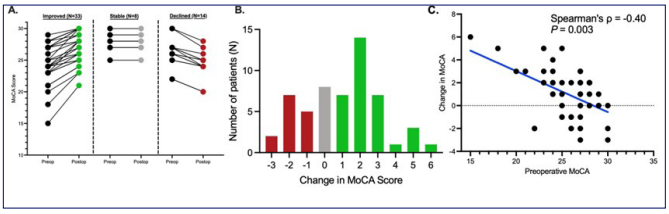
Design
Prospective cohort study

Introduction
A common concern is that the stress induced by adult spinal deformity (ASD) surgery may cause a post-operative decrease in cognitive function, especially in the elderly patients with some component of cognitive impairment. On the other hand, it is possible that ASD surgery could increase cognitive ability by increasing activity and decreasing pain. To date, this issue has not been directly investigated.

Methods
ASD patients treated with posterior spinal fusion of greater or equal to 10 vertebral segments for adult deformity were included. Only patients with 12 month follow up are included in this study. The primary outcome variable was performance on the Montreal Cognitive Assessment (MoCA) test of dementia and cognitive impairment, which was measured pre-operatively and at 12-month follow-up. We also collected outcome metrics including the Oswestry Disability Index (ODI), Scoliosis Research Society questionnaire (SRS-22) with sub-components. Pre-operative and post-operative morphine equivalent dose (MED) of narcotic medication was collected using patient surveys and verified using prescription data. A multi-variate logistic regression (LR) was used to predict improvements in MoCA scores.

Results
We enrolled 55 patients who met inclusion criteria. There was a significant increase in MoCA scores at 12-month follow-up compared to pre-operative MoCA scores (P < 0.001). Overall, 60% of patients exhibited an increase in MoCA scores, and 47.2% met minimally clinically important difference (MCID). More severely cognitively impaired patients tended to improve to a greater degree than less severely impaired patients (P = 0.003). While there was no clear association between reduction in postoperative opioid use and cognitive improvement, we observed a possible association between postoperative delirium and cognitive decline among patients with baseline cognitive impairment (P = 0.01).

Conclusion
ASD surgery may be associated with an improvement in cognitive function at one year follow-up. Further work is required to understand the drivers associated with cognitive improvement and worsening after ASD surgery.



Change in the MoCA score after ASD surgery (A, B). Change, relative to preoperative MoCA (C)

96. T4-L1 Pelvic Angle Mismatch as a Potential Risk Factor for Mechanical Complications After Long-Level Fusion Surgery

Myung-Hoon Shin, MD, PhD

Hypothesis
The L1 pelvic angle (L1PA), which directly measures spinopelvic alignment and is strongly associated with pelvic incidence (PI) and lumbar lordosis (LL), is expected to be nearly equivalent to the T4 pelvic angle (T4PA) in normal spines with normal global sagittal balance, aligning the T4-L1-hip axis.

Design
Retrospective cohort study

Introduction
Mechanical failure (MF), including proximal junctional kyphosis, is a common complication following surgical treatment of adult spinal deformity (ASD). Despite various radiographic parameters proposed to predict MF, the optimal method remains undetermined. This study aimed to evaluate the discrepancy in postoperative T4-L1 pelvic angle as a potential risk factor for mechanical complications after long-level lumbar fusion surgery.

Methods
Data were retrospectively extracted for ASD pa-

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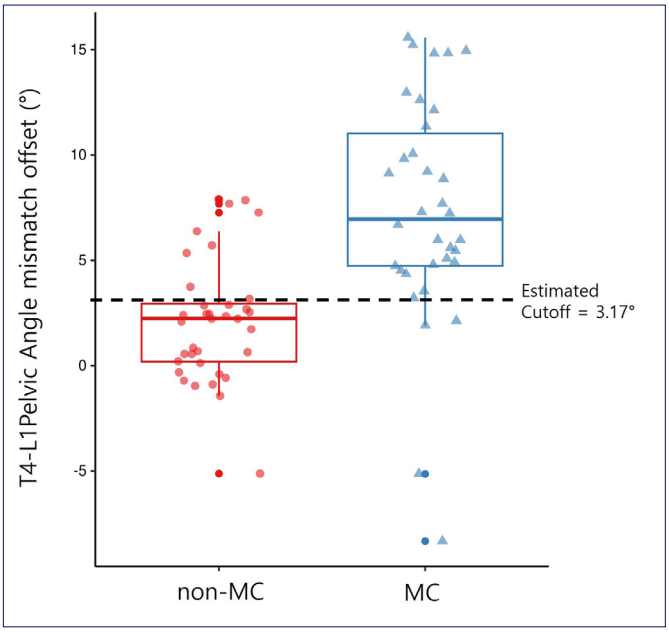
tients who underwent at least 4-level lumbar fusion surgery with >2 years follow-up. Demographics, operative details, preoperative and postoperative spinopelvic parameters, and global sagittal balance parameters were assessed. Differences and correlations in these variables were analyzed, followed by logistic regression and receiver operating characteristic curve analyses.

Results

70 patients were divided into two groups: 36 in the nonmechanical complication group (non-MC) and 34 in the mechanical complication group (MC). The mean age was 69.49 ± 7.44 years (range 47–86), with a mean follow-up of 63.72 ± 13.24 months (range 24.04–74.71). Preoperatively, the MC group had significantly greater T4PA (24.88 ± 10.98° vs. 16.12 ± 7.33°, $p < 0.001$), L1PA (17.01 ± 7.48° vs. 13.57 ± 6.83°, $p < 0.001$), and T4-L1PA mismatch (2.55 ± 3.53° vs. 7.87 ± 6.34°, $p < 0.001$) compared to the non-MC group, with similar PI (58.89 ± 6.66° vs. 58.40 ± 9.14°, $p = 0.399$). Postoperatively, the MC group showed a significantly greater T4-L1PA mismatch (7.32 ± 5.40°) than the non-MC group (2.13 ± 2.93°, $p < 0.001$). The optimal cutoff value of T4-L1PA was 3.17° (AUC 0.83, sensitivity 0.77, specificity 0.88). T4-L1PA mismatch was a significant predictor of MC (OR 26.25, 95% CI 7.11-96.90, $p < 0.001$).

Conclusion

Postoperative T4-L1PA mismatch is a stronger predictor of MC than other radiographic parameters. Surgical correction of ASD, especially when T4-L1PA mismatch exceeds 3.17°, is significantly linked to MC. Equivalence between T4PA and L1PA should be achieved after long-level fusion surgery.



97. The Benefit to Prone Lateral Approach in Minimally Invasive Adult Spinal Deformity Surgery: Cost-Benefit Analysis of Single Position vs. Staged/Flipped Procedures

Ankita Das, BS; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Anthony Yung, MMSc; Matthew Galetta, MD; Nathan Lorentz, MD; Jordan Lebovic, MD, MBA; *Peter G. Passias, MD*

Hypothesis

SP will have superior outcomes to staged/flipped procedures.

Design

Retrospective cohort.

Introduction

Improvements in adult spinal deformity (ASD) surgery techniques have expanded to include minimally invasive surgery (MIS). Single positioning (SP) via combined approach to ASD has been studied on its benefits. Cost-benefit analysis has yet to be done for prone lateral (PL) position compared to staged/flipped procedures.

Methods

Operative ASD patients >18 years w/ baseline (BL) and 2-year (2Y) follow-up included. Cohorts: SP robotics vs staged/flipped robotics. Cost analysis: avg. Medicare reimbursement cost accounting for approach, revision status, complications/comorbidities, and major complications/comorbidities defined by CMS.gov manual definitions. Reimbursement: standardized estimate using regression analysis of Medicare pay-scales for services w/in a 30 day window. Costs were inflation adjusted to 2022. QALY analysis: utility calculated using EQ-5D as previously published. ANCOVA and logistic regressions utilized to assess differences in outcomes, while accounting for covariates as appropriate.

Results

233 included: age 56.1±11.4Y, BMI 30.6±6.6kg/m2, 54%M, CCI 1.2±1.9. 103 same-day combined (lateral and posterior), with 22 in the PL SP. PL group older ($p<.001$) with lower BMI ($p=.030$) and higher CCI ($p=.013$). PL had lower EBL and operative time (both p-value<.001) and less osteotomies (10% v 43%;$p=.002$). PL had similar number of levels fused, but higher avg. LIV (L5 v S1;$p=.003$) and UIV (L2 v L3;$p=.004$). Correction: no significant differences preop/postop. PL had less pulmonary (0% v 4%;$p=.019$) and GI complications (0% v 3%;$p=.039$), but higher rates of urinary retention (14% v 5%;$p=.032$). Shorter LOS for PL (3.3 v 4.7D;$p=.004$) w/ lower discharge to a rehab facility (0% v 13%;$p<.001$). PL had greater improvement in 2Y SRS Total (-6.0 v -3.3;$p=.031$). Accounting for covariates, mean

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cost lower for PL ($43,806.98 v $55,549.13;p=.011). Equated to mean cost/QALY at 2Y of $38,771.16 PL v $46,501 Non-PL.

Conclusion
Prone-Lateral procedures resulted in overall improvement in outcomes compared to Staged and Flipped procedures in MIS ASD surgery. PL patients had significant improvement in LOS and discharge disposition with less surgical invasiveness, indicating increased benefit to less invasive surgical techniques in patient recovery postoperatively.

98. Use of a Novel Screw Fusion Implant for Pelvic Fixation: Results from a Prospective Multicenter Trial

Richard P. Menger, MD; Christopher J. Kleck, MD; Jeffrey P. Mullin; Kara Ashcraft, PhD

Hypothesis
The PAULA study is being performed to assess short- and long-term safety and effectiveness of a novel implant.

Design
PAULA (NCT05640908) is a multicenter, single-arm study with prospective and retrospective cohorts.

Introduction
Adult spinal deformity often requires complex fusions to restore sagittal and coronal balance. Constructs that span the lumbosacral junction commonly include pelvic fixation. Distal construct failure, including pseudarthrosis, rod or screw fracture, and set screw dissociation remain a challenge, occurring in up to 34% of cases. In 2022, FDA cleared a novel screw fusion implant (SFI) indication for fixation and sacroiliac joint fusion. The cancellous bone-mimicking surface promotes permanent biological fixation.

Methods
Participants enrolled in the prospective cohort will be followed at regular intervals for 2 years. The retrospective cohort contains one-year outcomes on consecutively treated patients at the participating clinical site. Adverse events, postoperative incidence of new onset SIJ pain, pseudarthrosis, and pelvic construct failures were collected.

Results
145 patients have been enrolled and treated. 54 prospective participants have completed 6-month follow-up, and 5 have completed 12-month follow-up. 29 retrospective participants are included in the 12-month follow-up results. To date, there are no reported failures of the SFI, including set screw dissociation or screw fracture. Four revisions have been reported: one case of a S1 pedicle fracture on POD #3 on a revision of a previous L5-S1 pseudoarthrosis case in the setting of spondylolisthesis. Three cases of early proximal junctional kyphosis (PJK) were reported, for an incidence of 1.4%. Two late (≥ 90 days) failures have been reported: one instance of PJK, and one instance of proximal rod disengagement. Neither of these resulted in revision surgery. The overall revision rate for any reason was 2.1%. PJF accounted for 67% of these; none were related to pelvic construct failure. No device related adverse events have been reported.

Conclusion
At one year, the novel SFI studied yielded no reports of loosening, set screw dissociation, implant or rod breakage, and no device-related adverse events. This compares favorably with current literature and supports the safety of the novel SFI. Study enrollment and long-term follow-up is still underway.

99. Oral Synthetic Tetrahydrocannabinol (osTHC) was safe but not effective at reducing opioid consumption after 1-3 level lumbar fusions: A double-blind, randomized, controlled trial

Jeffrey L. Gum, MD; Leah Y. Carreon, MD; Morgan-Brown, MS; Colleen Mahoney, BS; Christy L. Daniels, MS; Bren Hines, RN; *Steven D. Glassman, MD*

Hypothesis
Tetrahydrocannabinol (THC) is safe and effective at reducing opioid consumption after 1-3 level lumbar fusions

Design
Prospective double blind randomized clinical trial

Introduction
Given the current opioid epidemic, there is a need to minimize opioid exposure to avoid side-effects and long-term dependence. Recent studies have investigated the potential for orally administered synthetic active form of delta-9-THC to minimize opioid consumption in non-spine, orthopedic procedures with some success.

Methods
Patients scheduled for 1-3 level lumbar instrumented fusion for degenerative conditions were enrolled. Patients with depression, anxiety, or previous drug use disorder were excluded. State law did not allow assessment of pre-operative THC use. The treatment arm received 5mg of THC immediately prior to surgery and 5mg every 12 hours postoperatively for 96 hours. The placebo arm received a similar appearing capsule. A standardized opioid escalation protocol was utilized postoperatively and daily opioid consumption was collected. Patients and care team were blinded to treatment arm.

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Results

Sixty-three patients were offered study participation, with only 39 (62%) being randomized. Failure to enroll was resulted from secondary screening failure (14), cancellations (4), and refusal (7). There were no differences in demographics, preoperative, or operative parameters between groups. Post-operative opioid use was similar in in the THC and placebo groups. Post-operative complications were also equal in the two groups.

Conclusion

In this RCT, a low dose of oral synthetic THC was safe, but not effective in reducing post-operative opioid use. The study excluded patients with depression, anxiety, or prior drug use disorders which may have eliminated a population that would have benefitted from treatment. Pre-existing THC consumption might influence the effectiveness of an oral 5mg dose twice daily, and despite randomization, the study was small enough that a confounding effect might persist. Under the current study parameters, an osTHC is not effective in reducing opioid consumption, but does appear safe. Future efforts should consider patient specific dosing.

	Placebo	Dronabinol	
	16	**19**	
MME per Day consumed			
Intra-operative	11.45 (13.95)	10.92 (12.63)	0.906
Post-operative Day			
1	51.95 (38.8)	44.84 (37.33)	0.586
2	17.24 (35.54)	21.56 (32.82)	0.711
3	13.82 (28.53)	8.91 (15.78)	0.526
4	5.53 (15.17)	3.75 (15)	0.731
Cumulative MME per Day consumed			
Post-operative Day			
1	69.18 (63.79)	66.41 (67.28)	0.902
2	83 (86.25)	75.31 (78.37)	0.784
3	88.53 (94.86)	79.06 (84.52)	0.757
4	69.18 (63.79)	66.41 (67.28)	0.902

	Placebo	Dronabinol	
	16	**19**	
In-Patient			
Gastro-Intestinal (Ileus, Constipation)	7 (44%)	5 (26%)	0.311
Mental Status Change	2 (13%)	4 (21%)	0.666
Neuro Deficit	2 (13%)	2 (11%)	0.855
Six weeks Post op			
Radiculopathy	2 (13%)	4 (21%)	0.476
Wound Issues	3 (19%)	3 (q6%)	0.817
Mental Status Change	0	4 (21%)	0.109
Twelve weeks Post op			
Death	1 (6%)	0	0.457

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E-POINT PRESENTATION ABSTRACTS

100. Temporal Patterns of Mechanical Complications Across Heterogeneous Patient Subgroups following Adult Spinal Deformity Surgery: Leveraging Supervised Machine Learning Approach

Zhen Liu, PhD; Zhen Tian, MS

Hypothesis
Machine learning can help us identify high-risk patients better than traditional statistical methods

Design
retrospective study

Introduction
Despite advancements in orthopedic techniques and concepts, approximately 24%-65% of patients still experience mechanical complications (MC) after long-construct spine fusion. Due to the complex spinal malalignment, concurrent fragility, and individual surgical strategies, early and accurate risk-stratify their patients for mechanical failure remains challenging. Therefore, further investigation into the role of risk factors in the occurrence of MC will help us optimize spinal surgical workflows.

Methods
Of 4206 patients who underwent ASD surgery, 716 patients fulfilled the entry criteria. ASD patients were randomly allocated into training (60%, N=430) and test (40%, N=286) sets. Patient demographics, radiologic features, intraoperative factors, and other variables reported in literature, such as paraspinal sarcopenia and vertebral bone quality (VBQ) were included. 10-fold cross-validation was used to develop various ML models. SHAP analysis was used to identify key risk factors.

Results
The overall mechanical complication rate is 21.8% (N=156), with 70 patients (9.8%) experiencing at least one mechanical complication between post-op day 1- and 1-year post-op, 56 patients (7.8%) between 1- and 2-years post-op, and 22 patients (3.1%) between 2- and 3-years post-op. The random forest model showed the best comprehensive performance and identified the most critical features, in order of importance, were higher preoperative T1PA, etiology, paraspinal sarcopenia, pelvic fixation, poor vertebral bone quality (VBQ), and advanced age. The corresponding two-year survival rates are 70.9% (pre-T1PA > 10°), 60.6% (diagnosed with degenerative scoliosis), 72.2% (Severe paraspinal sarcopenia),71.8% (VBQ score > 2.5),60.9% (pelvic fixation), and 64.9% (older than 50 years).

Conclusion
Our study developed ML prediction model to identify clinically important variables associated MC in patients who underwent ASD correction. Estimation of timing and type of mechanical complication in different patient populations may provide us with valuable insights in surgical management and patients consultation.

102. Proximal Junction and Transitional Mechanics and Effect of a Novel Tether Pedicle Screw in Long-Segment Spinal Instrumentation.

Raphael Gmeiner, MD; Heiko Koller, MD; Sara Lener, MD, PhD; Christoph Orban, MD; Anto Abramovic, MD; Marko Konschake, MD; Werner Schmoelz, PhD; Claudius Thomé, MD; Sebastian Hartmann, MD, PhD

Hypothesis
To analyse the biomechanical characteristics of a Tether pedicle screw (TPS) in long-segment thoracolumbar instrumentation in terms of proximal junction mechanics and transitional motion patterns.

Design
A biomechanical study of ten human thoracolumbar (T7-L2) spine specimens was performed.

Introduction
Adult spinal deformity correction carries a high junctional failure risk. A soft-landing construct at a rigid construct cranial end might reduce the proximal junctional kyphosis (PJK) and failure (PJF) risks. Therefore, a novel TPS was designed to mitigate the PJK/PJF risk. The pedicle screw is characterized by a tether between the threaded shaft and the screw head, enabling motion among parts.

Methods
For initial flexibility tests, three instrumentation patterns were tested. Representing conventional instrumentation, standard thoracolumbar pedicle screw-rod instrumentation at T10-L2 was used (STD group). The TPS was tested at T9 (TPS+1 group), one level above the upper instrumented vertebra (UIV), and at T9 and T8 (TPS+2 group). Flexibility tests (±5 Nm) in all three motion directions were performed and repeated after cyclic loading (250 cycles, 1-10 Nm). Finally, specimens in the STD and TPS groups were subjected to screw pull-out testing at the index level to analyse the TPS stress-shielding effects.

Results
The TPS+2 group demonstrated the largest range of motion (ROM) decrease at T9-10 in the flexibility tests, with a smaller effect in the second adjacent segment at T8-9. No significant change in ROM was observed in the uppermost segment (T7-8) among all instrumentation pattern studies. Pull-out testing revealed greater mean forces at the T10 end-level in the TPS+2 group than in the STD group.

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Conclusion
The TPS effectively distributed the loads across three adjacent levels and softened the load transition compared to the rigid construct. The TPS also showed the potential to stress-shield the UIV (T10) and reduce the end-level screw loosening risk.

103. Novel "Rail Technique" Decreases Screw Strain During Spinal Deformity Cantilever Bending

Alekos A. Theologis, MD; Jason DePhillips, MS; Nathanial A. Myers, BS; Izabella T. Lachcik, MS; Jonathan M. Mahoney, BS; Brandon S. Bucklen, PhD

Hypothesis
The novel "rail technique" will decrease pedicle screw strain compared to the traditional cantilever bending technique.

Design
Biomechanical Study

Introduction
A novel "rail technique" has been proposed to help minimize bone-screw interface strains across a 3-column osteotomy (3CO). This study compares the mechanical behavior of traditional cantilever bending (CB) to CB over the "rail."

Methods
10 PCF foam blocks were implanted with 6 instrumented pedicle screws. For traditional CB, a pre-bent rod was placed in the screws and tightened on all screws cranial to the 3CO then underwent 3 CB tests (each with a n=7) with set screws placed on: (1) screws 4, 5, 6 (S4+S5+S6: "best-case"); (2) screws 4, 5 (S4+S5; "worst-case-1"); and (3) screw 4 (S4; "worst-case-2"). For "rail" CB, non-contoured primary/midline rods were placed and tightened above/below the 3CO. A pre-bent "rail" rod was secured to the midline rod above the 3CO via 2 W-connectors, which then underwent 2 CB tests (each with a n=7) with the "rail" rod bent to: (1) both W-connectors (W1+W2: "best-case"); and (2) W-connector closest to the 3CO (W1: "worst-case"). For all CB maneuvers, a manual force was applied until the rod was seated in the respective caudal screw.

Results
During "best-case" scenarios, screw #3 had significantly lower strain during CB over the "rail" compared to traditional CB. Although not significant, this trend was also observed for screw #4 (p = .775). Summing the total peak strain of the "best-case" scenarios, CB over the "rail" distributed the strain more evenly (#1-10%, #2-18%, #3-21%, #4-15%, #5-14%, #6-22%) compared to traditional CB (#1-8%, #2-13%, #3-36%, #4-21%, #5-9%, #6-14%). For "worst-case" scenarios, screw #4 was found to have significantly less strain during CB over the "rail" in which only W1 was engaged compared to traditional CB when only S4 was engaged ($p<0.001$). Screw #3 was also found to have less strain during "worst-case" CB over the "rail" compared to traditional CB in which S4+S5 were engaged ($p<0.001$) and when only S4 was engaged ($p<0.001$).

Conclusion
CB over the "rail" significantly reduced the amount of strain placed on a single pedicle screw adjacent to the 3CO compared to traditional CB. The "rail" accessory rod distributed the required corrective forces across multiple screws. Ongoing work is focused on acquiring data in cadavers.

a) CB and CB over the "rail" constructs; b) "best-case"; c) "worst-case"

104. Does Cervicothoracic Flexibility Affect Clinical Outcomes in Patients Undergoing Multi-Level Posterior Cervical Fusions?

Devender Singh, PhD; Eeric Truumees, MD; Ashley Duncan, RN; Matthew J. Geck, MD; John Stokes, MD; Morgan Laviolette, DPT; Vik Kohli, MD; Rory R. Mayer, MD

Hypothesis
Cervicothoracic flexibility had no impact on cervical alignment or clinical outcome in patients undergoing three or more level posterior cervical fusion

Design
Multi-center retrospective study

Introduction
The study aimed to quantify and compare the imaging measurements between the two imaging modalities and determine if cervicothoracic flexibility had an impact on cervical alignment or clinical outcome.

Methods
227 adult patients who underwent a three or more level posterior cervical fusion were assessed.

Results
Overall, the cohort was 53.7% female, with a mean age of 63 ± 13 years, 44% were never smokers. The

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most frequently treated spinal levels were C3-C7. Median Δ T1 Slope was 9°, with a range of -1° to 45°. T1 Slope cohorts: Group I with a Δ of <4°; Group II ≥4° to <15°; Group III ≥15°. Significant differences between Group I and Group III existed in VAS (4.19 and 6.59, respectively) and ODI (35.4 and 45.9, respectively). For Δ C2-C7 Lordosis, the median Δ value was 4°, with a range of -11° to 44°; Group I had a Δ lordosis of <2°; Group II ≥2 to < 7°; Group III ≥7°. Significant differences between Group I and III existed in VAS (4.6 and 6.3, respectively) and ODI (36.7 and 45.5, respectively). Median Δ C2-C7 SVA was 14.37mm, with a range of 37.6mm to 110.2mm. SVA Group I had a Δ of <7.87mm; Group II ≥7.87mm to <27.82mm; Group III ≥27.82mm. There were significant differences between Group I and Group III in VAS (4.8 and 6.4, respectively) and ODI (34 and 45.6, respectively). Revision and complication rates positively correlated with increased Δ measurement. ANOVA analysis of the effect of age, sex, gender, BMI and smoking status on each measurement technique demonstrated age having a significant effect on Δ C2-C7 SVA.

Conclusion

Larger Δ or cervical and upper thoracic flexibility between XR and MRI/CT measurements are positively correlated with higher complication and revision rates. In those patients in whom the delta between the simulated T1 slope from supine studies and the upright T1 slope was higher were found to have much greater post-operative cSVAs and reported significantly higher pain and disability scores compared to those with lower measurement Δ. Age was found to significantly impact Δ SVA measurement. Upper thoracic flexibility should be considered in selecting fusion levels and alignment goals in patients undergoing posterior cervical fusion surgery.

105. Radiographic and Clinical Outcome Analysis of Custom vs Surgeon Contoured Rods for Adolescent Idiopathic Scoliosis Deformity Correction §

Matthew J. Geck, MD; *Devender Singh, PhD*; Ashley Duncan, RN; John Stokes, MD; Eeric Truumees, MD; Vik Kohli, MD; Morgan Laviolette, DPT; Rory R. Mayer, MD

Hypothesis

Custom manufactured rods provide superior clinical and radiographic outcomes than surgeon contoured rods for Adolescent Idiopathic Scoliosis (AIS) deformity correction.

Design

Retrospective cohort study

Introduction

We compared clinical and radiographic outcomes between matched cohorts of AIS deformity patients with custom rods and surgeon contoured rods.

Methods

Two cohorts of AIS deformity patients undergoing surgical correction were created: standard rods that were hand bent intraoperatively vs. patient specific custom rods. The cohorts were matched based on curve types, number of levels treated, fusion to pelvis, age, and ASA score.

Results

57 patients, 77.2% female, were included in the custom cohort and 59 patients, 88% female, were included in the surgeon contoured cohort. There were no significant differences between the two cohorts in terms of mean age, body mass index, Risser score, and number of levels treated. Mean estimated blood loss (EBL), operative time (OR) and Length of stay (LOS) were comparatively higher in the custom cohort (EBL: 356±243 mls, OR: 258±49 minutes, LOS: 4.1±3.4 days) than their counterpart (EBL: 328±269 mls, OR: 242.7±43.9 minutes, LOS: 3.6±0.8 days). Mean time per screw placement was 2.3 minutes per screw (range: 1.68-3.2 minutes) for the custom and 2.6 minutes per screw (range:1.7-3.8 minutes) for the other group. At 12 months postoperative, custom cohort demonstrated higher mean % correction in Cobb angle (custom manufactured vs. surgeon contoured: 77.3% vs. 75.3%). Mean %improvement in T1 pelvic angle, PI-LL (PI: pelvic incidence, LL: lumbar lordosis) mismatch and C7 plumb line at 12 months were higher for the custom group than their counterpart. Both groups had similar improvements in PRO scores (custom vs. surgeon contoured: visual analog scale: 43.3% vs. 44.2%; oswestry disability index: 63.3% vs. 61.6%; scoliosis research society-22r: 61.4% vs. 58.7%). Postoperative complications were also similar between the two cohorts.

Conclusion

Patients who had deformity correction using adaptive spine intelligence generated custom rods demonstrated better % correction and less screw time but similar PRO scores and complication rates as those patients who had standard rods. There was a significant increase in EBL and OR time in the custom cohort. These cohorts will continue to be followed for long-term analysis.

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E-POINT PRESENTATION ABSTRACTS

106. Factors Predicting Mechanical Failure in Instrumentation without Fusion for Metastatic Spinal Tumor Surgery

Hyung Rae Lee, MD; Jae Hwan Cho, MD, PhD

Hypothesis
The hypothesis of our study is that lower Hounsfield Unit (HU) values are a significant predictor of mechanical failure in patients undergoing spinal instrumentation without fusion for metastatic spinal tumors.

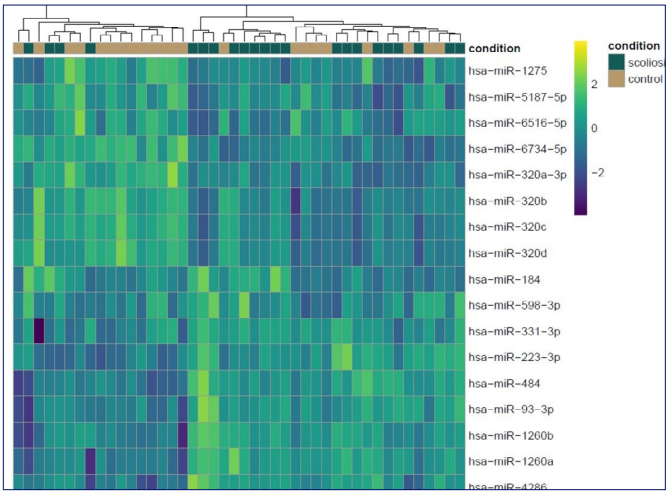
Design
The study was designed as a retrospective cohort analysis, utilizing propensity score matching to compare outcomes between patients with and without mechanical failure after spinal instrumentation without fusion for metastatic spinal tumors.

Introduction
Metastatic spinal tumors often lead to spinal instability, requiring surgical intervention to alleviate pain and prevent neurological deterioration. While spinal instrumentation without fusion is commonly employed, the risk of mechanical failure remains a significant concern, particularly in patients with compromised bone quality. This study aimed to identify risk factors that could predict implant failure in these patients.

Methods
We conducted a retrospective cohort study involving 220 patients who underwent spinal instrumentation without fusion for metastatic spinal tumors. Propensity score matching was applied to create balanced groups based on preoperative characteristics, resulting in 24 patients in the failure group and 72 in the non-failure group. Logistic regression and Kaplan-Meier survival analyses were performed to identify predictors of mechanical failure, with a focus on HU values from preoperative CT scans.

Results
Lower HU values at the Lowest Instrumented Vertebra (LIV) were identified as the only independent predictor of mechanical failure. A cutoff value of 127.273 HU at the LIV was determined to be significant for predicting mechanical failure. The sensitivity and specificity of this cutoff were 59.1% and 73.4%, respectively, with an AUC of 0.655 (95% CI: 0.49-0.79). Kaplan-Meier analysis revealed a significant difference in survival between groups with HU values above and below the cutoff at the LIV (P = 0.0057).

Conclusion
Preoperative HU values below 127.273 at the LIV are strongly associated with an increased risk of mechanical failure following spinal instrumentation without fusion in patients with metastatic spinal tumors. These findings underscore the importance of preoperative bone quality assessment at the LIV in surgical planning to enhance patient outcomes.



Kaplan-Meier curve shows significant difference in implant survival (P = 0.0057) for patients with LIV HU < 127.273, indicating higher failure risk.

108. Perioperative Considerations in Patients with Rett Syndrome as Compared to Those with Cerebral Palsy

Vishal Sarwahi, MD; Effat Rahman, BS; Katherine Eigo, BS; Jesse M. Galina, BS; Sayyida Hasan, BS; Andrew Ko, BS; Yungtai Lo, PhD; *Terry D. Amaral, MD*

Hypothesis
Rett syndrome and Cerebral palsy patient will have similar perioperative outcomes.

Design
Retrospective study

Introduction
Surgical correction in the treatment of scoliosis for patients with Rett syndrome (RS) has been shown to increase survival rate. Cerebral palsy (CP) patients, like RS patients, are often nonverbal, nonambulatory, with frequent surgical complications. Thus, the objective of this study was to compare perioperative outcomes of RS and CP patients to help guide surgical planning.

Methods
Retrospective review of 36 RS and 80 CP patients undergoing PSF from 2005-2023. Data and x-ray measurements were collected pre- and post-operatively. Sub-analysis was performed comparing non-ambulatory patients (GMFCS III-V). Wilcoxon-Rank Sum, Fisher's Exact, and Chi-square tests were utilized.

Results
Preoperative Cobb angle, levels fused, fixation points, length of stay, and complication rates were

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similar (p>0.05). EBL was significantly higher in CP patients, as was duration of anesthesia (p=0.001), rate of transfusion (p=0.001), and surgical time (p=0.001). Postop Cobb (p=0.002) was significantly higher for CP patients. There was no significant difference between CP and RS patients in both preop (p=0.383) and postop (p=0.051) coronal decompensation. Sub-analysis of non-ambulatory RS and CP patients revealed significantly higher postoperative Cobb (p=0.008), EBL (p=0.019) and surgical time (p=0.017) in CP patients compared to RS patients. There were no significant differences in preoperative Cobb, levels fused, fixation points, hospital stay, or complication rate (p>0.05).Nonambulatory status was associated with increased odds of having a postoperative complication (OR=6.17, 95% C.I. 1.36 – 28.04, p=0.019).

Conclusion
RS patients are shown to have better outcomes to CP patients in terms of surgical, perioperative, and radiographic variables. Ambulatory status was identified as an independent risk factor for complications. There were no differences in respiratory complications between Rett syndrome and Cerebral palsy patients. These findings can be attributed to our institution providing care for many Rett syndrome patients, allowing for familiarity among staff and physicians regarding this rare condition.

109. Older Congenital Scoliosis Patients can Attain Similar Curve Correction and Outcomes as AIS Patients without Hemivertebra Excision

Vishal Sarwahi, MD; Effat Rahman, BS; Katherine Eigo, BS; Yungtai Lo, PhD; *Terry D. Amaral, MD*

Hypothesis
Correction of congenital scoliosis can be achieved through the use of pedicle screws and a posterior-only approach without hemivertebra excision.

Design
Retrospective study

Introduction
Hemivertebra (HV) excision in patients is the current gold standard for congenital scoliosis patients, resulting in the best possible correction while decreasing the number of levels fused. However, it is a technically challenging procedure and complications can include spinal cord injury, nerve root injury and CSF leak. We have utilized a HV-sparing approach in patients alongside multi-level Ponte osteotomies and all pedicle screw constructs. The fusion levels are determined in a similar manner as in AIS, as the HV patients have presented at a later age (>10 years) with deformities that extend over multiple segments.

Methods
IRB-approved review of spine deformity patients operated on between 2005 – 2024. 35 patients with congenital scoliosis and associated HV were included. These patients were matched to a pool of 311 AIS surgeries by gender, preop Cobb angle, and levels fused. 35 pairs were analyzed. Wilcoxon rank-sum test and Fisher's Exact test were utilized. HV patients were given an SRS-22 survey to assess clinical outcomes.

Results
Age(p=0.27), BMI(p=0.17) and preoperative Cobb(p=0.56) were similar between HV and AIS patients. Cobb correction(71.8% vs 70.1%, p=0.69) and EBL(p=1.0) were similar. Surgical time and length of stay were similar between the groups (p=0.06, p=0.78). Complication rates were also similar between the groups (p=1.0).SRS-22 survey results for HV patients; pain: 4.2, function 4.8, self-image: 4.4, mental health: 4.6, satisfaction: 4.5.

Conclusion
Choosing fusion levels in congenital patients, on similar principles akin to AIS, leads to avoidance of hemivertebra excision in most cases, including lumbosacral hemivertebrae. Radiographic and perioperative outcomes in these patients were similar to AIS patients. This hemivertebra-sparing approach is safer compared to excision and has similar or better curve correction than previously reported. HV patients also experienced positive clinical outcomes and satisfaction as reported by SRS-22 scores. Patients with congenital scoliosis, in most cases, can avoid hemivertebra excision, while obtaining similar curve correction and perioperative outcomes to AIS patients.

110. Pain, Length of Stay, and Economic Benefits of Rapid Recovery Pathway Protocol Utilizing Intrathecal Morphine

Vishal Sarwahi, MD; Katherine Eigo, BS; Effat Rahman, BS; Nora Donahue, BS; Cole Dutton, BS; Yungtai Lo, PhD; Jon-Paul P. DiMauro, MD; Benita Liao, MD; *Terry D. Amaral, MD*

Hypothesis
Rapid Recovery Pathway (RRP) protocol utilizing intrathecal morphine (ITM) will reduce pain, opioid consumption, and have important cost-saving outcomes.

Design
Retrospective cohort study

Introduction
Many institutions have begun utilizing rapid or enhanced recovery protocols to encourage early oral intake, mobilization, and discharge. However, patient-controlled analgesia (PCA) is still in use with

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these protocols. At our institution, our RRP protocol, introduced in 2018, utilizes ITM (ITM-RRP) which has allowed for the elimination of PCA. We sought to investigate both patient and cost outcomes from ITM-RRP in this large sample.

Methods
Patients with AIS undergoing primary instrumentation and fusion by three senior attendings between 2014-2023 were included. Patients who were operated on prior to the ITM-RRP protocol (2014-2017) were in the PCA group (n=250). Patients operated on after 2018 were in the ITM-RRP group (n=400). Patient outcomes measured include operative time, anesthesia time, estimated blood loss (EBL), maximum pain score at activity (POD 0 – 2), time to OOB, LOS, rate of transfusions, 90-day complications, narcotic refills, and morphine consumption at various timepoints. Cost outcomes measured included intraoperative anesthesia cost, postoperative anesthesia cost, ICU stay cost, total length of stay cost, operating room cost, and total cost. Wilcoxon rank-sum, Kruskal-Wallis, and Chi-Squared tests were used in data analysis to determine statistical significance.

Results
PCA patients were significantly younger than ITM-RRP patients (p=0.002). Operative time (p<0.001), anesthesia time (p=0.03), EBL (p<0.001), LOS (p<0.001), time to OOB (p<0.001), and morphine consumption at every timepoint (p<0.05) were significantly lower in the ITM-RRP group compared to the PCA group. Maximum VAS pain scores at activity were lower on POD 0, 1 and overall for the ITM-RRP group. Intraoperative (p<0.001) and postoperative anesthesia cost (p<0.001) was lower in the ITM-RRP group. Hospital stay cost (p<0.001) and total cost (p<0.001) were also significantly lower in the ITM-RRP group.

Conclusion
ITM-RRP is not only effective in pain management for patients after a spinal fusion, allowing for earlier mobilization and discharge, but also reduces opioid requirements significantly. This has important economic implications as it results in significant cost-savings for institutions and patients.

111. Intraoperative Cranio-Pelvic Traction: A Novel Aid for the Correction of Neuromuscular and Syndromic Scoliosis §

Patton Robinette, MD; Emily Peairs, MD; *Robert K. Lark, MD, MS*

Hypothesis
Intraoperative cranio-pelvic skeletal traction through percutaneously-placed pins in the supra-acetabular ilium is a safe and effective correction aid in patients with neuromuscular or syndromic scoliosis.

Design
Retrospective chart review

Introduction
Intraoperative traction has been described as an aid for the correction of scoliosis and pelvic obliquity during posterior spinal fusion (PSF) in patients with neuromuscular or syndromic scoliosis. Cranio-femoral traction, utilizing a halo or Mayfield tong proximally and distal femoral skeletal or cutaneous traction distally, is typically used. While shown to be safe and effective, traction pulled through the lower extremities distal to the pelvis in patients with hip flexion contractures can result in undesired iatrogenic sagittal plane deformities, typically hyper-lordosis. To provide more direct control of the pelvis outside of the operative field and to mitigate the risk of iatrogenic sagittal plane deformity, the authors propose a novel technique of applying distal traction through 4.8-mm threaded pins placed percutaneously in the bilateral supra-acetabular ilium.

Methods
A retrospective chart review was performed on all patients at a single institution with either neuromuscular or syndromic scoliosis who underwent PSF with intraoperative cranio-pelvic traction from 2018-2023. Data collected included demographic data, pre- and post-operative coronal and sagittal plane radiographic measurements, and complication-related data.

Results
24 patients met the selection criteria with 16 patients having early onset scoliosis (EOS) undergoing growth friendly surgery (average age 6.8 yrs) and 8 patients undergoing definitive fusion (DF; average age 14.9 yrs). Average pre-op Cobb angle in the EOS group was 96 deg and was 106 deg in the DF group. Average pelvic obliquity was 20 deg in both groups. Post-operatively, the Cobb angle corrected by 50% in the EOS group and by 77% in the DF group. Pelvic obliquity corrected to under 7 deg on average in both groups, with only 3 patients having post-operative pelvic obliquity >15 deg (13%). There were no pelvic traction pin-related complications. 3 patients had intraoperative neuromonitoring alerts with no sustained post-operative neurologic complications.

Conclusion
Intraoperative cranio-pelvic skeletal traction is safe and effective as a correction aid in patients with neuromuscular and syndromic scoliosis.

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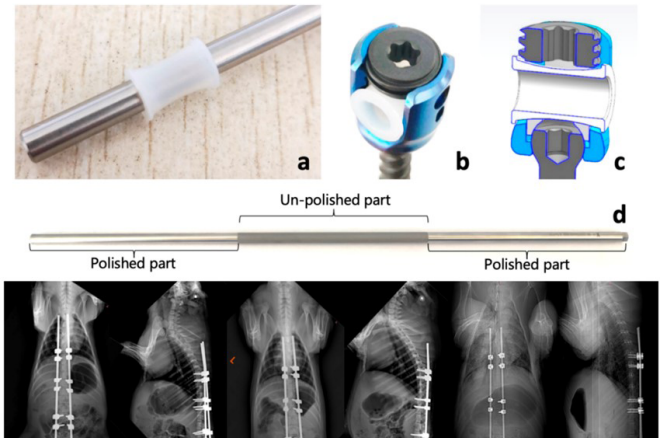

112. A Novel Cage-Hinge Correction Technique for Vertebral Column Resection in Severe Angular Kyphosis

Hong Zhang, MD; David Ross, MFA; Daniel J. Sucato, MD, MS

Hypothesis
The incorporation of an adjustable and controllable hinge mechanism at the apical region is essential to safeguard the spinal cord and enhance the correction of severe angular kyphosis (SAK) in the vertebral column resection (VCR) procedure.

Design
Introducing a novel cage-hinge (CH) correction device and technique for VCR to correct SAK and evaluating its efficacy and feasibility using a simulated sawbones and a pig angular kyphosis model.

Introduction
Neurological complications often arise during VCR procedures, particularly in cases of SAK. The current VCR implant strategy poses risks of intraoperative deficits due to spinal segment instability.

Methods
A simulated thoracolumbar angular kyphosis, with the apex at thoracic vertebra 11, was induced in a sawbones spine model. The resulting deformity was corrected using the CH to assess the device's efficacy. Subsequently, a three-month-old pig model was employed to induce thoracolumbar angular kyphosis, and the CH was utilized to correct the induced deformity, evaluating its feasibility for VCR in reducing angular kyphosis.

Results
In the sawbones model, the initial 52° thoracolumbar angular kyphosis was successfully corrected, achieving a 100% correction rate (Fig. A-B). This correction resulted in a 53.3% shortening of the posterior column, a 17.3% reduction in the middle column, and a 76.9% elongation of the anterior column at the resection gap. The mean apical vertebral translation from the dorsal to the ventral aspect measured 65.9 mm, while the overall spine length showed an average increase of 8.8%. During the resection phase in the pig model (Fig. C), the CH device effectively maintained spinal segment stability, with the resected gap showing an average change of only 0.2 ± 0.1 mm. Pathological anatomy assessments of the neural axis indicated that the CH device successfully prevented excessive shortening or lengthening of the spinal cord during VCR correction of SAK.

Conclusion
The CH consistently stabilized spinal segments, acting as an adaptable and controllable hinge mechanism. Its effectiveness in addressing SAK through VCR was affirmed in the sawbones model. In the pig model, the CH showcased feasibility and potential safety without evidence of excessive stress to the spinal cord.

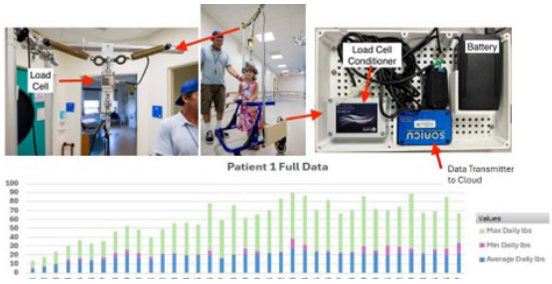

Fig.

113. The Contributions of Interbody Spacers and Supplemental Fixation to the Stability of LLIF Constructs

Theresa Pazionis, MD, FRCS(C), BS; Jonathan M. Mahoney, BS; Joshua P. McGuckin, MS, BS; Emily K. Eichenlaub, BS; Samantha Panich, MD, BS; Jake Carbone, MD, BS; Mattan R. Orbach, MS, BS; Brandon S. Bucklen, PhD

Hypothesis
Expandable spacers with posterior and integrated fixation would have similar stability as static spacers with posterior fixation and lateral plates/screws.

Design
In vitro biomechanics study.

Introduction
Lateral lumbar interbody fusion (LLIF) allows for extensive discectomy and large spacer footprints. Static LLIF spacers are typically supplemented with posterior and lateral fixation for added stability. Expandable spacers allow for anatomical fit to minimize trialing and integrated fixation allows for slimmer profiles to reduce morbidity. This study investigated the con-

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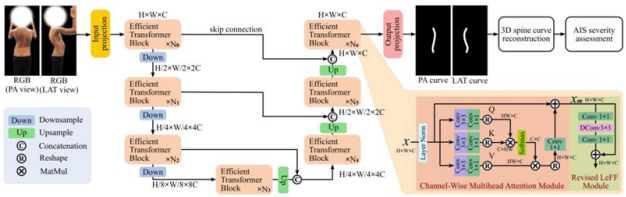
tributions of supplemental fixation to the stability of static and expandable LLIF spacers.

Methods
Range-of-motion (ROM) of healthy fresh-frozen human cadaveric spines (n=17, L2-5) was measured before L3-4 LLIF via static spacers with lateral plates/screws (Static) or expandable spacers with integrated fixation via lateral screws (Expandable+Screw) or anchors (Expandable+Anchor). ROM was measured after spacer insertion (Spacer-Only), lateral fixation (Lateral-Only), and bilateral pedicle screws (BPS+Lateral) in flexion-extension (FE), lateral bending (LB), and axial rotation (AR) using a custom-built motion simulator (±7.5Nm). Lateral-Only constructs were fatigued at 1Hz for 1,000 cycles of FE, LB, and AR.

Results
In Spacer-Only constructs, expandable LLIF spacers were more stable than static (FE: 36% vs 55%; LB: 35% vs 56%; AR: 66% vs 90%). Expandable+Screw was the most stable Lateral-Only construct (FE: 23%; LB: 24%; AR: 41%). Post-fatigue, Static Lateral-Only gained more motion (LB: +22%; AR: +24%) than Expandable+Screw (LB: +16%; AR: +17%) and Expandable+Anchor (LB: +15%; AR: +18%). Independent of construct, Expandable+Screw was significantly more stable ($p<0.05$) than Static in FE, LB, and AR. Independent of group, ROM dropped in all bending planes by 24-57% from intact after spacer insertion, 3-19% after integrated/lateral fixation, and 17-31% after posterior fixation.

Conclusion
Expandable spacer-only constructs had greater stability than their static counterparts. Expandable spacers with integrated screws were significantly more stable than static spacers and saw minimal added stability from posterior fixation. Expandable spacers with integrated fixation, via lateral screws or anchors, demonstrated greater primary and dynamic stability than static spacers with lateral plates and screws.



L3-4 ROM in (A) FE, (B) LB, and (C) AR.

114. Pelvic Obliquity: A Possible Risk Factor of Curve Progression After Lumbosacral Hemivertebra Resection With Short Segmental Fusion

Yiqiao Zhang, MD; Zhuosong Bai, MD; Owen Yuechuan Zhang, MD; Yunze Han, MD; Shixuan Liu, MD; Jianguo Zhang, MD; *Qianyu Zhuang, MD*

Hypothesis
Preoperative pelvic obliquity was an independent risk factor for the curve progression

Design
Retrospective study

Introduction
1-stage posterior hemivertebra resection with short segmental fusion is a standard surgery for patients

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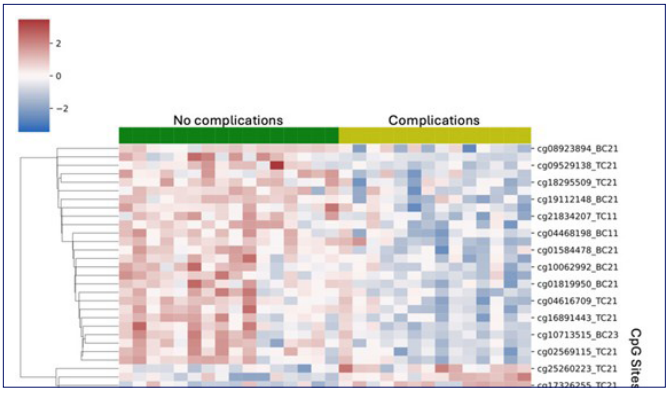
with congenital scoliosis, and the curve progression often occurs after surgery due to the above reason. The objective of this study is to investigate the risk factors of the curve progression in patients who have undergone 1-stage posterior hemivertebra resection with short segmental fusion.

Methods
This study included 58 congenital scoliosis patients who had undergone 1-stage posterior hemivertebra resection with short segmental fusion from June 2004 to July 2022 at a single institution. Baseline information, related radiographic parameters and the Scoliosis Research Society-22 (SRS-22) questionnaire were collected preoperatively, 3 months postoperatively and at last follow-up. Risk factors for the curve progression were evaluated by logistic regression analysis and receiver operating characteristic (ROC) curve analysis.

Results
The mean age at surgery was 7.3 years old with an average follow-up of 7.5 years. 9 patients (15.5%) were diagnosed as the curve progression at the final follow-up. Compared to the preoperative condition, patients exhibited a significant reduction in main curve (P<0.001), compensatory curve (P<0.001) and coronal balance (P<0.001) postoperatively. The SRS-22 total score (P<0.001), the function domain score (P<0.001), the self-image domain score (P<0.001), and the satisfaction domain score (P<0.001) demonstrated statistically significant difference compared with baseline data for the entire cohort. Compared with non-progression group, the progression group had a larger preoperative pelvic obliquity angle (P=0.008)The logistic regression analysis revealed that preoperative pelvic obliquity (Odds Ratio=1.653, P=0.017) was a significant independent risk factor for the curve progression. The ROC analysis revealed that preoperative PO had good discriminatory capability (area under the ROC curve, AUC=0.876, P < 0.001), and the cut-off value was 3.7°.

Conclusion
In summary, preoperative pelvic obliquity was an independent risk factor for the curve progression, and the cut-off value was 3.7°, which means preoperative measures should be done to ensure minimal pelvic obliquity in patients to prevent the curve progression effectively.



115. The Influence of Growth Blocking of the Neurocentral Cartilages on the Development of the Spinal Canal. An Experimental Study in Pigs

Rafael Llombart-Ais, MD, PhD; Rafael Llombart-Blanco, MD, PhD; *Gonzalo Mariscal, MD*; Carlos Barrios, PhD; José Luis Beguiristáin, MD, PhD

Hypothesis
The introduction of pedicle screws in the immature spine may have implications for the growth of the vertebra.

Design
Experimental study.

Introduction
The placement of pedicle screws in the immature spine raises concerns regarding its impact on vertebral growth. The specific effects of NCC blocking on vertebral growth remain unclear. The objective of this experimental animal study was to investigate whether bilateral epiphysiodesis of the NCC using pedicle screws can induce spinal canal narrowing at the thoracolumbar spine.

Methods
A total of 24 domestic pigs were operated on by bilateral blocking of the NCC using pedicle screws. The animals were divided into 4 groups depending on the level of blockage: A, low thoracic levels; B, thoracolumbar transitional hinge; C, upper lumbar spine; and D, blocking of the caudal lumbar level below L5 segment. Animals were operated on at two months of age and were follow-up until 8-9 months (the period in which the NCC of the pigs are active). Morphological, morphometric, and radiological parameters were analyzed to compare NCC-blocked animals with 14 untreated animals used as a control group. The radiological study was performed by taken standard X-rays of the whole spine and of each individual vertebra.

Results
None of the animals that underwent NCC epiphysiodesis showed asymmetrical spinal growth inducing

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deformities in the different planes. Whatever the level involved, NCC epiphysiodesis caused shortening of the sagittal length of the pedicles and a subsequent decreasing of the antero-posterior diameter of the spinal canal, particularly at lumbar levels. These features resulted in spinal stenosis at the operated levels being more severe in the lower lumbar segments (from L3 to L6). The transverse diameter of the spinal canal was conserved in the coronal plane.

Conclusion
Symmetrical NCC growth arrest using pedicle screws induces spinal canal narrowing by decreasing the sagittal diameter. The spinal stenosis seems to be related to the lack of the physiologic development of the vertebral pedicles. This was most evident at lumbar segments where a significant shortening of the length of then pedicles was found. These results may have clinical implications since the use of thoracolumbar pedicle screw should be limited in immature patients with NCC still open.

116. Risk Factors For Early (<5 years) and Lates (≥5 years) Clinical Adjacent Segment Pathology (CASP) after Single/ Double-level Lumbar Fusion Surgeries – Are They Comparable?

Dhruv Patel, MS; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Vikas Hanasoge, MBBS, MS, DNB, FISS; Ayon Ghosh, MS

Hypothesis
Pelvic parameters, preoperative radiographic changes at adjacent segment, fusion type, and Demographics of patients affects early development of ASD after lumbar fusion surgeries.

Design
Retrospective study single centre study

Introduction
Adjacent segment degeneration (ASD) is a long-term complication that can occur after lumbar fusion surgery. This study aimed to assess the risk factors associated with the development of Early (<5 years) and Late (≥ 5 years) ASD after lumbar fusion surgeries performed at a single centre over a period of 23 years.

Methods
Retrospective study. 2850 patients were screened, out of which 67 patients were diagnosed with ASD. Patients demographic data, clinical data (initial diagnosis, BMD, history of smoking), radiographic data (pre-existing disc degeneration and facetal fluid, PI, LL, PT, PI-LL mismatch), surgical data (type of fusion surgery, fusion levels, floating vs non-floating fusion, and interventions) were recorded.

Results
25(0.87%) and 42(1.62%) patients were classified as Early and Late groups respectively. Diagnosis of ASD was made at 2.82±1.11 (Early group) and 7.96±2.41 years (Late group) post-operatively. Levels/ type of fusion, and floating vs non-floating fusion was statistically insignificant. Incidence of ASD was more in the proximal segment (N=60, 89.55%) vs in distal segment (N=7, 10.45%) in the cohort. Pre-operative pathology at the operated level and the type of ASD seen later were not significantly different between the groups (p=0.620, p=0.134). Preoperative disc and facet degeneration at adjacent segments showed no significant intergroup difference (p=0.23). Smoking (56%; p=0.024); LL (p≤0.0001), PT (p=0.025) and PI-LL Mismatch (p=0.003) measured after index fusion surgery were statistically significant, except PI (p=0.105).

Conclusion
Our study demonstrated a strong positive correlation of smoking and post-operative pelvic parameters(LL, PT, PI-LL mismatch) on the development of early ASD.

117. Evaluation of Spinal Deformities in SMA To Assess Their Deformity Patterns and Their Management Outcomes. §

Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Ayon Ghosh, MS; Dhruv Patel, MS

Hypothesis
Disease Modifying Drugs (DMD's Nusinersen/Risdiplam) lessens curve progression for Scoliosis in Spinal Muscular Atrophy (SMA) and provides an improvement in quality of life

Design
To evaluate clinically and radiologically, spinal deformity patterns, deformity progression, pelvic obliquity and motor function & quality of life {Hammersmith Functional Motor Scale Expanded for SMA (HFMSE)} of newly diagnosed SMA patients who are on DMD's (Risdiplam/Nusinersen)

Introduction
SMA produces proximal muscle weakness leading to neuromuscular scoliosis. Scoliosis prevention attempts made by bracing, DMD's, physiotherapy & surgery. There is no published literature on SMA scoliosis & their treatment outcomes in the Indian population

Methods
Prospective matched cohort study analyzing data from 2 centers from Jul 2022 to Jul 2023 with a minimum of 1yr follow up. Age, sex, type, HFMSE & ODI recorded at 1st visit, 6months & 1year. Whole Spine-X-rays-sagittal & Coronal Cobb,Sagittal and coronal

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balance,Pelvic-Obliquity and Hip-Dislocation assessed. Coronal Cobb > 20 braced. Analysis done between groups getting DMD's (Group1–Risdiplam(1a)/Nusinersen(1b)) and not receiving drugs(Group2),including subgroup analysis(1avs1b)

Results
60 patients(M:F=29:31,age10.29+/-7.05) with Type2(n=45) & Type3(n=15) included. 23 randomized patients received DMD's(Group1a-12,Group1b-11). Scoliosis emerged in 76.6% patients with a progression of 15.45°/yr. Coronal Cobb in Group1 at presentation 40.21+/-31.7 & at 1yr 54.91+/-40.32 and for Group2-48.21+/- 40.8 and 64.14+/-40.44. Sagittal Cobb in Group1 at presentation 26.74+/-26.75 & at 1yr-34.35+/-32.0 and for Group2-33.67+/-32.0 and 44.97+/-35.74. Commonest pattern was single C curve(61.6%) & located in TL region(66.7%). Group1-ODI increased initially but then declined. Group2-ODI gradually worsened. HMFSE improved in Group1 whereas Group2 had a declining trend. ODI and HMFSE improved in sub-groups. Sagittal & Coronal imbalance was strongly related to worsening HMFSE & ODI. Progression of Coronal Cobb had strong correlation with worsening HMFSE(r=0.776) & ODI(r=0.901).No significant difference noted in change in Cobb(Sagittal/Coronal) at 1yr between 2 groups but among sub-groups significant decrease in curve progression(Group1b)noted

Conclusion
No significant change in progression of scoliosis in between 2groups but DMD's are important in order to improve the quality of life & motor function

118. Early term outcomes of Non Fusion Anterior Scoliosis Correction(NFASC) in Non-Idiopathic Scoliosis(NIS)- a single centre experience §

Sajan K. Hegde, MD; Appaji K. Krishnamurthy, MD; Vigneshwara M. Badikillaya, MD; Sharan T. Achar, MS; *Harith B. Reddy, MS*

Hypothesis
NFASC is effective in selected NIS/Early onset scoliosis(EOS) patients in terms of cobbs correction,coronal balance maintenance at 2year follow up(FU)

Design
Prospective Cohort Study

Introduction
NFASC/Vertebral Body Tethering(VBT) as growth modulating and motion preserving deformity correction surgery has been described for idiopathic scoliosis patients.NIS,encompassing the entire gamut of congenital/neuromuscular/syndromic causes,has an average incidence of 0.019% compared to 1-4% incidence of idiopathic cause.NFASC in such cases with significant growth remaining would be exemplary.

Methods
10 NIS patients of the total 120 patients treated with NFASC between 2014 to 2022 were analysed.Etiology was syndromic in 4,congenital-4& neuromuscular-2. Among the syndromic-2 had Neurofibromatosis,2-Marfan's syndrome;congenital cause-2 lumbar hemivertebrae,2 multiple segmentation anomaly& neuromuscular cause was post-polio residual paralysis(PPRP).Clinical& radiological parameters-coronal& sagittal cobbs correction,balance restoration were assessed.Cobbs angle maintaining at <35 with no revision surgery was considered as success at 2 year FU[HoernschemeyerDG 2020,NewtonPO 2020].

Results
The mean age at surgery was 11.3+4.71yrs(5-20) (except 1 patient operated at 41yrs age-k/c/o PPRP). The mean risser score was <3 in 7 patients.The cobbs angle was corrected from 50.86+13.38 to 26.7+14.4 thoracic(5pt) and from 47.28+10.58 to 24+6.76 lumbar(5pt).47% thoracic& 49% lumbar curve correction was maintained at 2yrFU(7/10pt).3 patients(1neuromuscular+2congenital with multiple segmentation anomaly) had poor outcomes(2 required fusion surgery for progressive curve >50,other had significant truncal shift).Success was associated with age>-10years,smaller cobbs immediate postop(30vs43 in poor outcome patients,p=0.005),type of scoliosis(Congenital/Syndromic causes better outcomes compared to Neuromuscular,p=0.07). There was tether break in 4 patients,2 with no significant loss of correction(9&12) maintaining good global balance,2 required growth rod surgery,eventually final fusion procedure(6,9years post index surgery).No intra/postop complications were noted.

Conclusion
Selected NIS pt can be successfully treated with NFASC,but with a higher failure rate(30%),higher tether breakage rate(40%) which were associated with younger age,large curves,inadequate intra operative correction& neuromuscular etiology.

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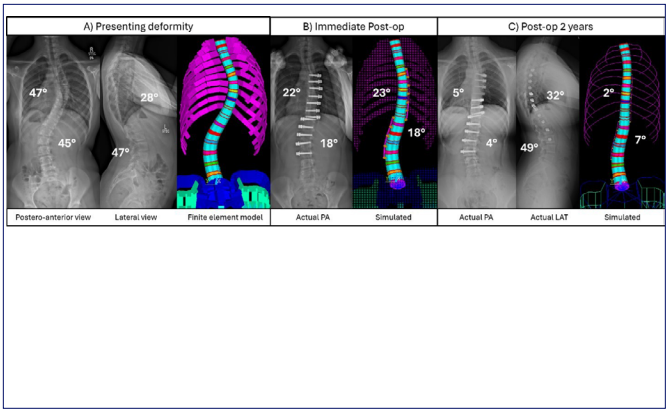

Figure 1: i-12yr old boy with D13 hemivertebrae with structural double curve,treated by hemivertebrae excision& NFASC of both the curves;ii-8yr old boy with neurofibromatosis with Mehta's ribvertebral angle 31.2(>20) maintained good correction at 4yr FU inspite of tether breakage;iii-7&1/2yr old girl with multiple segmentation anamoly treated with NFASC-decompensation at 3 yearFU,treated with magnetic growth rod;iv-Table showing data of all the 10 non idiopathic patients treatedwith NFASC with salient features

119. Connective Tissue Disease Patients Do Not Have Higher Rates of PJK Compared with Idiopathic EOS Following Growth Friendly Instrumentation §

Kenneth A. Shaw, DO; John T. Smith, MD; Joshua M. Pahys, MD; Pediatric Spine Study Group; Brandon A. Ramo, MD

Hypothesis
EOS patients with connective tissue disease (CTD) would have higher rates of PFK following growth friendly instrumentation (GFI)

Design
Retrospective review of multicenter database

Introduction
Proximal junctional kyphosis (PJK) is a condition frequently encountered in children with EOS undergoing GFI. Previous studies have identified risk factors but have not compared how this compares between children with CTD and idiopathic EOS (iEOS).

Methods
Retrospective review of a multicenter EOS database was performed. Patients with EOS undergoing GFI with a minimum of 5 years follow-up were identified and isolated to those with CTD (Marfan, Loeys-Dietz, Ehlers-Danlos, Soto, Larsen) and idiopathic etiologies. PJK was defined as requiring revision surgery or as having >10 degree change in proximal junctional angle (PJA). Surgical factors and implant variables were recorded. Radiographic parameters and complication development were compared between groups.

Results
A total of 253 children (mean 5.7 years, 57% female) were identified (CTD:49, iEOS:204). A total of 58 patients developed PJK (23%) with only 11 (18.9%, 4% of total cohort) undergoing revision surgery at 5 years following implantation. There were no surgical factors or radiographic variables associated with the development of PJK. In comparing the CTD and iEOS cohorts, there was no difference in PJK (CTD:26.5%, iEOS:22.1%; P=0.5). Additionally, there were no significant differences in patient variables or preoperative or 5-year follow-up radiographic parameters, although there was a trend toward greater increased in PJA over treatment in CTD patients (CTD: 2.4+/-13.9deg vs -0.01+/-9.9 deg; P=0.089). CTD patients gained a mean 26.6mm vs 26.9mm (P=0.8) of thoracic height. There was no difference in the overall complication rate but CTD patient did experience a greater number of complications/patient (3.1 vs 2.0; P=0.004)

Conclusion
PJK is a pervasive complication in EOS, occurring in 23% of patients undergoing GFI. Having an underlying CTD did not increase the risk of PJK development within 5 years of treatment.

120. Short-segment Fusion vs. Decompression Alone in Patients with Cobb Angle Exceeding 20 Degrees

Tomoyuki Asada, MD; Atahan Durbas, MD; Chad Simon, BS; Takashi Hirase, MD; Nishtha Singh, BS; Annika Bay, MD; Olivia Tuma, BS; Kasra Araghi, BS; *Eric Zhao, BS*; Eric Mai, BS; Adin Ehrlich, BS; Sereen Halayqeh, MD; Tarek Harhash, BS; Adrian Lui, MD; Andrea Pezzi, MD; James E. Dowdell, MD; Sheeraz Qureshi, MD; Sravisht Iyer, MD

Hypothesis
In patients with a Cobb angle >20°, fusion surgery offers superior outcomes compared to decompression alone for lumbar spinal canal stenosis (LSCS).

Design
A retrospective analysis of a prospectively collected registry.

Introduction
While both decompression and short-segment fusion are established treatments for LSCS, even in moderate Cobb angles, data on patients with moderate coronal deformity (>20°) remains sparse. This study aims to evaluate the comparative benefits of fusion versus decompression in this subset.

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Methods
This study included patients with Cobb angle exceeding 20 degrees who underwent 1- or 2- levels of lumbar surgery for LSCS. Patients diagnosed with marked spinal deformity were excluded. Patient-reported outcomes (PROs) included Oswestry Disability Index (ODI), VAS back, and VAS leg at preoperative, 12-week postoperative, and 1-year postoperative timepoints. Preoperative and postoperative spinopelvic alignment was assessed using Cobb angle, pelvic tilt, sacral slope, pelvic incidence, lumbar lordosis and PI minus LL. Propensity score-matched analysis with overlap weighting was performed to compare PROs between the two surgical groups.

Results
Before overlap weighting, the fusion and decompression groups differed significantly in age and diagnosis, with no marked sagittal malalignment (decompression: 7.4° vs. fusion: 11.5°). After weighting, cohort characteristics were well-balanced. At 1 year, the fusion group demonstrated significantly better ODI (16.6 vs. 28.1, P=0.013) and VAS back scores (1.5 ± 2.1 vs. 3.7 ± 1.9, P<0.001). (Fig)

Conclusion
In patients with LSCS and Cobb angle >20°, short-segment fusion yields better short-term outcomes compared to decompression alone.

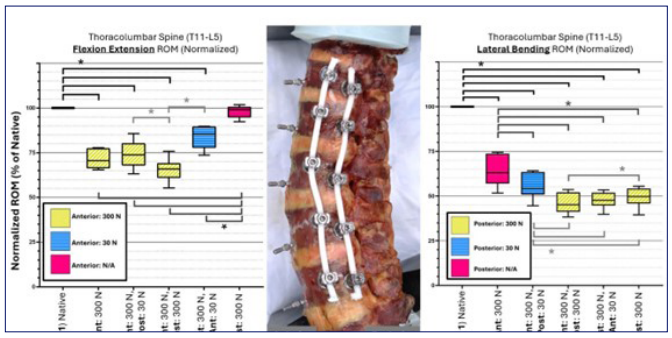

Figure. Postoperative PROMs change between decompression alone and fusion surgery after overlap weighting. Overlap weighting was conducted to obtain background matched cohort based on propensity score calculated by age, sex, BMI, smoking, anxiety status, NTPA, preoperative Cobb angle, PI-LL, and VAS back score, and diagnosis for surgeries. A significant difference in ODI and VAS back was observed at 12-week and 1-year postoperatively. *, P<0.05.

121. Leave it Alone: The Natural History of Growth Friendly Graduates Without a Final Fusion

Bryan Ren, MD; *Christina K. Hardesty, MD*; Rayyan Abid, BA; Robert F. Murphy, MD; Jeffrey R. Sawyer, MD; John (Jack) M. Flynn, MD; John B. Emans, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; Norman Ramirez, MD; Pediatric Spine Study Group

Hypothesis
The survivorship of growth friendly graduates without final fusion shows few UPROR but outcomes are worse for patients who must have their implants removed.

Design
Retrospective analysis of a multicenter database

Introduction
The natural history of growth friendly graduates treated with growing instrumentation, but no final fusion is unknown. Two small reports, including 30 patients who had traditional growing rods (TGR) and 12 patients treated with vertical expandable prosthetic titanium rib (VEPTR), exist, but there is no comprehensive analysis in the literature.

Methods
The Pediatric Spine Study Group database was queried for patients treated with TGR or VEPTR who had at least two years of follow up. Patients met inclusion criteria if they had not undergone a final fusion procedure but had completed planned interventions for early onset scoliosis. Radiographic data included major/minor Cobb angles and levels, spinal height, sagittal kyphosis, and proximal junctional degree.

Results
Of 1215 patients who underwent TGR or VEPTR with no documented final fusion, 234 had minimum 2 years follow-up. Diagnoses were heterogeneous (99 congenital, 71 neuromuscular, 43 syndromic, 20 idiopathic, and 1 other/not-specified). Definitive treatment strategy was implant maintenance in 204 (87%) and removal in 30 (13%). Of those who did not keep their implants, 18/30 (60%) had an UPROR sometime prior to implant removal and 1/30 (3%) had an implant removal. Of patients who retained their implants, the UPROR rate prior to definitive procedure was 30% (62/204). In that group, 9/204 (4%) had an UPROR following their definitive procedure. The proportion of patients who successfully avoided an UPROR after definitive procedure was similar between those who retained their implants and those who removed implants. Patients whose implants were removed lost a mean 7° of curvature compared to 3° in those who retained implants. All other measurements, including minor cobb angle, spinal height, and kyphosis were similar between the two groups.

Conclusion
Growth friendly graduates who do not undergo a final fusion have a high UPROR rate, but only 4% after their definitive procedure. The curve magnitude

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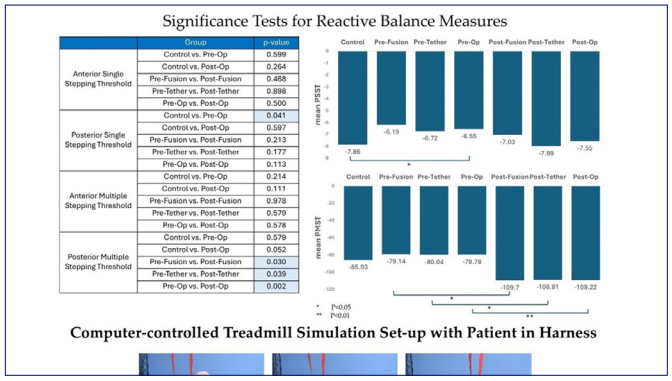
has been well maintained in this cohort whether implants were removed or kept. Patients with growing constructs who do not undergo definitive fusion maintain their curves with or without implant removal, and exhibit higher rates of UPROR overall.



122. Assessing the Effect of Intercostal Nerve Cryoablation on Pain Levels Following Posterior Spinal Fusion with Thoracoplasty for Adolescent Idiopathic Scoliosis Patients

Vishal Sarwahi, MD; Katherine Eigo, BS; Effat Rahman, BS; Sarah Trent, MD; Yungtai Lo, PhD; *Terry D. Amaral, MD*

Hypothesis
Cryoablation of intercostal nerves affected by thoracoplasty significantly reduces the pain burden from this additional procedure performed during posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS).

Design
Retrospective chart review

Introduction
The addition of thoracoplasty during PSF, while beneficial in reducing residual rib hump deformity in scoliosis patients, contributes to a significant increase in postoperative pain. Cryoablation involves rapid heat extraction which causes axonal disruption of the intercostal nerve, thus inducing Wallerian degeneration. Through this grade II peripheral nerve injury, nociception is prevented while the nerve regenerates. We sought to investigate whether cryoablation use in thoracoplasty reduces postoperative pain following PSF for AIS.

Methods
Retrospective chart review of 210 patients with AIS who underwent PSF with concurrent thoracoplasty for their rib hump deformity. 34 patients underwent cryoablation (Cryo group) and 176 control patients underwent thoracoplasty without cryoablation (Standard group). Data collected on Visual Analog Scale (VAS) pain scores during activity and at rest, intra-operative, postoperative (0-24, 24-48, 48-72), total morphine consumption, time to out of bed (OOB), length of hospital stay (LOS), and 30-day complications including respiratory complications. Other surgical variables such as estimated blood loss (EBL) and operative time were also evaluated.

Results
No differences were observed in demographic characteristics, pre- and post-operative Cobb angle, and levels fused (p>0.05). Operative time was significantly lower in the Cryo group (p=0.002). No differences were observed in VAS pain scores (p>0.05) or 30-day complications (p=0.51). Both groups experienced similar respiratory complication rates (p=0.44). Total morphine consumption was significantly lower, decreased by approximately 50% in the Cryo group compared to the Standard (p<0.001). One-hundred percent of Cryo patients were OOB by POD 1 compared to 96.3% in the Standard group (p=0.31). LOS was not statistically significant between the two groups median of 3 days compared to 4 (p=0.37).

Conclusion
Thoracoplasty creates an additional pain burden on patients undergoing PSF for AIS. Inducing reversible intercostal nerve injury with cryoablation can prevent pain in the affected ribs and therefore can serve as an effective adjunct in postoperative pain control.

123. Perioperative Opioid Consumption in Patients Who Undergo Surgery due to Spine Related Pain. -A Danish Nationwide Cohort Study.

Andreas K. Andresen, MD, PhD; *Leah Y. Carreon, MD, MS*; Carsten R. Bjarkam, MD, PhD; Carsten Bruun, MD; Jon Caspersen, MD; Kjeld Dons, MD; Louise M. Jørgensen, MD, PhD; Mikkel M. Rasmusssen, MD, PhD; Michael Nielsen, MD; Casper F. Pedersen, PhD student; Rikke Rousing, MD, PhD; Simon T. Skov, MD, PhD;

Hypothesis
The purpose of the current study is to describe long-term opioid use following lumbar spine surgery and, to investigate risk factors associated with prolonged use of opioids in patients undergoing spine surgery to treat chronic pain.

Design
Retrospective cohort study

Introduction
During the last decade, the use of opioids in management of non-malignant pain has been a topic of interest to surgeons and politicians worldwide with reference to the "opioid epidemic" in the United States. Although WHO guidelines advice against use of opioids to treat chronic low back pain in

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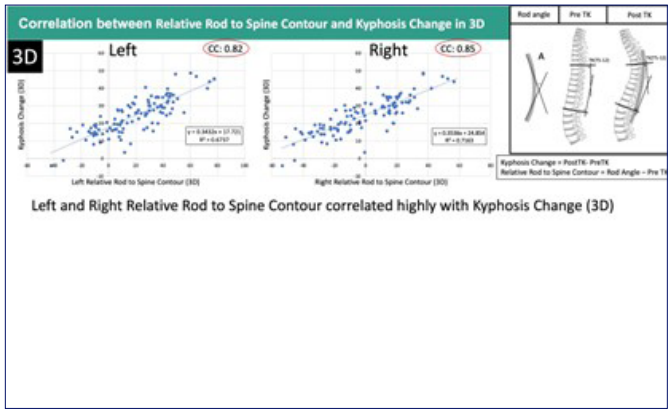
patients with degenerative spine orders, such therapy is administered to vast numbers of patients all of the world.

Methods
This is an observational study of 14,082 patients based on a nationwide database of spine surgeries (DaneSpine) during the period 2016-2022. We included patients who underwent lumbar spine surgery to treat spinal stenosis, spondylolisthesis and disc herniation. Statistical analysis included descriptive statistics and Relative Risk analysis for factors associated with one-year postoperative opioid use.

Results
We had available data on pre- and postoperative use of pain medicine and opioids on 14.082 patients who underwent spine surgery due to spinal stenosis (n=7.932), disc herniation (n=4.573) and spondylolisthesis (n=1.577). 36% of patients were on prescription opioids before surgery, as compared to 17% of patients at 1-year follow-up after surgery. (p<0.001). Overall, patients with preoperative opioid use had an increased relative risk (RR) of 4.70 (p=0.002) of being prolonged opioid users in all patient groups combined. Modifiable risk factors for prolonged postoperative opioid use included pain duration(figure1), body mass index and smoking.

Conclusion
In general we found that opioid use is diminished during the seven-year study period. While most patients came of opioids within 1 year after surgery, the strongest predictors for prolonged use was preoperative opioid use and duration of symptoms. This questions the current regime of prolonged conservative treatment and prescription of opioids which have been praticed over the 7 year study period.



Left and Right Relative Rod to Spine Contour correlated highly with Kyphosis Change (3D)

Pre- and postoperative opioid usage (2016 - 2022) divided by duration of preoperative leg pain.

124. 3-Dimensional True Spine Length in Growth-Guidance Surgery vs. Magnetically Controlled Growing Rodsfor Idiopathic Early Onset Scoliosis

Francisco Narro Garcia, BS; Jennifer K. Hurry, MASc; Richard E. McCarthy, MD; Ron El-Hawary, MD; *Scott J. Luhmann, MD*; Pediatric Spine Study Group

Hypothesis
Growth Guidance Surgery (GGS) and Magnetically Controlled Growing Rods (MCGR) provide similar radiographic outcomes 2 years (yrs) postop

Design
Retrospective case series

Introduction
GGS and MCGR are aimed to correct, control severe progressive spine deformity while maintaining growth. Past studies yield comparable results between constructs using vertical coronal measures failing to account for growth outside plane of measurement due to 3 dimensional (3D) deformity. Study compare GGS/MCGR outcomes in idiopathic early onset scoliosis (i-EOS) using 3D true spine length (TSL), validated method measuring spine length in 3D.

Methods
International, multi-center EOS database queried i-EOS patients (pts) undergoing MCGR/GGS with min 2yr follow-up. 31 GGS/130 MCGR pts included, preop, postop, and 2 yr measurements. Mixed-model statistics allowed for missing data points including age, construct, and visit as fixed factors with subject as random. Growth was calculated with paired values; thus, growth numbers may not equal change in values.

Results
161 pts (99 female) mean age at surgery 8.1 yrs. 19.3% GGS, 8.5% MCGR underwent repeat surgeries within study period. Age, # of instrumented levels, preop kyphosis/scoliosis similar between groups. GGS reduced major deformity from 67° to 26°, 9° loss of correction at 2 yrs (35°, 46% final correction, p=.02). MCGR reduced major deformity 71° to 40° w/o significant loss of correction (+2°; final 42°, 34% correction). No difference between constructs at 2 yr. GGS maintained kyphosis perioperatively with increase at 2 yrs (+8°, p=.004), yet MCGR decreased at postop (-7°, p<.001) with an increase of 6° at final (p=.002). Total cohort demonstrated T1-S1 height increase from preop (281 mm) to postop (314 mm) and 2 yr (336 mm) (p<.001). 3D-TSL did not significantly change perioperatively (338 to 342 mm) for either construct. At 2 yrs GGS 3D-TSL increased 32.6 mm (16.8 mm/yr), MCGR increased 27.5 mm (14.2 mm/yr) (p=.29). No difference between GGS and MCGR.

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Conclusion
In i-EOS MCGR and GGS increased T1-S1 height preop to postop, but no change in 3D-TSL. Postop to 2 yr 3D-TSL increased in both constructs: 16.8 mm/yr (GGS), 14.2 mm/yr (MCGR). 3D-TSL is more reliable indicator of spine growth than linear T1-S1 measures after i-EOS surgery. Overall, GGS and MCGR offer similar outcomes 2-yrs postop assessed by 3D-TSL.

	GGS 3D(mm)	GGS Coronal (mm)	MCGR 3D (mm)	MCGR Coronal (mm)
Preop	352.6	302.0	334.4	274.5
Postop	356.1	328.3	338.0	310.3
Final	386.4	350.6	366.6	332.4
Change Preop to Postop	+1.0	+24.4*	+2.4	+31.9*
Change Postop to Final	+32.6*	+24.7*	+27.5*	+21.7*

Table 1- Comparison of T1-S1 Coronal height and 3D-TSL over time.

T1-S1 Coronal height & 3D-TSL over time

125. Rod Fracture After MCGR is Related to Rod Diameter but Lower Than TGR

Matthew Weintraub, BSE; Omar Taha, BS; Ritt Givens, BS; Matan Malka, BA; Kevin Lu, MA; Paul D. Sponseller, MD, MBA; Peter F. Sturm, MD; John B. Emans, MD; Francisco Javier S. Perez-Grueso, MD; *Michael G. Vitale, MD, MPH*; Benjamin D. Roye, MD, MPH; Pediatric Spine Study Group

Hypothesis
Rods with a diameter ≤ 5mm are more prone to fractures than those with a diameter > 5 mm in both MCGR and TGR constructs.

Design
This retrospective study compared rod fracture rates in patients with early onset scoliosis (EOS) undergoing surgery with traditional growing rods (TGR) versus magnetically controlled growing rods (MCGR).

Introduction
Rod fracture is a significant complication of growth friendly surgery for early onset scoliosis (EOS). This study uses a large sample of patients with growth friendly implants to quantify and compare failure rates in MCGR and TGR.

Methods
EOS patients undergoing bilateral TGR or MCGR instrumentation were identified from the Pediatric Spine Study Group registry. Subgroup analyses were performed between rods with diameters ≤ 5 mm and > 5 mm and between MCGR and TGR. A chi-squared test was used to compare incidence of rod fracture amongst subgroups. A log rank survival analysis over a 5-year period was performed. A Mann-Whitney U test was performed to compare patient characteristics.

Results
1,588 included patients, represented 3,176 rods. 1,251 (39.4%) were TGR and 1,925 (60.6%) were MCGR. 2,225 (70.1%) rods had a diameter ≤ 5 mm and 951 (29.9%) had a diameter > 5 mm. There was no clinically important difference in pre-operative cobb angle or maximum kyphosis between MCGR and TGR groups. There were more TGRs in congenital and syndromic patients, and more MCGRs in idiopathic and neuromuscular patients ($p < 0.001$) 77 (4.85%) patients experienced a rod fracture within two years of surgery, representing a total of 97 rod fractures, resulting in an overall two year risk of rod fracture of 3.05% with a mean and median time to fracture of 1.3 years and 1.4 years respectively. Risk of fracture was higher in TGR vs MCGR (4.96% Vs. 1.82%, $p < 0.001$). Amongst MCGR's, rods with diameter ≤ 5 mm fractured more often than those > 5mm (2.65% Vs. 0.63%, $p = 0.001$).The 5-year survival analysis (Figure 1) showed decreased survival amongst MCGR rods <5mm ($p= 0.004$) and that TGR survival decreased compared to MCGR ($p < 0.001$). TGR survival was not affected by rod diameter.

Conclusion
Although rare, the risk of rod fracture in EOS patients may be higher than previously reported. Overall risk of rod fracture is higher with TGR compared to MCGR. Smaller rod diameter led to increased risk of fracture in MCGR constructs, but rod diameter was not associated with fracture risk in TGR.

Figure 1: Posteroanterior (PA) Radiographs Comparing the Sacral CSVL (A) and Iliac CSVL (B) Methods

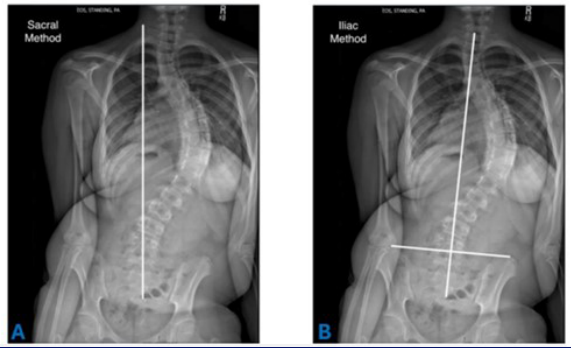

Figure 1. Survival by rod type

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E-POINT PRESENTATION ABSTRACTS

126. Do Chronic Oral Glucocorticoids Preferentially Decrease Bone Mineral Density of the Anterior Lumbar Vertebral Body?

Eric Zhao, BS; Tim Xu, BS; Lingling Hu, MD; John A. Carrino, MD; Matthew Greenblatt, MD, PhD; Sravisht Iyer, MD

Hypothesis
The anterior vertebral body will have lower bone mineral density (BMD) than posterior in glucocorticoid-treated (GC) patients.

Design
Retrospective Cohort Study

Introduction
A recent Nature study has demonstrated unique anterior and posterior lineages of vertebral skeletal stem cells (vSSCs), distinct from long bone stem cells, in mice and humans. Murine models suggest that the anterior lineage may be more sensitive to glucocorticoid-induced osteoporosis. We analyzed anterior and posterior BMD of L1 and L2 in GC and naive (control) patients.

Methods
Adult patients (> 18 years) with preoperative lumbar computed tomography (CT) within 6 months of any surgery were included. The GC cohort included patients with > 6 months oral GC prior to imaging. Volumetric BMD measurements were made with QCT Pro bone densitometry software, Version 6.1 (Mindways Software, Austin, TX) in the hospital radiology department QCT workstation. L1 and L2 were selected due to their lower probability of degenerative changes compared to other lumbar levels. Four measurements were made per level (upper and lower anterior; upper and lower posterior); cortical bone, areas of sclerosis, Schmorl nodes, and cysts were avoided. Total anterior BMD at a given level was the average of upper and lower anterior; posterior BMD was similarly calculated.

Results
382 patients (GC = 110) were included. There were no differences in age, sex, or body mass index. Posterior BMD was greater than anterior BMD at L1 ($p < 0.0001$) and L2 ($p < 0.0001$) for the control cohort. Posterior BMD was also greater than anterior at L1 ($p = 0.003$) and L2 ($p = 0.002$) for the GC cohort. Comparing anterior L1 ($p < 0.01$), posterior L1 ($p < 0.01$), anterior L2 ($p < 0.05$), and posterior L2 ($p < 0.05$), between GC versus control, the control cohort had greater BMD in all cases. Current or former smoking status decreased bone mineral density at both L1 and L2 in both cohorts compared to non-smokers ($p < 0.05$).

Conclusion
Chronic oral glucocorticoids do not appear to preferentially impact anterior vertebral bone density in the lumbar spine.

	Pre-Operative†	Post-Operative†	Post-operative Change	Percent correction†
Proximal Thoracic	34.1 (22.5, 41.4)	6.3 (2.3, 10.6)	-27.2 (-34.9, -9.6)	-77.7 (-92.0, -63.7)
Main Thoracic	86.2 (76.4, 91.6)	18.9 (13.4, 25.1)	-66.3 (-77.9, -50.4)	-78.3 (-83.7, -62.4)
Lumbar	43.5 (36.0, 55.3)	15.3 (9.8, 24.7)	-31.1 (-39.2, -22.2)	-66.1 (-73.9, -53.6)
Kyphosis				
K-T2-T12	43.4 (20.5, 55.6)	36.8 (27.8, 48.7)	-0.1 (-19.6, 10.8)	0.1 (-42.8, 45.5)
K-T2-T5	5.5 (1.7, 19.1)	9.7 (6.0, 18.0)	3.2 (-9.5, 7.4)	59.9 (-22.5, 594.8)
K-T5-T12	28.1 (13.5, 52.1)	28.4 (19.7, 34.1)	-4.1 (-18.5, 10.6)	-14.9 (-39.7, 56.4)
Lordosis				
T12-S1.	56.6 (50.4, 68.4)	59.6 (50.6, 63.8)	-0.1 (-8.9, 7.3)	-0.2 (-17.5, 13.7)

† Median (IQR)

4 volumetric measurements of BMD per level are shown.

127. Growth Modulation Correction at 2 Years With Various Lumbar VBT Intraoperative Correction Levels in Pediatric Idiopathic Scoliosis §

Marine Gay; Nikita Cobetto, PhD; Christiane Caouette, PhD; A. Noelle Larson, MD; Isabelle Villemure, PhD; Dan Hoernschemeyer, MD; Melanie E. Boeyer, PhD; Ron El-Hawary, MD; Ahmet Alanay, MD; *Carl-Eric Aubin, PhD*

Hypothesis
Intra-operative correction significantly influences immediate and after 2 years growth modulation correction.

Design
Computational biomechanical modeling of growth and growth modulation after lumbar VBT with various intra-op correction levels.

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Introduction
Although VBT is increasingly used to treat pediatric idiopathic scoliosis, it remains difficult to correctly adjust the level of intraoperative correction needed to optimize correction at the skeletal maturity and avoid under- or over-correction. The aim was to assess the influence of intraoperative VBT correction on growth modulation correction at two years.

Methods
Retrospective data of 17 idiopathic scoliotic cases treated with lumbar VBT were included (mean lumbar Cobb: 47° (38°-63°); mean Sanders (SS): 4 (3-6)). For each case, a validated finite element model (FEM) of the presenting deformity, calibrated for SS, weight and patient flexibility, was build and used to virtually simulate intraoperative lateral decubitus positioning and lumbar VBT using the actual UIV (between T9-T12) and LIV (L2-L4). We simulated the effect of three different experimental levels of intra-operative correction (35%, 50%, 70%) on immediate post-operative and after 2 years of growth modulation correction.

Results
Simulated intraoperative correction of 35%, 50% and 70% led to an average correction of 19%, 39% and 64% (immediate post-op) and 17%, 46% and 84% (2 years) as compared to the presenting deformity (Figure 1). With 50% intraoperative correction, correction at 2 years was significantly greater than initial postoperative correction only for SS3 cases ($p<0.05$). A 70% intraoperative correction led to higher corrections, which was significantly better for cases with SS3 and SS4 ($p<0.05$).

Conclusion
The level of intraoperative correction significantly influences correction at 2 years when accounting for preoperative SS and remaining growth. Our patient-specific FEM could help better plan lumbar VBT, determining appropriate intraoperative correction, with a predictable postoperative outcome.

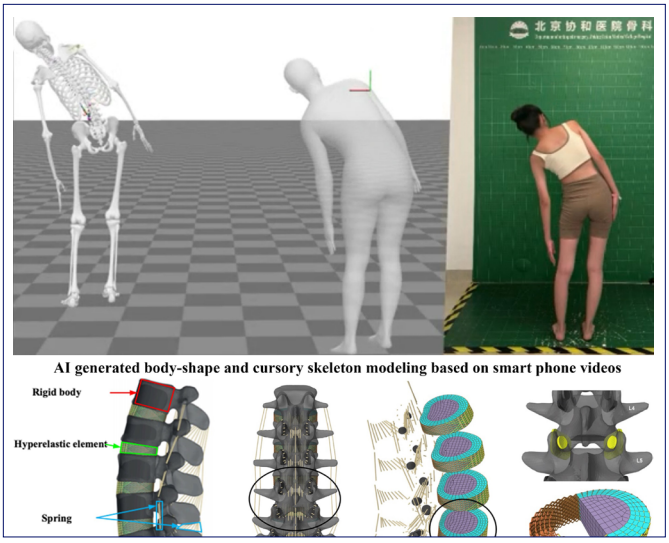


Figure 1 – Simulated post-operative correction after 2 years of growth & growth modulation corresponding to each simulated level of intra-operative correction (X = average; whiskers = minimum and maximum correction).

128. The Unipolar Shilla Technique: Results, Complications, and Outcomes

Omar Taha, BS; Matthew Weintraub, BSE; Thomas Zervos, MD; Ritt Givens, BS; Fthimnir Hassan, MPH; Nicole Bainton, CPNP; Amber S. Mizerik, PA-C; Lawrence G. Lenke, MD; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH

Hypothesis
A modified "unipolar" Shilla technique may allow correction of severe and complex spinal deformity with an acceptable safety profile while allowing for spinal growth.

Design
Retrospective review of "unipolar" Shilla cases performed by 3 surgeons at a single institution over an 8-year period.

Introduction
The Shilla technique provides direct apical control while allowing for continuous cranial and caudal guided growth in early onset scoliosis (EOS). The advantage of this technique over traditional growing rods is avoidance of repeated surgeries for manual distraction. When certain curve pattern or anatomical features preclude the possibility of bipolar growth, we used a novel modified "unipolar Shilla technique" which seeks to allow unipolar growth paired with short segment fusion (Figure 1).

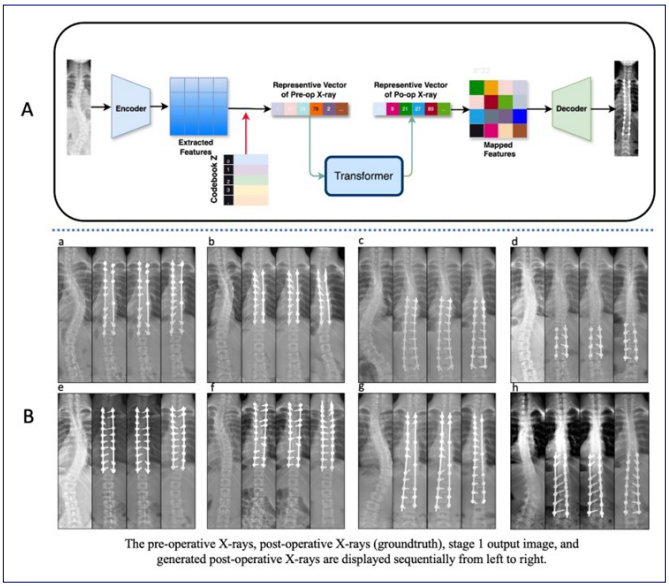
Methods
Unipolar Shilla patients were identified and socio-clinical variables, radiographic parameters, and

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

various metrics for spinal growth and lengthening of construct were measured. Rod slide is a measure of intra-Shilla construct growth.

Results
13 patients with a unipolar Shilla were identified. Average time from Shilla to skeletal maturity or definitive fusion was 5 years. The mean age at time of Shilla was 9.3 (range of 7-11) years old. All patients were Risser 0 and 11/13 had open triradiate cartilage. Vertebral column resection (VCR) was performed in 5 patients at time of index Shilla. The mean major cobb angle was 69° pre-Shilla and 19° post Shilla. Mean T1-12 kyphosis was 45° pre-Shilla and 31°post-Shilla. At minimum one year follow up, there was an average rod slide of 6 mm (n=9) with 78% of these patients having greater than 5 mm of rod slide. Thoracic height (T1-T12) increased from 17.7 ± 1.6 cm pre-operatively, to 22.0 ± 2.1 cm at final Shilla f/u. T1-S1 height increased from 27.3 ± 3.0 cm to 34.0 ± 3.1 cm.

Conclusion
Our results support the use of the modified "unipolar" Shilla technique in appropriately selected patients. We show excellent correction that was maintained without significant progression. The only complication was one unplanned return to OR for an elective trimming of a prominent distal rod. While all patients in our cohort had some Shilla growth, the magnitude was modest in most cases. We therefore recommend considering this technique in patients with a complex deformity that requires definitive control of the apex with limited growth remaining, as well as patients for whom close follow-up may be challenging.



The pre-operative X-rays, post-operative X-rays (groundtruth), stage 1 output image, and generated post-operative X-rays are displayed sequentially from left to right.

129. Preliminary Clinical Assessment of Bone Mineral Density Agreement Between a Dual Energy Stereoradiography System and Conventional DXA

Olivier Fantino, MD; *Jean-Charles Le Huec, MD, PhD*; Houda Tamouza; Alexander W. Turner, PhD

Hypothesis
The null hypothesis is that there is no significant agreement between the 2 systems.

Design
Multi-site, IRB-approved, prospective, observational study of agreement between 2 systems.

Introduction
Poor bone health has been linked to increased mechanical complications and decreased fusion rates, diminishing patient outcomes. Routine use of DXA for BMD assessment in this population is challenged by access. A recently available dual energy protocol for a low dose stereoradiography system (dual energy stereoradiography "DESR" protocol), allows concurrent acquisition of diagnostic images and estimates of BMD. This study evaluated initial clinical performance of the DESR protocol compared with conventional DXA, with the intention of informing enhancements by the manufacturer.

Methods
All patients received conventional DXA exams and full body, standing, stereoradiography imaging using the new DESR protocol. Prototype software estimated DESR spine BMD (AP L1-L4). T-scores from both systems were calculated using published coefficients. Bland-Altman agreement between the systems was evaluated. Subgroup analysis included age (<60, ≥60 yrs) and BMI (<25, ≥25).

Results
Ninety-one patients from the first site (Lyon) had both DXA and DESR exams. After excluding subjects with implants, fractures, extra vertebrae and severe deformity, 83 remained, of which 78 were female. The average age was 62 years (range: 29-88) and average BMI was 23.0 (range 16.2-41.5). On average, the prototype software underestimated DXA BMD by 0.056 g/cm2 (Bland-Altman bias), equivalent to a T-score difference of 0.51 (Figure, $p<0.001$). The distance between the Bland-Altman limit of agreement (LoA) and bias was 0.074 g/cm2, equivalent to a T-score distance of 0.67. When comparing ages, the T-score LoA-bias distance was 0.67 in the younger group, and 0.65 in the older group. For BMI, the T-score LoA-bias distance was 0.65 for normal subjects and 0.62 for overweight/obese.

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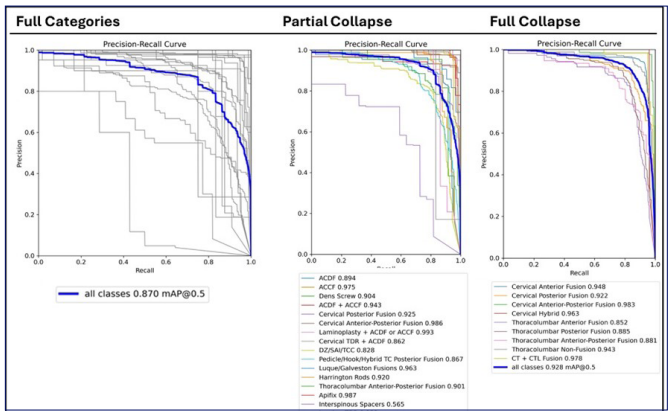
Conclusion
The study demonstrates encouraging limit of agreement results between the DESR and conventional DXA systems. Agreement was similar for age and BMI. Proposed improvements to the prototype software include a new equation to convert DESR BMD to DXA-equivalent BMD to reduce the bias, based on the current study data. Future work will validate the clinical performance of updated software versions.



Agreement between conventional DXA and DESR T-scores

130. The Prevalence of Sarcopenia in Adult Spinal Deformity Patients Differs Significantly Across Measurement Methods

Alexa M. Semonche, MD; Anthony L. Mikula, MD; Thomas Wozny, MD, PhD; Justin K. Scheer, MD; Winward Choy, MD; Aaron J. Clark, MD; Christopher P. Ames, MD

Hypothesis
The baseline prevalence of sarcopenia in the adult spinal deformity patients differs by measurement method

Design
Cross-sectional observational study

Introduction
Sarcopenia has been associated with adverse outcomes after spine surgery. However, current studies use many different criteria used to define sarcopenia. Thus, it remains unclear what the true prevalence of sarcopenia is in the adult spinal deformity (ASD) population. We sought to measure and compare the baseline prevalence of sarcopenia in ASD patients using 3 methods of measurement included in the Sarcopenia Definitions and Outcomes Consortium (SDOC) consensus criteria.

Methods
ASD patients at a single tertiary-care center were assessed preoperatively for grip strength and gait speed. Bioimpedance analysis (BIA) was performed using the Inbody970 Body Composition Analyzer (Inbody, USA) to determine Skeletal Muscle Index (SMI), which is appendicular skeletal muscle mass (ASM) divided by height2. The following SDOC-proposed cutoff points for sarcopenia were utilized: grip strength <35.5kg for men and <20.0kg for women, gait speed <0.8m/s, and SMI of <7.26kg/m2 for men, <5.45kg/m2 for women. Differences in sarcopenia prevalence by each measurement method were evaluated using Chi-square analysis.

Results
Between 2023-2024, 97 ASD patients were evaluated for sarcopenia preoperatively. Sixty-four (66.0%) were female. The average age did not differ significantly between women and men (65.2 vs. 61.9 years, respectively, P=0.26, Student's t test). For grip strength, 34 of 66 (53.1%) women and 20 of 33 (60.1%) men met the sarcopenia cutoff. For gait speed, 56 of 60 (93.3%, 4 patients excluded based on inability to ambulate) women and 29 of 33 (87.8%) men had a gait speed <0.8m/s. In contrast, based on BIA data, 3 of 64 (4.7%) women had a SMI <5.45 and 2 of 33 (6.1%) men had a SMI <7.26. Chi-square analysis showed the proportion of sarcopenic individuals differed significantly within male and female (P<0.0001) by measurement method.

Conclusion
The prevalence of sarcopenia in the preoperative ASD patients varied from 4.7-93.3% of women and 6.1-87.8% of men based on 3 methods put forth by SDOC consensus criteria. These results highlight the need for a standardized diagnostic criterion for sarcopenia in ASD patients. Such a criterion would improve the validity of studies investigating the impact of sarcopenia on surgical outcomes.

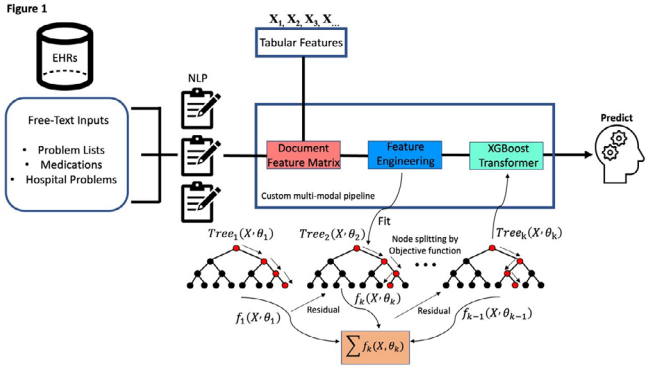


Table 1

131. Selection of Proximal Fusion Level in Chronic

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E-POINT PRESENTATION ABSTRACTS

Osteoporotic Vertebral Compression Fracture (OVCF) with Spinal Kyphosis: The Importance of Hounsfield Unit

Junyu Li, MD; Yiqiao Zhang, MD; Ben Wang, MD; Baitao Liu, MD; Xueshi Tian, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Yan Zeng, MD; Weishi Li, MD

Hypothesis
The selection of the upper instrumented vertebra (UIV) in chronic Osteoporotic Vertebral Compression Fracture (OVCF) has been proven to be related to postoperative complications. CT value can effectively reflect bone mineral density (BMD) and the biomechanical state of the vertebra. It might be possible to select the right UIV by the CT value.

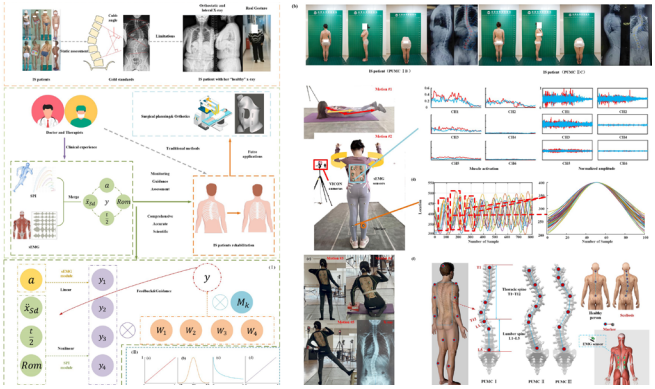
Design
Retrospective cohort study

Introduction
With population aging, the Osteoporotic Vertebral Compression Fracture (OVCF) has become an important public problem. Meanwhile, the deformity correction strategy of OVCF has been a concern and reaches no consensus, especially for selection of fusion level, which has been proved to be related to postoperative complications, such as proximal junctional kyphosis (PJK) and adjacent segment degeneration (ASD). To find the most stable vertebra as the UIV in OVCF patients, we came up with the upper maximal vertebra (UMV) and upper sagittal reverse vertebra (USRV) by Hounsfield Unit.

Methods
This clinical research included 70 chronic OVCF patients (14 males and 56 females) with a mean age of 63.24 ± 7.83 years and mean follow-up of 48.13 ± 20.22 months. Whole spine CT were performed for each patient. The patients were divided into groups according to whether their UIV was below the UMV or USRV. The incidence of ASD and PJK was evaluated in each subgroup.

Results
The average HU value of all patients was 80.88 ± 39.84. All sagittal parameters improved significantly after operation and at follow-up. For UMV, the UIV of 31chronic OVCF patients was located on or above the UMV, while that of 39 patients was not. There was a significant difference in the rates of ASD (p=0.003) and PJK (p=0.010) between the 2 groups. 55 patients (78.57%) were identified to have USRV. The UIV of 26 patients was located on or above the USRV while that of 29 patients was not. There was a significant difference in the rate of ASD between the two groups (p=0.010).

Conclusion
HU values should be considered in the selection of UIV. Locating UIV on UMV might decrease the incidence of PJK and ASD, and taking USRV into the fusion level might reduce the occurrence of ASD.



The definition of the UMV and the USRV

132. Cervical Deformity Correction: Comparison of Neurologic, Radiographic, and Patient Reported Outcome Measures by Three Column Osteotomy Level

Anthony L. Mikula, MD; David Mazur-Hart, MD; Zach Pennington, MD, BS; Alexa M. Semonche, MD; Winward Choy, MD; Thomas Wozny, MD, PhD; Jaemin Kim, BS; Terry Nguyen, BS; Aaron J. Clark, MD; Vedat Deviren, MD; Christopher P. Ames, MD

Hypothesis
When performing a three-column osteotomy (3CO) to correct cervical deformity, a difference will be observed in the neurologic, radiographic, and patient reported outcome measures when performed at the more cephalad motor nerve root levels (C7-T1) versus those without functional motor nerves at the more caudal levels (T2-T6).

Design
Retrospective chart review

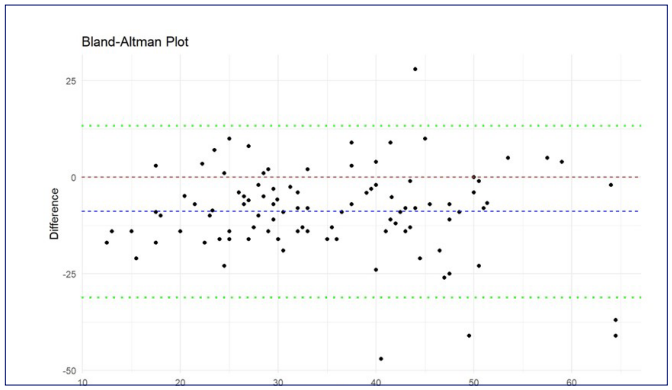
Introduction
Surgery to correct cervical deformity often involves a 3CO in combination with a long spine fusion construct. Choosing the 3CO level can have significant implications on the neurologic, radiographic, and functional patient outcome measures.

Methods
A retrospective review was performed of patients who underwent a cervical or upper thoracic 3CO for cervical deformity correction by the senior author from 2008 to 2024. Collected outcome measures included neurologic, mechanical complication rates, spinopelvic alignment, and patient reported outcome measures. Minimum follow up was one year.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Results
One hundred and fourteen patients were identified who underwent a cervical or upper thoracic 3CO for cervical deformity correction, of which 77 met inclusion criteria for this study. Average age was 66, BMI 27, and 43% were male. Sixteen patients underwent a 3CO at the C7-T1 levels and 61 from T2-T6. C7-T1 3CO patients were more likely to suffer a new postoperative neurologic deficit compared to the T2-T6 3CO patients (56% vs 18%, p=0.004), had less correction in their T1 slope (6° vs 18°, p=0.027), had less correction in C2-T4 sagittal vertical axis (2.8cm vs 4.9cm, p=0.043), and had a worse neck disability index (NDI) at one year compared to baseline (7% increase versus 12% decrease, p=0.033).

Conclusion
Cervical deformity patients who underwent a 3CO at C7-T1 had a higher rate of postoperative neurologic deficits, less radiographic correction, and had worse NDI scores at one year compared to patients who underwent a 3CO from T2-T6. Although 3CO level selection is multifactorial and patient specific, surgeons should consider a more caudal 3CO level when feasible.



133. The Predictive Value of Multifidus Degeneration in Osteoporotic Vertebral Compression Fracture Patients with Kyphosis Deformity

Junyu Li, MD; Zimo Wang, MD; Gengyu Han, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Lin Zeng, MD; Yan Zeng, MD

Hypothesis
Quality of life and the possibility of mechanical complications in patients with OVCF with kyphotic deformity are associated with multifidus muscle degeneration.

Design
Retrospective cohort study

Introduction
OVCF causes pain, kyphosis and neurological damage, which significantly affect patients' quality of life. Patients with OVCF are often elderly and have severe osteoporosis, which makes preoperative symptom more serious , postoperative recovery worse and the incidence of postoperative complications high. The paraspinal muscles have been well studied in adult spinal deformities, but there is no conclusive evidence that their findings can be applied to OVCF. The purpose of this study was to evaluate the associations between multifidus parameters and the sagittal parameters, symptom score, and postoperative complications.

Methods
The study included 108 OVCF patients with kyphosis deformity who underwent corrective surgery and were followed for two years. MRI were performed preoperatively to evaluate the paraspinal muscle morphology. VAS, ODI, JOA, and SRS-22 were conducted preoperatively. Preoperative, postoperative and last-follow up spine sagittal parameters were recorded. The occurrence of postoperative mechanical complications, including adjacent segment disease, screw loosening, PJK, and DJP were recorded. We analyzed the relationship between MF degeneration and the above parameters.

Results
Strong crrelation was observed in VAS and MFFI(p=0.000),MFrFCSA(p=0.001) and MFrGCSA(p=0.005), as well as ODI and MFrFCSA(p=0.042). Preoperatively, strong correlations were observed between MFrFCSA and LL(p=0.010),TLK(p=0.026),TK(p=0.048).MFrGCSA and LL(p=0.039),TLK(p=0.043),TK(p=0.030),GK(p=0.002) were also strongly correlated. Our study showed strong correlations between MFFI and TLK loss(p=0.003),TK loss(p=0.045);MFrGCSA and SVA loss(p=0.050),TPA loss(p=0.030);MFrGCSA and TPA loss(p=0.031),MFFI and GK loss(p=0.027). MFFI was significantly higher in the complication-presence group(p=0.045).

Conclusion
Multifidus degeneration is significantly associated with QoL, sagittal parameters and mechanical complications in OVCF patients with kyphosis deformity. The pathological changes of paravertebral muscles should be included in the surgical strategy and postoperative paravertebral muscle rehabilitation should be adopted to improve the clinical outcomes of OVCF patients.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

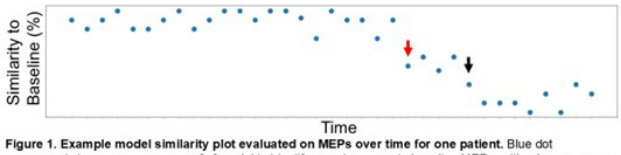


Figure 1. Example model similarity plot evaluated on MEPs over time for one patient. Blue dot corresponds to average accuracy of of model to identify muscle groups to baseline MEPs, with a low accuracy indicating an anomaly. Red arrow marks correspond to red flag warnings, or a a drop greater than 20% in accuracy from the prior MEP. Black arrow is the earliest change noted by the attending neuromonitoring team.

Typical Cases

134. FoxO4/mTORC1/RPTOR Negative Feedback: A New Perspective on Congenital Scoliosis Pathogenesis

Chong Chen, MD; Xingchen Zhao, MBBS; Wenlin Ye, MBBS; Yunbin Chang, MD

Hypothesis

The negative feedback loop involving FoxO4/mTORC1/RPTOR, through interactions with β-catenin and Smad3, regulates early chondrogenic abnormalities and constitutes a pathogenic mechanism for congenital scoliosis (CS).

Design

This research investigates the chondrogenic differentiation of bone marrow mesenchymal stem cells (BMSCs) using a combination of CRISPR/Cas9-mediated FoxO4 knockout in zebrafish models and cartilage tissue-specific knockout mice, both in vitro and in vivo.

Introduction

Congenital scoliosis (CS), resulting from the anomalous development of vertebrae associated with somitogenesis malformations, remains inadequately understood in terms of its pathogenesis. It has been documented that CS can be induced by vitamin A deficiency (VAD) during pregnancy. In prior research, we established that FoxO4 plays a significant role during the early to mid-stages of somitogenesis in a VAD rat model. However, the mechanisms underlying the transition from the embryonic mesenchymal period, often referred to as the prochondral stage, to the chondrogenesis period remain unclear.

Methods

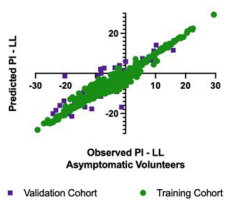
We intend to perform bioinformatics analysis, molecular docking model, confocal immunofluorescence, Co-IP, ChIP-seq, ChIP-PCR, luciferase assay, Western-blot, foxO4-morpholinos knockdown and CRISPR/Cas9 foxO4-knockout zebrafish models to detect the spatiotemporal expression of FoxO4, the relationship between FoxO4/mTORC1/PRTOR negative feedback regulation, BMSCs chondrogenic abnormal differentiation in vitro and in vivo.

Results

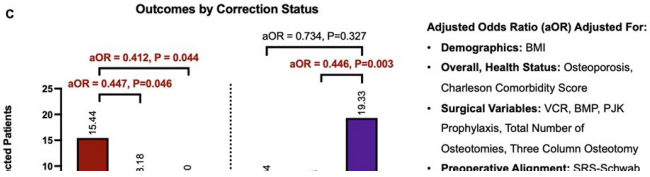
In the present study, we found that deletion of FoxO4 by in vivo in zebrafish leads to the appearance of the scoliosis phenotype. Further molecular mechanism studies showed that mTOR directly phosphorylates FoxO4 and inhibits its transcriptional function, while FoxO4 activates RPTOR gene transcription and regulates the functional activity of mTORC1, thus forming a negative feedback loop of mTORC1/FoxO4/RPTOR, which are jointly involved in the process of chondrogenic differentiation of hBMSCs.

Conclusion

In conclusion, our results reveal the critical role of FoxO4/mTORC1/PRTOR molecules in vertebral cartilage formation in CS patients, providing insights into the molecular mechanisms underlying this disorder.



Age Cohort					
<35	-11.52 (± 5°)	-7.23 (± 5°)	-5.58 (± 5°)	0.04 (± 5°)	3.74 (± 5°)
35-45	-5.36 (± 5°)	-4.52 (± 5°)	-6.39 (± 5°)	-0.54 (± 5°)	8.69 (± 5°)
45-55	-5.84 (± 5°)	-8.02 (± 5°)	-0.46 (± 5°)	3.05 (± 5°)	13.53 (± 5°)
55-65	-3.51 (± 5°)	0.15 (± 5°)	3.03 (± 5°)	6.68 (± 5°)	13.99 (± 5°)
65-75	-2.82 (± 5°)	2.89 (± 5°)	3.03 (± 5°)	6.49 (± 5°)	15.12 (± 5°)
75+	-0.54 (± 5°)	0.82 (± 5°)	7.32 (± 5°)	11.77 (± 5°)	17.44 (± 5°)



A:mTOR and FoxO4 were co-localized; B:The treatment of mTORC1 inhibitors could increase FoxO4 intranuclear transfer; C:foxO4-knockdown and foxO4-knockout zebrafish models showed body axial curvature deformity.

135. Modified Pedicle Subtraction Osteotomy for Osteoporotic Vertebral Compression Fractures: A Retrospective Study of 104 Patients

Junyu Li, MD; Jiahao Zhang, MD; Siming Xian, MD; Wenbin Bai, MD; Yihao Liu, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Hypothesis

Modified PSO is an effective solution for the treatment of OVCF.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

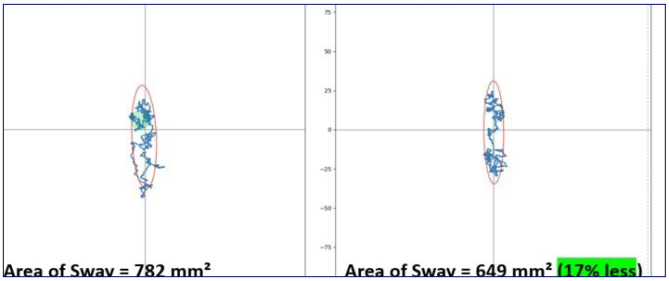
Design
case-control study

Introduction
Osteoporotic vertebral compression fractures caused by osteoporosis is a common clinical fracture type. There are many surgical treatment options for OVCF, but there is a lack of comparison among different options. Therefore, we counted a total of 104 cases of OVCF operations with different surgical plans, followed up the patients, and compared the surgical outcome indications before, after and during the follow-up.

Methods
104 patients who underwent posterior osteotomy and kyphosis correction surgery at our hospital between April 2006 and August 2021 with a minimum follow-up period of 24 months were included. All cases were injuries induced by a fall incurred while standing or lifting heavy objects without high-energy trauma. The mean CT value was 71 HU, indicating severe osteoporosis. The indications for surgery included gait disturbance due to severe pain with pseudarthrosis, increased kyphotic angle, and progressive neurological symptoms. Pre- and postoperative CL, TLK, TK, PrTK, TKmax, GK, LL, PI, SS, PT, SVA, TPA, were investigated. Additionally, We evaluated estimated blood loss, surgical time and perioperative symptoms.

Results
After operation, TLK (37.32 ± 10.61° vs. 11.01 ± 8.06°, $P < 0.001$), TK (35.42 ± 17.64° vs. 25.62 ± 12.24°, $P < 0.001$), TKmax (49.71 ± 16.32° vs. 24.12 ± 13.34°, $P < 0.001$), SVA (44.91 ± 48.67 vs. 23.52 ± 30.21, $P = 0.013$), CL (20.23 ± 13.21° vs. 11.45 ± 9.85°, $P = 0.024$) and TPA (27.44 ± 12.76° vs. 13.91 ± 9.24°, $P = 0.009$) were improved significantly in modified Pedicle subtraction osteotomy (mPSO) after operation. During follow-up, TLK (37.32 ± 10.61° vs. 13.88 ± 10.02°, $P < 0.001$) and TKmax (49.71 ± 16.32° vs. 24.12 ± 13.34°, $P < 0.001$) were improved significantly in Modified PSO group. In additon, estimated blood loss (790.0 ± 552.2 ml vs. 987.0 ± 638.5 ml, $P = 0.038$), time of operation (244.1 ± 63.0 min vs. 292.4 ± 87.6 min, $P = 0.025$) were favorable in Modified PSO group compared to control group.

Conclusion
To conclude, mPSO could acquire a favorable degree of kyphosis correction as well as early and high bone union. Compared with other surgical methods, it also has the advantages of less surgical trauma and shorter operation time. It can be an effective solution for the treatment of OVCF.



Modified PSO osteotomy diagram & typical cases

136. Stability of L2-S1 Spinal Fusions Utilizing the Minimally Invasive Antepsoas Approach (MIS-ATP) Supplemented by Posterior Percutaneous Fixation (PPF): Is Additional Pelvic Fixation Necessary?

Rehan R. Khan, BS; Aziz Saade, MD; Nader El Hajj, BA; Brian S. Tao, BS; Rahul Bhale, MD; Hayley Denwood, BS; Zi Jun Deng, MD; Neil V. Shah, MD, MS; Jude Abiad, BA; Tony Tannoury, MD; Chadi Tannoury, MD

Hypothesis
L2-S1 fusions via MIS-ATP + PPF confer spinal stability obviating the need for pelvic fixation.

Design
Retrospective cohort.

Introduction
Long segment instrumented lumbosacral fusions are notorious for implant failure. The use of additional pelvic fixation, although mechanically protective, has been a topic of debate.

Methods
A retrospective chart review of 96 patients who received L2-S1 fusions, without pelvic fixation, between 2006 and 2024 was conducted to evaluate the incidence of mechanical hardware failure. Patients who had at least 1 year follow up were identified (n=55). Implant failure was defined as either: rod breakage, screw breakage, screw pull out, implant related proximal / distal junctional failure, and the corresponding need for surgical revision. Patient demographics included sex, body mass index, comorbidities (diabetes, osteoporosis), lifestyle factors (smoking, alcohol), past surgical history (previous spine surgery, previous hip surgery, previous abdominal surgery), and diagnoses at initial presentation. Radiographs were reviewed to ascertain the development of implant failure.

Results
In this study we found that most implant failures manifested as: implant related proximal junctional failure (PJF) (n=1, 1.82%), pseudarthrosis (n=1, 1.82%), and distal junctional failure at L5-S1 (n=3, 5.46%). Among the distal junctional L5-S1 failures, we noted

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1 S1 screw pullout and 2 S1 screw breakages. Overall, 2 patients (3.64%) underwent revision surgeries for hardware failure (1 case of PJF, and 1 case of screw breakage at L5-1).

Conclusion
L2-S1 MIS-ATP fusions + PPF without pelvic fixation offers acceptable stability and low implant failure rate, especially at L5-S1.

137. Analysis of Smartphone Accelerometer Data Reveals Epidural Injections Before Spine Surgery Lead to Improved Mobility

Ryan Turlip, BA; Hasan Ahmad, BS; Daksh Chauhan, BS; Harmon Khela, BS; Kevin Bryan, BA; Omkar Anaspure, BS; Robert Subtirelu, BS; Yohannes Ghenbot, MD; Michael Y. Wang, MD; Jang Yoon, MD

Hypothesis
In this study, we explored the relationship between various types of conservative management strategies and patient activity levels measured by smartphones throughout the perioperative period.

Design
Retrospective study design.

Introduction
Conservative treatments are commonly employed for back pain, but, as symptoms advance, surgical intervention is a viable option for patients to pursue. However, the influence of this phase of treatment before surgery on postoperative outcomes and patient mobility remains unclear. Recently, the emergence of smartphone-based objective activity tracking has proven to be a useful tool in prognostication and outcome evaluation in spine surgery.

Methods
A retrospective review of 34 patients undergoing spine surgery between 2017 and 2021 was performed. Over a two-year perioperative period, patient daily step counts were obtained remotely through smartphones and statistically normalized to allow for comparisons between patients. Demographics variables and the utilization of preoperative conservative management techniques, such as epidural steroid injections (ESI), were extracted from the electronic health record. Heteroskedastic t-tests were employed for statistical comparisons.

Results
Postoperative activity levels did not differ according to physical therapy (p=0.182) or oral steroid medication (p=0.313) medication usage. However, patients who were administered ESIs (n=20) exhibited enhanced functional outcomes postoperatively, as they not only reached baseline activity levels quicker but also attained higher activity levels than those without ESIs (n=14) (p=0.024). These two groups were not significantly different in age, BMI, Charlson comorbidity index, or type of surgery performed (24 decompression, 10 fusion). Smartphone-captured patient mobility did not significantly vary between the groups prior to surgery. Following surgery, patients in the pre-operative ESI group experienced an average of 180 days [95% CI: 65, 170] with activity levels above their baseline compared to only 118 days [95% CI: 144, 216] for those who did not receive pre-operative ESIs.

Conclusion
Our results demonstrate that the inclusion of ESIs in the conservative management phase correlated with improved postoperative mobility. Mechanistically, we posit that ESIs may exert enduring anti-inflammatory and pain relief effects, thereby augmenting patient recovery.

138. Thoracic Inlet Insufficiency: A Novel Form of Thoracic Insufficiency: Diagnosis and Treatment

Blake Montgomery, MD; Emily Eickhoff, BS; Shawn Izadi, MD; Amir Taghinia, MD; David Zurakowski, PhD; Russell W. Jennings, MD; Christopher Baird, MD; *Brian D. Snyder, MD, PhD* §

Hypothesis
Thoracic inlet insufficiency is clinically unique, can be diagnosed using a CT-based metric, and can be successfully treated using a novel surgical technique: opening wedge sternoplasty

Design
Retrospective Case Control

Introduction
We describe a novel pathoanatomic syndrome, Thoracic inlet insufficiency (TII), where deformity of the spine (scoliosis/hypokyphosis), sternum (pectus excavatum) and/or thorax (dysplastic ribs) constrict the great vessels, trachea and/or esophagus. Clinical manifestations include exercise intolerance, dyspnea, cough, pain, dysphagia, and/or palpitations. A CT-based metric was derived to grade severity. Increasing thoracic inlet depth by expansion sternoplasty, augmented by suspension pexies of the great vessels relieved pathoanatomic compressions and clinical symptoms.

Methods
TII was identified by CT-angiography. The thoracic inlet index (transverse distance between 1st rib margins ÷ narrowest depth between anterior vertebral body to posterior sternum) was determined for symptomatic patients relative to 40 controls to derive a disease threshold (ROC). Modeling the thorax as an elliptical tube hinged posteriorly at the spine (ellipse

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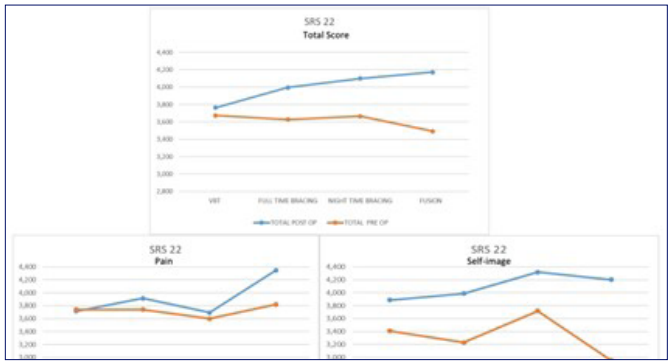
foci), treatment consists of performing a midsagittal opening wedge sternoplasty using interposed transversely oriented autogenous rib segments or allograft ilium to maintain distraction, therby increasing the depth and cross-sectional area of the mediastinum, supplemented by pexies to elevate vascular structures compressing the trachea and/or, esophagus. Pathoanatomic and clinical metrics were compared pre- vs. post-operatively.

Results
12 patients (median age=14.5yrs, 7♀) with congenital, syndromic or connective tissue diseases were diagnosed with TII. The TI index was greater ($p<0.01$) in TII patients (3.1, SD=1.0) vs controls (2.2, SD=0.3). An index >2.6 was 67% sensitive and 90% specific for discriminating at-risk patients. Expansion sternoplasty increased the mediastinal space available for the aerodigestive organs: +24.9% ↑A-P depth (SD=22.8, $p<0.01$); +57.5% ↑trachea cross-section-area (SD=69.1, $p<0.01$). The TI index decreased 43.7% (SD=22, $p<0.01$) to normal (mean=2.24, SD=0.44). All patients improved clinically.

Conclusion
Patients with spinal and/or thoracic deformity experiencing dyspnea and/or dysphagia may have TII. We elucidate the pathoanatomy, provide a radiographic metric to identify at risk patients and describe a treatment that alleviates the pathoanatomic aerodigestive compression and clinical symptoms.



139. Transition Rods Only Versus Transition Rods Combined With Junctional Tethering in the Prevention of Proximal Junctional Kyphosis in Adult Spinal Deformities Surgery

Francesco Lolli, MD; Carmela Altruda, MD; Andrea Baioni, MD; Ilaria Barni, MD; Marco Cancedda, MD; Riccardo Draghi, MD; Andrea Messina, MD; Nicolò Regge Gianas, MD; Ignazio Borghesi, MD

Hypothesis
To evaluate the effectiveness of transition rods with or without junctional tethering in the prevention of proximal junctional kyphosis

Design
Retrospective study

Introduction
Proximal junctional kyphosis (PJK) is one of the most problematic complications in the field of spinal deformities surgery. Aim of the study is to compare the use of transition rods versus transition rods combined with junctional tethering to prevent this complication

Methods
59 consecutive patients were included in the study. All patients had been treated by "long" posterior instrumented fusion (screws only construct, with or without anterior lumbar support), extended from the proximal thoracic segment (T1-T5) to the pelvis, for an adult spinal deformity in the coronal or sagittal plane. Exclusion criteria were: oncological or infective spinal diseases, neurologic diseases (like Parkinson). Patients were divided into two groups. In 32 cases (TR Group) transition rods (3.5 mm, titanium or cobalt crome) were used in the proximal thoracic segments (1 or 2 levels), in 27 cases (TRJ) transition rods were associated with junctional tethering (UIV + 2). The 2 groups were comparable in terms of age (67.2 vs 68.5 years), prevalence of female sex (84.3 vs 77.8%), underlying pathology (adult idiopathic scoliosis 15 vs 12 cases, failed back surgery 12 vs 11 cases, global kyphosis 5 vs 4 cases)

Results
At a mean follow up of 16 months (range 12 to 22), PJK radiologically occurred in 3 cases in TR group, in 2 cases in TRJ group (difference not statistically significant, $p<0.05$). In all cases, PJK occurred in first two months after surgery (in 2 cases due to a fracture of the superior endplate of the upper instrumented vertebra), without hardware failure and without clinical symptoms. In no case revision surgery was needed. No PJF occurred. Clinical results, evaluated with VAS and Oswestry questionnaires, were similar in both groups of patients

Conclusion
The use of transition rods has been shown to be effective in preventing PJK in adult spinal surgery. The association with junctional tethering has not shown significant advantages in the prevention of this complication. A study on a larger sample of patients and with longer follow-up is needed to confirm these results

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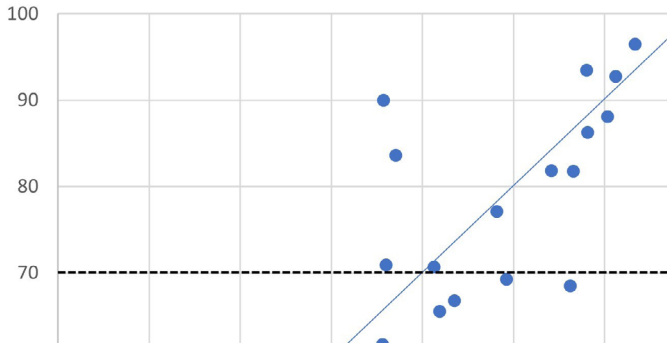

Adult scoliosis treated with posterior T3-pelvis instrumented fusion with transition rod at a 1 year follow up

140. Imaging Characteristics and Quality of Life in Cervical OPLL Patients with and without Diffuse Idiopathic Skeletal Hyperostosis: A Retrospective Study

Jiang Gan, MD, PhD

Hypothesis
Although there have been numerous previous epidemiological studies, the exact pathogenesis of OPLL remains unclear. In our clinical practice, it has been observed that patients with cervical OPLL may concurrently develop diffuse idiopathic skeletal hyperostosis (DISH), which is associated with exacerbated neurological symptoms compared to those without DISH. However, to our best knowledge, the severity of OPLL in patients with DISH compared to those without DISH has not been comprehensively investigated.

Design
We reviewed cervical OPLL patients treated at our institution from 2017 to 2022, comparing imaging parameters and clinical outcomes between patients with and without DISH.

Introduction
Both DISH and OPLL can co-exist in the same patient. However, the severity of cervical OPLL in patients with and without DISH had not been comprehensively investigated.

Methods
A total of 192 consecutive cervical OPLL patients underwent posterior cervical surgery in our institution were included from January 1, 2017 to November 1, 2022. All these cases were divided into two groups based on the presence of DISH or not. Imaging parameters including the ossification index (OP-index), canal narrowing ratio (CNR), C2-7 lordosis angle, C7 Slope and C2-7 SVA were measured to assess the severity of cervical OPLL and sagittal balance. Quality of life was also compared between two groups by JOA and VAS scores.

Results
There were 152 patients in DISH(-) group and 40 patients in the DISH(+) group. Continuous-type OPLL (P=0.004) was most prevalent classification in the DISH(+) group, exhibiting a significant incidence of OPLL at the C2, C3, and C4 levels. Patients in DISH(+) group had higher OP-index (P=0.001), higher CNR (P=0.001) and higher preoperative C2-7 angle(P=0.014) than those without DISH. Both preoperative and postoperative JOA scores (pre: P=0.001; po: P=0.002) were lower and VAS scores (pre: P=0.005; po: P=0.018) were higher in patients with both OPLL and DISH.

Conclusion
DISH had an adverse influence on the severity of cervical OPLL and quality of life.

141. Brace and Kyphosis Specific Exercises Can Effectively Treat Scheuermann Kyphosis at the Peak of Growth

Nikos Karavidas, PT, MSc

Hypothesis
A combined conservative treatment with brace and kyphosis specific exercises (KSE) can be efficient for Scheuermann kyphosis treatment at the peak of growth

Design
Prospective cohort study

Introduction
Scheuermann Kyphosis is defined by radiological (3 consecutive wedged vertebrae) and clinical (angular hump and rigidity) criteria. The aim of non-operative treatment is to stop progression, avoid surgery, improve kyphotic angle and aesthetics. To date, only few studies investigated the effect of conservative treatment for Scheuermann kyphosis.

Methods
89 patients (18 girls - 71 boys, mean age 14.1 years, Risser sign 1.8, kyphotic Cobb angle 61.8o) enrolled in our study, from our prospective database. Our inclusion criteria were Scheuermann kyphosis radiological and clinical signs, Risser 0-3 and age > 10 years. All subjects prescribed brace and Schroth-kyphosis specific exercises (KSE). Our outcome parameters were pre/post kyphosis angle, vertebra wedging at apical region and SRS-22 questionnaire scores. Fail of treatment was defined as progression > 5o. Average follow-up time was 33.5 months. Compliance was self-reported. Paired t-test was used for statistical analysis.

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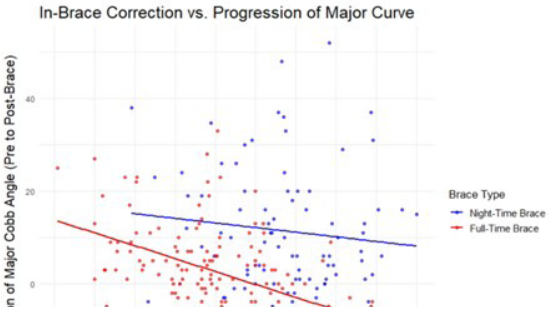
Results
In total, 53 patients (59.6%) improved their kyphotic angle > 5o, 30 remained stable (33.7%) and 6 worsened (6.7%). The mean in-brace correction was 43.8%. Mean kyphotic angle post-intervention was significantly improved (49.4o, p=0.002). A statistically significant improvement was measured for the vertebra wedging at apical region, from 9.4o to 7.3o (p=0.03). Self-image (from 3.2 to 4.1, p= 0.02), pain (from 3.6 to 4.1, p=0.05), mental health (from 3.4 to 4.2, p=0.02) and total SRS-22 score (from 72.3 to 81.6, p=0.004) improved after treatment. Only, function did not significantly change (from 4.3 to 4.5, p=0.09). Only 3 patients (3.4%) decided to have a spinal fusion.

Conclusion
Brace and Schroth-kyphosis specific exercises achieved a success rate of 93.3% for Scheuermann kyphosis treatment, avoiding progression. Our study confirms that also some growth modulation can be observed, improving the wedging of the vertebra after treatment. Finally, all health related quality of life measurements were significantly better post-treatment. To conclude, non-operative treatment can be effective for Scheuermann kyphosis at the peak of growth.



Excellent clinical and radiological correction of a young girl with Scheuermann kyphosis

142. Enhanced Osseointegration and Antibacterial Properties of Bio-PEEK for Spinal Fusion: A Comparative Study

Hasan Ahmad, BS; Daksh Chauhan, BS; Omkar Anaspure, BS; Harmon Khela, BS; Robert Subtirelu, BS; Ryan Turlip, BA; Kevin Bryan, BA; Yohannes Ghenbot, MD; Connor Wathen, MD; Jang Yoon, MD

Hypothesis
In this study, we rigorously evaluate the biocompatibility, bioactivity, and antibacterial properties of Bio-PEEK, aiming to establish a new standard in spinal implant technology and improve patient outcomes.

Design
Comparative study design.

Introduction
Spinal fusion, a critical surgical intervention, often uses Polyetheretherketone (PEEK) cages for mechanical stability and pain relief. However, PEEK cages face high failure rates, low bioactivity, and bacterial infections. Integrating bioactive ceramics with Fused Filament Fabrication (FFF) technology offers a promising solution. This combination is expected to enhance osseointegration, reducing implant failure and infection risks.

Methods
Biocompatibility was assessed using inductively coupled plasma (ICP) analysis. Mouse pre-osteoblasts were seeded onto the filaments, and cages were immersed in Simulated Body Fluid (SBF) at 37°C for 7 days to compare bone-like apatite deposition. Cell growth kinetics were measured using a Thiazolyl blue tetrazolium bromide (MTT) assay. Antimicrobial properties were assessed with LIVE/DEAD analysis, and biofilm formation was examined using scanning electron microscopy (SEM) to compare S. aureus adherence on Bio-PEEK and bare PEEK.

Results
Bio-PEEK showed improved biocompatibility and bioactivity over PEEK, with higher cell adhesion and bone-like apatite deposition. It exhibited faster cell growth kinetics and lower bacterial growth in LIVE/DEAD analyses. SEM images indicated Bio-PEEK's superior inhibition of biofilm formation, with fewer S. aureus adhering to Bio-PEEK compared to bare PEEK.

Conclusion
Bio-PEEK demonstrated enhanced biocompatibility, bioactivity, and antibacterial properties compared to traditional PEEK. This improvement could reduce the need for costly bone-stimulating proteins, simplifying and lowering the cost of spinal fusion surgeries. Additionally, Bio-PEEK's enhanced antibacterial properties may decrease the risk of post-operative infections, improving patient recovery and implant success. Bio-PEEK marks a significant advancement in medical implants, promising more functional and cost-effective solutions in spine surgery and aligning with the trend towards personalized, patient-specific implants.

143. Sacroiliac Fixation Using Dual S1-Iliac and S2-Iliac Screws for Neuromuscular and Early Onset Scoliosis

Kevin M. Neal, MD; Tarek Obeid, MS; Caroline Epstein, MD; Joseph Larwa, MD; *Anna J. Rambo, MD*

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Hypothesis
Dual S1-iliac and S2-iliac screws provide stable fixation and correction of pelvic obliquity with lower complications than S2-iliac screws alone.

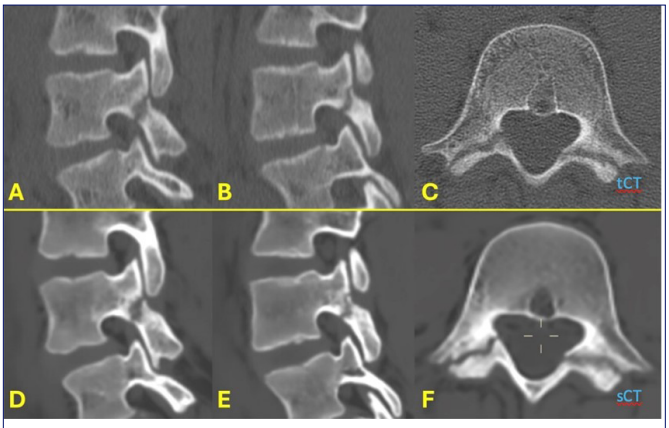
Design
Retrospective

Introduction
Patients with neuromuscular (NM) scoliosis or early onset scoliosis (EOS) may require instrumentation to the pelvis with sacroiliac screws to correct pelvic obliquity (PO). Complications of sacroiliac screws can include infection, implant prominence, implant pullout, implant breakage, and sacroiliac pain, with reported revisions up to 25%. This study analyzes whether dual, bilateral S1-iliac and S2-iliac screws can minimize complications, compared to bilateral S2-iliac screws alone.

Methods
All patients with NM scoliosis and/or EOS who required pelvic fixation at a single institution from 2011 to 2021 and who had minimum 2 year follow up were retrospectively reviewed. In addition to demographic variables, the main curve size and PO were analyzed preoperatively, on the 1st erect X-Ray, and at final follow up (FU). Incidences of infection, implant prominence, breakage, or pullout, sacroiliac pain, and revision surgery were recorded. A group with bilateral S1-iliac and S2-iliac screws (S1-S2) was compared to a group with only bilateral S2-iliac screws (S2).

Results
78 patients were included (S1-S2 N=23, S2 N=55). There were no significant differences in age (P=0.21), sex (P=0.70), or preoperative main curve size (P=0.54) between the groups. Average FU was 50 months for S1-S2 and 52 months for S2 (P=0.84). Average preoperative PO was 17° for S1-S2 and 12° for S2 (P=0.03). Main curve correction was 67% for S1-S2 and 59% for S2 on the 1st erect X-Ray (P=0.22) and 66% for S1-S2 and 53% for S2 at final FU (P=0.08). Average PO correction was 52% for S1-S2 and 50% for S2 on the 1st erect X-Ray (P=0.51) and 45% and 31% at final FU (P=0.75). There were no documented cases of implant prominence or sacroiliac pain. 1 patient from S1-S2 and 7 from S2 had implant breakage (P=0.27). There were 0 cases of screw pullout for S1-S2 and 1 case for S2 (P=0.90). There were 0 cases of revision pelvic implant surgery for S1-S2 and 5 cases for S2 (P=0.54).

Conclusion
Pelvic fixation with bilateral S1-iliac and S2-iliac screws had better correction of the main curve and PO on the 1st erect X-Ray and at final FU, with a lower rate of complications, though these differences failed to reach the threshold for statistical significance.



145. Does Socioeconomic Status Affect Neuromuscular Scoliosis Severity at the Time of Surgery and Influence Postoperative Complications?

Margaret Crownover, BS; Petya Yorgova; Suken A. Shah, MD

Hypothesis
Lower socioeconomic status (SES) and public insurance status independently affect preoperative diagnosis severity and may affect postoperative complications.

Design
Retrospective

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Introduction
Pediatric patients with severe neuromuscular scoliosis (NMS) often require posterior spinal fusion (PSF) surgery. Curve magnitude (among other comorbidities) is a risk factor for worse post-operative outcomes.

Methods
We utilized the Area Deprivation Index (ADI) and insurance type (private vs. public) to stratify groups for analysis. Higher ADI corresponds to greater deprivation (i.e., lower income). We studied 170 patients with NMS who underwent PSF >13 levels from 2015-2019 at our institution (81 (48%) female/89 (52%) male); the most common diagnosis was quadriplegic CP [134 (78.8%)].

Results
Race slightly favored Caucasian [99 (58.2%)] and more patients had public rather than private insurance [91 (54%),79 (46%)]. Non-white individuals had a higher mean ADI than white individuals (52.2 vs. 41.0,[p=0.016],fig. 1C). Patients with higher ADI had a greater preoperative curve magnitude ([p=0.02], fig. 1A-B) and higher no-show rates [p=0.002]. They were more likely to be publicly insured [p=0.038], non-white [p=0.024], and from single guardian households [p=0.036]. Compared to privately insured patients, publicly insured patients had a higher mean ADI (52.0 vs. 38.3 [p = 0.038], fig. 1D), were more likely to be of non-white race [p<0.001], and presented with more comorbidities [p=0.003]. They were less likely to seek second opinions [p=0.005], had higher outpatient no-show rates [p<0.001], and were older at the time of surgery [p=0.016]. They had more unplanned readmissions (3.5 vs. 2.0, [p=0.032]) and ED presentations (6.7 vs. 4.0, [p=0.004]) during a similar mean follow-up time (46 months).

Conclusion
Patients with higher ADI were more likely to be non-white, publicly insured, present with larger scoliosis curve magnitudes, and have higher no-show rates. Barriers to accessing specialized care (i.e., transportation and cost) and varying levels of health literacy likely affected these findings. Greater diagnosis severity at presentation may limit the improvements afforded by surgery and pose higher postoperative risks. Efforts should focus on identifying this at risk population preoperatively and providing resources to mitigate the effect of SES on postoperative outcomes after PSF for NMS.

Table 1: Raw proportions and GEE-estimated proportions with 95% confidence intervals of each RCN technical difficulty

	Raw Frequency (%)	Estimated Proportion (95% CI)
Robotics and navigation technical difficulty	148 (27%)	26% (15, 41)
Type of robotic technical difficulty		
Loss of calibration	34 (6%)	7% (4, 14)
Loss of registration	42 (8%)	9% (6, 13)
Inability to perform trajectory	50 (9%)	9% (7, 12)
Screw malposition	27 (5%)	6% (3, 13)
Neurodeficit/Dural leak/Visceral injury	2 (0.4%)	0.4% (0.3, 0.4)
System malfunctions	27 (5%)	5% (2, 10)
Other	3 (1%)	0.4% (0.2, 0.8)

†Estimated from a GEE model that includes a compound-symmetry correlation structure to account for within-site correlation.

146. Changes in Thoracolumbar Vertebral Pelvic Angles Between Standing and Sitting

Atahan Durbas, MD; *Han Jo Kim, MD*; Robert N. Uzzo, MBA; Gabrielle Dykhouse, BS; Justin Samuel, BS; Chad Simon, BS; Tejas Subramanian, BS; Myles Allen, MBchB; Michael Mazzucco, BS; Michael Kelly, MD; Jeffrey M. Hills, MD; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

Hypothesis
ΔVPAs vary significantly between standing and sitting positions, and these positional changes are influenced by age, BMI, and gender.

Design
Single-center retrospective study

Introduction
Spinal realignment targets are based on standing radiographs, but multiple studies have shown that lumbar lordosis decreases in the sitting position. Sitting alignment has not been described using VPAs, which are becoming more popular measures of spinal alignment. This study examined the differences in VPAs between standing-sitting and the effects of PI, age, BMI, and gender on these changes.

Methods
Cross-sectional imaging analysis of lateral XRs of patients under consideration for hip replacement in standing and sitting positions. Patients with previous spinal fusions or scoliosis (defined as a max coronal Cobb angle ≥20°) were excluded. The primary outcome was the change in VPAs (ΔVPA), which were measured through the uppermost visible level on sitting lateral XR. ΔVPA was defined as Standing VPA–Sitting VPA. Multiple linear regression was used to assess the impact of PI, age, BMI, and gender on ΔVPA.

Results
The study included 1470 patients (786 females, 684

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

males), mean age 62.8 (±11.3) years, BMI 28.9 (±5.8) kg/m², and PI 52.8° (±12.4) were identified. The most proximal level observed on lateral XRs was T10 (n=519). Thoracic VPAs increased more with sitting compared to lumbar VPAs (Figure 1). Multiple linear regression demonstrated older age was associated with increased ΔVPAs from L5 to T10 (p=.02 for L5 and p<.001 for all others, B=.02, =.07, =.14, =.19, =.23, =.28, =.30, =.35, respectively). BMI showed positive associations with ΔVPAs at T11 (p=.01), T12 to L4 (all p<.001) (B=.11, =.20, =.11, =.11, =.09, =.06, respectively).

Conclusion

VPAs are higher in the sitting position, with a larger ΔVPA moving from distal to proximal. Older age and increased BMI are associated with larger ΔVPA between sitting and standing.

Patient Demographics (N=80)	Mean±SD or N(%)
Age	15±2 years
Gender: Female Male	 59 (73%) 21 (27%)
Pre-Op Lenke Type Type 1 Type 5	 54 (68%) 26 (33%)
Operative Findings	
Procedure Time	111±37 min
Blood Loss	42±38 mL
Hospital Length of stay	1 Day

VPA and PT changes (ΔVPAs) between standing and sitting at T6-L5 levels.

147. Eyes in the Sky: Preoperative Ultralow-Dose Preoperative CT-Guided Navigation with Optical Registration for Adolescent Idiopathic Scoliosis Fusion Surgery

Hans K. Nugraha, MD; Ria Paradkar, BS; Todd A. Milbrandt, MD, MS; *A. Noelle Larson, MD*

Hypothesis

The workflow in preoperative ultralow dose CT with optical registration would improve as the team gained familiarity with the new technique & that preoperative CT would result in shorter operative times than cases with intraoperative CTs

Design

Retrospective Cohort

Introduction

Fusion surgery for AIS is indicated in patients with progressive severe curves. Intraoperative navigation has become increasingly used for posterior spinal instrumentation given the frequently small & dysplastic pedicles. The authors' center recently switched from intraoperative CT to preoperative ultralow dose CT with optical registration

Methods

After obtaining institutional IRB, a single-center retrospective review was done on patients with AIS who underwent fusion surgery utilizing a preoperative CT with intraoperative optical registration (7D System;Seaspine,CA,USA). Patients were then evaluated based on their estimated blood loss (EBL), length of procedure (LOP), and length of hospital stay (LOS). Previous work noted that mean radiation dose per scan was 0.7mSv - similar to 7 chest x-rays or 2 standard scoliosis x-rays. All statistics was performed with GraphPad Prism 10.2.0 (GraphPad Software Inc;San Diego,CA,USA)

Results

68 patients underwent spinal fusion aided by the system from 2021 to 2024. An average of 11.5±2.4 levels were instrumented. All the scans registered and were deemed safe & accurate. Mean EBL was stable over the 3-year period with 438 mL in 2021 to 331 mL in 2024. Similarly, LOP was stable at 371 minutes in 2021 to 355 minutes in 2024. There has been no change in LOS from 3.6 days in 2021 to 3.5 days in 2024. There was also no correlation found between the number of instrumented levels with the LOP, EBL, and LOS. Further individual t-test analysis between 2 surgeons who utilized most of the technology also showed no differences when comparing their first 5 cases to their subsequent 5 cases. No patients required anesthesia for the preoperative scan. All cases were successfully completed without turning to other navigation strategies

Conclusion

This series has demonstrated stable surgical efficiency for using preoperative navigation system including operative time, hospital stay, and EBL over a 3-year period. An ultralow dose CT navigation system with intraoperative optical registration was safe and effective for pedicle screw placement over the study period

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Table 1: Descriptions and Outcomes of False Negative IONM Events

Procedure	Diagnosis	IONM Modalities	Postoperative Neurologic Result	Final Neurologic Outcome
Deformity PSF/ASF	Syndrome	SSEP and DNEP	Monoplegia LUE; no change elsewhere	Partial Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	No dorsiflexion or plantarflexion RLE; weakness R hand; paresthesia right hand and foot	Unknown
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	Paraplegia	No Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP and DNEP	Weakness/Paresthesia LUE; no changes elsewhere	Resolved
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	1/5 LLE Dorsiflexion; no changes elsewhere	Partial Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	R Quad Weakness; RLE Paresthesia	Unknown
Deformity PSF	Idiopathic	SSEP and DNEP	Weakness/Paresthesia RLE	Unknown
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	L Quad 0/5	No Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	0/5 motor and sensory R L5 distribution	No Recovery
Deformity PSF	Kyphosis/Kyphoscoliosis	SSEP and DNEP	Monoplegia RLE	Partial Recovery
Deformity ASF/PSF	Spondylolisthesis/Spondyloptosis	SSEP only	0/5 L Dorsiflexion	No Recovery
Deformity PSF	Idiopathic	SSEP and DNEP	L Dorsiflexion weakness	Resolved
Deformity PSF	Idiopathic	SSEP and TcMEP	L Foot Drop	Partial Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	R Foot Drop	Partial Recovery
Deformity PSF	Spondylolisthesis/Spondyloptosis	SSEP only	weak bilateral dorsiflexion, left>right	No Recovery
Deformity PSF	Not Given/Unknown	SSEP and DNEP	L L5 weakness	Resolved

148. Optimizing Vertebral Body Tethering: Surgical Technique, Patient Selection, and Failure Mechanisms

Julia Todderud, BA; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD; D. Dean Potter, MD

Hypothesis

We hypothesize that preoperative curves 65° or less, flexible curves bending to less than 35°, and curves corrected to 20° or less intraoperatively would result in improved patient success at latest follow-up.

Design

This is a single-center retrospective review of patients that underwent VBT between 2017 and 2022 with minimum 2-year follow-up.

Introduction

Optimizing patient selection and surgical technique for vertebral body tethering (VBT) has become a focus for improving patient outcomes. With this study, we developed and applied criteria to optimize VBT.

Methods

Our ideal surgical criteria include: a preoperative primary curve ≤65°, bending to <35° on flexibility radiographs, and intraoperative correction to ≤20°. Radiographs were reviewed preoperatively to latest follow-up. Success is defined by a curve ≤35° with no reoperation, not including cord release.

Results

66/101 patients met the ideal criteria for surgery. At 2-year follow-up, all patients were successful. At latest follow-up (mean 2.8 years) 92% were successful. Most patients had closed triradiate cartilage (N= 60, 91%), were Risser 0 (N=34, 52%), and Sanders skeletal maturity 3B (N=20, 30%). Most curves were Lenke 1A (N=32, 48%). The mean preoperative primary curve measurement was 50° (36-65). Mean primary curve on bending films was 23° (6-34), representing a curve correction of 54% (34-88) relative to standing curve magnitude. Patients averaged 8 instrumented vertebral levels (5-12). The intraoperative major curve measurement was 12° (1-20). First erect postoperative imaging averaged 26° (2-46), representing a percent correction of 49% (17-95). At 2 years post-operation, mean major Cobb was 25° (5-35) (50% correction). At latest follow-up (2.8 years, range 2-7), curve correction was 49% (7-86), for a mean curve measurement of 25° (6-40). 5 of the ideal patients were unsuccessful (success rate 92%), with 2 reoperations (reoperation rate 3%). 3 patients had tether breakage with progression of the primary curve, with 1 undergoing cord revision. 1 patient had overcorrected with subsequent spinal fusion. 1 patient developed an additional curve above the instrumented levels. 5 patients underwent cord release by latest follow-up.

Conclusion

Our study reports on guidelines for optimizing VBT indications in order to improve patient outcomes. For the patients that met our ideal criteria, the success rate was 100% at 2-years and 92% at latest follow-up.

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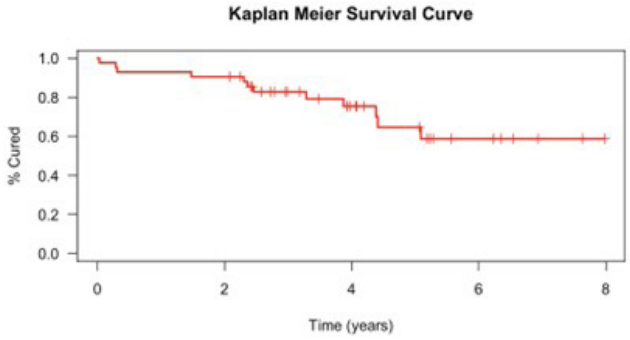


149. Intraoperative Facet Joint Block Reduces Postoperative Pain after Oblique Lumbar Interbody Fusion: A Double-Blind, Randomized, Placebo-Controlled Clinical Trial

Sung Hyun Noh, MD, PhD

Hypothesis
Intraoperative facet joint block decreases pain perception during OLIF, thus reducing opioid consumption and the severity of postoperative pain.

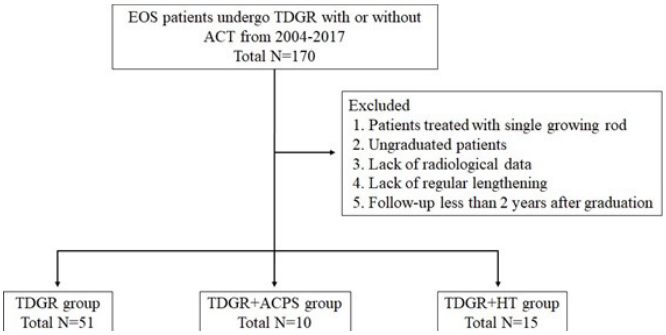
Design
RCT

Introduction
In the case of oblique lumbar interbody fusion (OLIF) surgery, the damage to tissues around the spine, such as muscle, ligament, and bone injuries, is significantly less compared to other surgeries but immediate postoperative pain persists after surgery. However, the widening of the facet joint was noted among the structural changes in the vertebral body after OLIF. We hypothesized that this facet joint widening may be one of the causes of severe postoperative back pain post-OLIF. This study aimed to evaluate the analgesic effects of facet joint injections on postoperative pain after OLIF.

Methods
This randomized, double-blind, placebo-controlled study separated patients into two groups based on a random table generated using R. Patients assigned to active group received an intra-articular injection of a compound mixture of bupivacaine and triamcinolone, whereas placebo group received the same amount of normal saline injection. The visual analog scale (VAS)-Back and VAS-Leg were evaluated at 12, 24, 48, and 72 h post-surgery. Clinical outcomes were evaluated preoperatively and 6 months postoperatively using the Oswestry Disability Index (ODI) and VAS for back and dominant leg pain.

Results
Of the 61 patients included, 31 were randomized to placebo group and 30 to active group. Postoperative fentanyl consumption from the PCA and rescue analgesia was higher in placebo group than in active group up to 36 h and decreased gradually in both groups ($p<0.01$) The VAS scores were significantly higher in placebo group than in active group up to 48 h after surgery. On average, patients in active group had a higher satisfaction score ($p=0.038$) and were discharged 1.3 days earlier than those in placebo group.

Conclusion
Intraoperative facet joint block decreases pain perception during OLIF, thus reducing opioid consumption and the severity of postoperative pain. This effect contributes to a reduction in the length of the stay.



150. Development and Validation of the Forgotten Spine Surgery Score- Cervical (FS3-C): A Forgotten Joint Outcome Measure in Cervical Spine Surgery

Chad Simon, BS; Arsen Omurzakov, BS; Cole Kwas, BS; Gregory Kazarian, MD; Joshua Zhang, BS; Tomoyuki Asada, MD; Sheeraz Qureshi, MD; Sravisht Iyer, MD; *Eric Zhao, BS*

Hypothesis
A forgotten joint score adapted to the cervical spine will evaluate postoperative awareness and differentiate between cervical disc replacement (CDR) and anterior cervical discectomy and fusion (ACDF) patients.

Design
Patients who underwent primary one- or two-level CDR or ACDF at a single institution (2017-2023) with a minimum three-month follow-up were included. Exclusion criteria: three-level CDR/ACDF, CDR implant revision, or hybrid CDR-ACDF constructs. Three cohorts: pilot CDR, CDR validation, and ACDF validation.

Introduction
The Forgotten Joint Score (FJS), used in joint arthroplasty, has high discriminatory capacity. No equivalent exists in spine surgery. The FJS is useful in evaluating the outcomes of CDR vs. ACDF. CDR, a relatively novel procedure, offers benefits like reduced risk of adjacent segment disease and preserved range of motion, but PROMs for these procedures are not sig-

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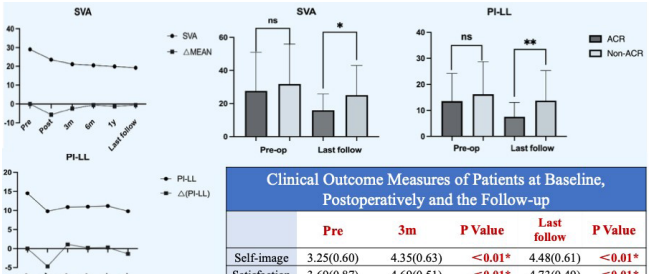
nificantly different. Current surveys may not detect subtle CDR advantages. We developed and validated the Forgotten Spine Surgery Score – Cervical (FS3-C) to evaluate postoperative awareness after cervical spine surgery.

Methods
A pilot CDR cohort was administered a 20-item questionnaire via REDCap or phone. Based on psychometric properties, 12 items were selected for the final FS3-C. The CDR validation cohort was co-administered FS3-C and Neck Disability Index (NDI). An ACDF validation cohort was also co-administered FS3-C and NDI.

Results
The pilot cohort had 41 patients (age: 45 ± 8 years). Questions with high missing responses or strong ceiling effects were excluded. Eight items were combined into four, creating the final 12-item FS3-C. The CDR validation cohort included 127 patients (age: 44 ± 9 years). The FS3-C showed high internal consistency and strong item-total correlation. It correlated strongly with NDI (r=-0.606, p<0.001). The ACDF cohort included 112 patients (average age 61 ± 11 years). FS3-C had a higher Cronbach's alpha than NDI (0.95 vs 0.88). FS3-C differentiated CDR and ACDF outcomes, unlike NDI. Average NDI scores were 5.2 ± 6.2 for CDR and 6.3 ± 6.2 for ACDF (p=0.074). FS3-C scores were 59.9 ± 19.6 for CDR and 53.2 ± 22.2 for ACDF (p=0.012). Effect sizes were 0.17-NDI and 0.33-FS3-C.

Conclusion
FS3-C demonstrated strong validity, consistency, and the ability to differentiate outcomes between CDR and ACDF patients. It can detect subtle symptom differences.



151. A Novel Perioperative Pain Management Regimen for Lumbar Fusion Improves Patient Outcomes and Decreases Opioid Use

Gregory K. Paschal, MS; Fedan Avrumova, MS; Philip K. Paschal, MS; Frank P. Cammisa Jr, MD; Darren R. Lebl, MD; Celeste Abjornson, PhD

Hypothesis
We hypothesize that the use of IV acetaminophen will provide significant pain management, thereby reducing hospital stay, opioid consumption, and co-morbidity, and that it will do so more effectively than oral acetaminophen.

Design
A single center, prospective, randomized control trial.

Introduction
Opioids are a common choice for the management of post-op pain after spinal surgery. Opioid use is associated with side effects, often leading to increased morbidity and extended length of stay(LOS). Combined, spine and orthopaedics account for over one fourth of all cases of opioid abuse stemming from prescription to previously opioid-naïve patients. In pursuit of reducing opioid consumption, alternatives such as intravenous(IV) acetaminophen have demonstrated considerable potential.

Methods
Under IRB approval, consented patients were randomized into IV or PO groups. Patients underwent circumferential fusion at 1 or 2 levels. Pre-op baseline surveys including demographics, Visual Analog Score(VAS), Oswestry Disability Index(ODI), and medication use were collected. The first dose of acetaminophen was administered within 3 hours prior to surgery. Post-op, 7 additional doses were given every 6 hours, with access to supplemental opioids as needed. Morphine equivalent opioid consumption(MME) and VAS were calculated daily until discharge, 6 weeks, and 6 months post-op. ODI was recorded at 6 weeks and 6 months post-op. Statistical analysis was performed comparing outcomes in each group.

Results
83 patients were enrolled in the study. Demographics between groups were statistically similar. LOS was the same between groups. Daily MME was statistically significantly lower for the IV group than the PO group during the regimen($p < 0.001$). After the completion of the study regimen, the PO group showed an increase in MME. VAS Back pain and VAS Leg pain scores were similar for both groups prior to discharge. ODI decreased similarly by Month 6.

Conclusion
Although both groups reported similar clinical outcomes with regard to pain and disability, the IV group was able to achieve this reduction with statistically significantly less opioid usage and IV patients did not show an increase in MME consumption after the completion of the regimen. Our findings suggest that IV acetaminophen is a safe and effective alter-

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native to current opioid-based post-op regimens and should be considered.

152. Are There Distinct Patterns of Clinical Deficits in Cervical Deformity? A Discriminant Analysis of Health-Related Quality of Life Measures

Mikael Finoco, MD; Renaud Lafage, MS; Peter G. Passias, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; Themistocles S. Protopsaltis, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Frank J. Schwab, MD; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis
Distinct patterns of HRQOL deficits exist among CD patients and are associated with established radiographic morphotypes.

Design
This study was a retrospective review of a prospective multicenter database

Introduction
While health-related quality of life (HRQOL) measures have been extensively quantified in cervical deformity (CD) patients. However, this clinical dimension has not yet been fully integrated into our understanding of CD radiographic subtypes prior to surgery.

Methods
Patients with CD, aged 18 years or older were included. Patient-reported outcomes consisted of NDI, mJOA, and SWAL-QoL. After performing a principal component analysis (PCA) on the individual questions of the NDI, mJOA, and SWAL-QoL, four factors with eigenvalues greater than one were retained. These were included in a cluster analysis to assign patients into homogeneous groups of outcomes. Additionally, a subgroup of patients with severe deformity was described and analyzed.

Results
Out of the 134 patients (59% female, mean age 60.9±10.8 years), HRQOL scores were as follows: NDI=49.1±17.6, mJOA=13.5±2.7, EQ5D=0.7±0.1). Factor analysis involving NDI, SWAL-QoL, and mJOA revealed the presence of four clusters. Cluster A included patients primarily affected by sleep problems, whereas Cluster B consisted of patients with the lowest levels of neck disability. Cluster C represented the group with the highest levels of disability, particularly in terms of dysphagia and neck disability. Lastly, Cluster D included patients who predominantly suffered from myelopathy. Among the 71 patients with severe deformities, the distribution of cervical morphotypes significantly differed across the 4 clusters of disability (p=0.009). Cluster C was predominantly composed of patients with cervico-thoracic deformities (66.7%, p=0.002); cluster D had a large contingent of focal deformities, also at 66.7% (p=0.007). Patients in Clusters A and B frequently exhibited "flat neck" deformities, with 57.9% and 46.4% of the respective groups showing this pattern (p=0.02)

Conclusion
Distinct patterns of HRQOL deficits were observed across a heterogeneous population of CD patients, and these patterns were associated with specific radiographic morphotypes. These findings provide a framework for the next generation of CD classification, wherein HRQOL measures are combined with radiographic parameters.

153. Can Proximal Junctional Failure be Predicted after ASD Surgery by Experienced Deformity Surgeons Based on Patient, Surgical and Radiographic Parameters?

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Hypothesis
Experienced spine surgeons can predict the occurrence of PJF based on patient, surgical, and pre-discharge radiographic evaluation.

Design
Case-based survey

Introduction
Despite the substantial growth in the literature examining Adult Spinal Deformity (ASD) surgery the 2-year failure rate remains unacceptably high. Proximal Junctional Failure (PJF) is a common cause of revisions but is challenging to anticipate.

Methods
20 ASD patients requiring PJF revision were identified. Another 20 patients with similar characteristics but without PJF served as a control group. Detailed patient vignettes included demographics, frailty, medical history, DEXA, and Health-Related Quality of Life scores. Surgical details covered instrumentation, procedures, approach, graft use, osteotomies, cage incorporation, and PJF prophylaxis. Pre-operative

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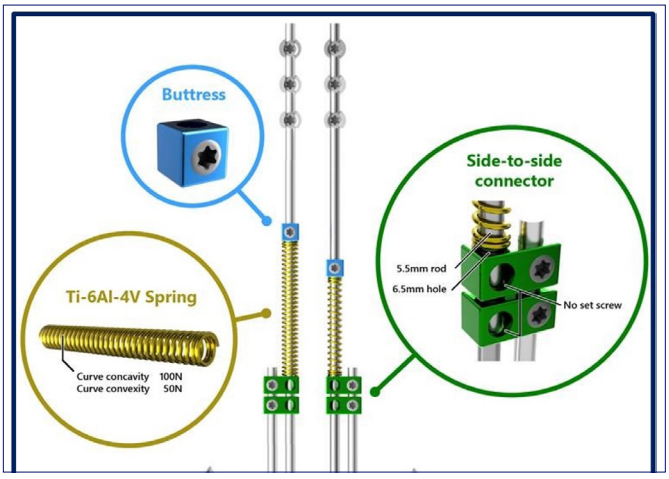
and post-operative radiographs were provided. A panel of 21 experts in spine deformity surgery was then tasked to review these vignettes and to predict the risk of junctional failure, choosing from six possibilities ranging from "Extremely likely" to "Extremely unlikely."

Results
The median follow-up was 2 years with no difference between PJF and control groups (p=0.52). The median time to failure was 5.5 months. Of 782 predictions, only 136 were extreme (i.e., "Extremely likely/unlikely"); most responses were uncertain (42.8% "somewhat likely/unlikely" to fail). Prediction accuracy varied between experts (37% to 65%), precision ranged from 40% to 69%, and sensitivity from 35% to 100% (Figure). Aggregated consensus yielded an accuracy of 61%, precision of 67%, and sensitivity of 50%. Only 4 experts had an accuracy above the consensus, and 1 had better precision. Factors influencing predictions included post-operative sagittal alignment for success and various patient factors (age, BMI, frailty, bone quality) for PJF. 5/7 surgeons regularly performing MIS Surgery ranked in the top 10 for accuracy.

Conclusion
Experienced spinal deformity surgeons have a poor ability to predict PJK and PJF. Expert predictions varied, with consensus achieving 61% accuracy. Factors influencing predictions included post-operative sagittal alignment for success and patient-related factors for PJF. The findings highlight the complexity of predicting PJFK, emphasizing the need for improved risk assessment tools in ASD surgery planning.



154. Predicting Inpatient Stay Following Biportal Lumbar Endoscopic Decompression – A Fragility Scoring Analysis

Don Y. Park, MD; *Thomas Olson, MD*; Alexis Cheney, BS; Jeannie Park, MD; Jordan Holler, MD; William Sheppard, MD

Hypothesis
Patient specific factors may contribute to the need to stay beyond the same day following biportal lumbar endoscopic decompression, such as age, BMI and comorbidities. Fragility and sarcopenia may aid in identifying those patients who may require longer stays after surgery.

Design
A retrospective study design.

Introduction
Biportal spinal endoscopy has been shown to be safe and effective for treating lumbar degenerative conditions in the outpatient setting. This study investigated patient-specific variables that contribute to the need for overnight or inpatient stay following biportal lumbar endoscopic decompression.

Methods
84 patients underwent one- or two-level lumbar decompression for lumbar disc herniation, lumbar spinal stenosis. Trauma, tumor, infection, and revision cases were excluded. Patients were divided into cohorts of same-day discharge and those staying one or more nights. Patients were scored using a proposed fragility index score. Sarcopenia was quantified using a previously established psoas muscle index (PMI) in preoperative imaging. Youden's J statistic and receiver operating curve (ROC) analysis was used for analysis.

Results
Same-day patients were younger than inpatients (55.3 v. 68.5, respectively; p=0.0003) with lower American Society of Anesthesiologists (ASA) score (2.0 v. 2.7; p<0.0001) and Charlson Comorbidity Index (1.6 v. 3.5; p<0.0001). There was no difference in mean BMI (p=0.4341). Outpatients more likely underwent discectomy, inpatients more likely underwent unilateral laminotomy, bilateral decompression (ULBD) (p<0.0001). Inpatients more likely underwent two-level surgery (p=0.0014). Using the proposed fragility scoring system, a cutoff value of ≥9 points was found to predict a stay of one or more nights with an area under the curve (AUC) of 0.791. There was no difference in PMI between inpatient and outpatient groups (p=0.6732) with an AUC of 0.417. The correlation between the proposed fragility score and PMI is -0.130.

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Conclusion
The fragility scoring system proposed can predict the likelihood of an inpatient stay following biportal lumbar endoscopic decompression, with a cutoff score of ≥9 points. The absence of a significant difference in BMI and PMI suggests that body habitus and sarcopenia are less predictive. The fragility index can serve as a useful tool in preoperative planning, helping to identify patients at higher risk for extended recovery times.

155. Nearly One Out of Five Spondylolysis Are Missed by MRI

George Michael, BS; Andy Liu, BS; Suhas Etigunta, BS; David L. Skaggs, MD, MMM; Vivien Chan, MD; *Kenneth D. Illingworth, MD*

Hypothesis
A significant proportion of spondylolysis cases are missed on MRI, leading to delayed diagnosis and treatment.

Design
This was a single-center retrospective cohort review.

Introduction
Spondylolysis is a common cause of pediatric back pain. Computed tomography (CT) is the most effective diagnostic tool but widespread use limited by radiation exposure. Magnetic Resonance imaging (MRI) is more commonly used as a frontline study to evaluate patients with low back pain. Previous studies have noted that spondylolysis is frequently missed on MRI; however, these studies have been limited due to the small number of patients. The aim of this study was to evaluate the rate of missed diagnosis of spondylolysis on MRI with a larger patient cohort.

Methods
Patients with confirmed spondylolysis diagnoses were identified using either CT or MRI interpreted by providers based on edema in the pars interarticularis on STIR sequences. All imaging was evaluated by two pediatric spine surgeons, with official radiology reports compared to the surgeons' interpretations. In addition, analysis of radiology reads included imaging center type (i.e. hospital vs. private) and radiologist's qualifications (i.e. fellowship training in neuroradiology or musculoskeletal).

Results
86 patients with an average age of 14.9 years old met inclusion criteria. 79 diagnoses were made via surgeon interpretation of MRI, while seven required additional CT confirmation. Among the 86 patients, 17 (19.8%) had spondylolysis missed on official MRI reports; 70.6% (n=12) of these cases were from private imaging centers. Twelve of the missed diagnoses came from radiologists without formal fellowship training in musculoskeletal or neuroradiology. Patients with missed MRIs had a longer time to diagnosis, averaging 9.0 months compared to 6.4 months for those correctly diagnosed.

Conclusion
MRI radiology reports missed a spondylolysis diagnosis in nearly 20% of cases, potentially delaying treatment. In cases with a high suspicion of spondylolysis, careful evaluation of MRI STIR images for pathognomonic edema is essential, rather than relying solely on radiology reports. Involving a fellowship trained radiologist improves documented radiology diagnosis and facilitates earlier specialist referral.

Table 1. Rate of patient temperature change at varying room temperatures.

Group (Temperatures in degrees Fahrenheit)	Rate of Temperature Change (degrees/min)
1 (<70)	0.010
2 (70.1-72.5)	0.013
3 (72.6-75)	0.006
4 (75.1-77.5)	0.012

A 14-year-old male with bilateral edema in the L4 pedicle and pars interarticularis on lumbar MRI STIR. Official radiology report was normal MRI.

156. Assessment of Lung Function in a Unique Departure From Standard Technic No Chest Tubes Were Inserted at Non Fusion Anterior Scoliosis Correction Surgery in All Lenke Types AIS Patients With Bilateral Thoracotomy at 4 Years

Harith B. Reddy, MS; Sharan T. Achar, MS; Akshyaraj Alagarasan, MS; Vigneshwara M. Badikillaya, MD; Appaji K. Krishnamurthy, MD; Sajan K. Hegde, MD

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Hypothesis
Bilateral thoracotomy in NFASC for Adolescent idiopatic scoliosis has no detrimental effect in pulmonary function

Design
prospective

Introduction
Numerous studies that have assessed pulmonary function test (PF) following spinal fusion are abundant in the literature and have produced inconsistent findings. The impact of non-fusion anterior scoliosis correction (NFASC) surgery over PF in patients with Lenke 3 & 6 Adolescent Idiopathic Scoliosis (AIS) is not well documented in the literature. The purpose of the current study is to determine how PF in AIS patients is not affected by the double thoracotomy method for NFASC

Methods
100 Lenke AIS patients who had at least two years of follow-up were assessed. Preoperatively and at follow-ups after six months, a year and two years. The percent-predicted values of forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and total lung capacity (TLC) were assessed. The information was shown as mean ± standard deviation. No chest tube insertion was done after the surgery in all the patients.

Results
At the time of surgery, the cohort consisted of 10 male and 90 female members, with a mean age of 13.5 years. The average Risser score was 4.2±0.5, Sanders was 7.1±0.6. 51.1°±6.7°, 52.1°+ 6.7° was the mean preoperative main thoracic (MT) & Thoracolumbar (TL/LL) Cobbs. The baseline values for TLC%, FEV1%, and FVC% were 93±15, 82±10, and 88±13. FEV1, FVC, TLC showed Improvement at six months (88±12), (90±9), (94±10) and at one year follow-up (91±8), (91±7) and (98±15) respectively. Follow-up FEV1, TLC, and FVC are all stable at two years. There was only one case of post op atelectasis requiring chest tube insertion and ICU monitoring. All the patients were made to walk and started on aggressive chest physiotherapy 4 hours following surgery

Conclusion
Our study proves that ICD insertion was not essential even in bilateral thoracotomy patients undergoing NFASC surgery if meticulous surgical approach, techniques and enhanced recovery pathway are followed. PF improved at one year following surgery, after which it stabilised at two years. At a 2-year follow-up, we find that NFASC by mini-open thoracotomy does not adversely affect PF in all lenke types AIS patients.

157. Presence of Compensatory Curve Predicts Postoperative Curve Progression in Congenital Scoliosis After Thoracolumbar Hemivertebra Resection and Short Fusion §

Yanjie Xu, MD; Dongyue Li; Jie Li, MD, PhD; Zongshan Hu, PhD; *Zhen Liu, PhD*; Zezhang Zhu, PhD; Yong Qiu, PhD

Hypothesis
Presence of the compensatory curve was associated with a higher incidence of postoperative curve progression in patients with CS who underwent thoracolumbar HV resection and short fusion.

Design
A retrospective study.

Introduction
Postoperative curve progression is a type of unexpected scoliosis emerging from the initial fusion segments after surgery. Previous studies hypothesized that the occurrence of progression may originate from the preoperative compensatory curve. Currently, it remains unclear whether the presence of compensatory curves affects the emergence of postoperative curve complication and whether the current surgical approach is still applicable to these CS patients.

Methods
This study retrospectively reviewed a consecutive cohort of patients with CS who underwent thoracolumbar HV resection and short fusion with a minimum of 2 years follow-up. According to the preoperative curve pattern, patients were divided into compensatory curve group non-compensatory curve group. Based on the postoperative coronal curve evolution, patients were further divided into the progressed group (Group P, with curve decompensation ≥ 20°) and the non-progressed group (Group NP, characterized by well-compensated curves).

Results
A total of 127 patients were included in this study, with 31 patients in the compensatory curve group and 96 patients in the non-compensatory curve group. The incidence of postoperative coronal curve progression was significantly higher in the compensatory curve group than that in non-compensatory curve group (35.5% vs. 13.5%, p=0.007). In the compensatory curve group, patients who experienced postoperative curve progression showed fewer fusion segments (p=0.002), greater preoperative UIV translation (p=0.006), greater preoperative LIV tilt (p=0.017), and larger postoperative UIV tilt (p<0.001) compared with patients in group NP. Multiple logistic regression demonstrated that the shorter fusion segments and greater postoperative UIV tilt

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were two independent risk factors for postoperative curve progression.

Conclusion
The presence of the compensatory curve was associated with a higher incidence of postoperative curve progression in patients with CS who underwent thoracolumbar HV resection and short fusion. Shorter fusion segments and greater postoperative UIV tilt were found to be the risk factors for postoperative curve progression.

158. Contemporary Treatment of Complex Adult Spine Deformity Using Bone Morphogenic Protein: A Comparative Analysis of Outcome and Complication Profiles

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Hypothesis
To assess outcomes in patients undergoing ASD surgery with or without BMP use

Design
Retrospective cohort

Introduction
There is controversy surrounding the use of bone morphogenic protein (BMP-2) in spine surgery with multiple off-label uses. The widespread use of BMP-2 is spine deformity surgery remains unsupported by literature.

Methods
ASD patients with fusions from thoracolumbar spine to pelvis with clinical and radiographic data were assessed for suitability. ASD diagnosed by SRS-Schwab radiographic criteria (SVA > 5cm, PI-LL > 10°, or PT > 20°). Patients were stratified on whether they received intra-operative BMP (BMP+) or not (BMP-). Means comparison testing and logistic regression analyzed differences between groups. Quality gained was calculated from ODI to SF-6D and translated to quality-adjusted life years (QALYs). Cost was calculated using the PearlDiver database and CMS definitions for complications and comorbidities.

Results
512 patients were included (Age: 59.9 ± 14.4 years, BMI: 27.0 ± 5.5 kg/m2, CCI: 1.64 ± 1.67). 81% of patients were female. 60% of patients had BMP-2 used during their surgery (60% BMP+). At baseline, BMP+ patients were older (62.5 vs 60.8 years, p<0.001), but there were no other differences between both groups. There were no differences between both groups in radiographic or HRQL metrics at each follow up timepoint (all p>0.05). In BMP+, the mean BMP/level ranged from 2.7 to 3.7 mg/level, with the highest doses at L5/S1 (3.7 ± 2.4). BMP was much more likely to be used at L5/S1 than any other level (OR 51.6, 95% CI: 5.8-461.2, p<0.001). BMP use was associated with higher supplemental rod use (OR: 7.0, 1.9 – 26.2, p=0.004), higher levels fused (OR: 1.1, 1.03 – 1.17, p=0.003) and greater neurological complications (OR: 5.0, 1.3 – 18.7, p=0.017). Controlling for rod use and levels fused, BMP use was not associated with a lower risk of mechanical complications (OR 0.3, 95% CI: 0.2 – 3.0), rod breakage (OR: 3.3, 0.6 – 18.7, p=0.182) or implant failure (OR: 0.3, 0.04 – 1.51). At 2 years, BMP+ had a higher overall cost ($108,062 vs $95,144 , p=0.002), equivocal QALYs (0.163 vs 0.171, p=0.65) and lower cost effectiveness (p<0.001) at two years.

Conclusion
The off-label use of biologics such as BMP-2 remains unsubstantiated by current literature. BMP use was associated with higher costs, but did not demonstrate superior radiographic or clinical outcomes at two years.

Group	Complications Absent	Complications Present	p-Value
Idiopathic	21	32	**<.001**
Congenital	20	35	**<.001**
Neuromuscular	53	54	**<.001**
Syndromic	47	73	**<.001**
Idio vs. Cong			0.111
Age in years	12 (±4)	910 (±5)	**0.003**
Days in traction	76 (±170)	118 (±206)	**0.039**
Maximum % weight in traction	45.8 (±15.8)	51 (±18.1)	**0.007**

Complication Type	Number Reported
Pin Track "Infection(s)" - No Treatment	16
Pin Track Infection - Require Antibiotic Treatment	58
Pin Track Infection - Requiring Screw Replacement	10
Pin Track Infection - Requiring Screw Removal	5
Loosening of Pin(s) - Requiring unplanned screw removal w/o replacement	22
Loosening of Pin(s) - Requiring unplanned screw removal w/replacement	27
Fall causing skull fracture/pin motion requiring unplanned halo/screw revision	5
Traction paused for concerns of neuro changes - resumed	5
Traction discontinued because of confirmed neuro changes/deterioration	3
Family Opted to abort traction/treatment plan	2
Traction stopped/aborted because of lack of spinal improvement	1
Aborted Halo due to Intolerance	0
Plan of Care Change	4
Non-Compliance	2
Other	18

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E-POINT PRESENTATION ABSTRACTS

159. Smartphone Activity Data for Evaluating Socioeconomic Variations in Spine Surgery Outcomes

Daksh Chauhan, BS; Hasan Ahmad, BS; Ryan Turlip, BA; Kevin Bryan, BA; Harmon Khela, BS; Omkar Anaspure, BS; Robert Subtirelu, BS; Yohannes Ghenbot, MD; Michael Y. Wang, MD; Jang Yoon, MD

Hypothesis
Patients from lower socioeconomic backgrounds will have lower activity levels before spine surgery and take longer to return to their baseline activity levels after surgery.

Design
Retrospective Study Design

Introduction
While socioeconomic status is known to affect spine surgery outcomes, its impact on patient activity levels before and after surgery is unclear. Smartphone data offers a way to quantify mobility and better understand the influence of demographic and socioeconomic factors on recovery.

Methods
A retrospective was performed on patients who underwent spine surgery between 2017 and 2021. Patients' home ZIP codes were used to determine each patient's Area Deprivation Index (ADI) – an independently validated composite measure of socioeconomic health of a specific neighborhood relative to the entire United States. Using a mobile application on patient smartphones, patient data on daily step counts were also collected remotely over a one-year perioperative period and statistical normalization was applied to facilitate analyses between patients. Employing multivariate regression, we examined the association between ADI and patient mobility, while controlling for confounding factors such as age and obesity.

Results
A total of 49 patients were included in this study. The pre-operative activity levels of patients living in neighborhoods with an ADI below the 80th percentile nationally was significantly greater than that of patients living in neighborhoods above the 80th percentile (p=0.011). A direct positive correlation existed between patients' ADI and the number of days with below-average steps-taken-per-day during the pre-operative period (adjusted r2 = 0.822, p = 0.049). Post-operatively, patients with ADIs above the 80th percentile returned to their pre-operative baseline activity levels faster than patients with ADIs below the 80th percentile (post-operative day 56 vs. 108).

Conclusion
These findings reveal that patients residing in neighborhoods with an ADI below the 80th percentile were more active before surgery compared to those living in neighborhoods above the 80th percentile, although these disparities in mobility diminished postoperatively. The expedited recovery of patients from more affluent neighborhoods after surgical intervention may be attributed to increased healthcare utilization, availability of resources, and other potential factors we have yet to thoroughly examine.

160. Hip Coverage and PI Changes Following Correction for Adult Spinal Deformity: Are They Associated With Mechanical Failure?

Zhen Liu, PhD; Jie Li, MD, PhD; Zezhang Zhu, PhD; Yong Qiu, PhD

Hypothesis
Postoperative changes in hip joint coverage and pelvic incidence (PI) are associated with the occurrence of mechanical complications (MC), in adult spinal deformity (ASD) patients following sacral alar-iliac (S2AI) screw fixation.

Design
Retrospective study

Introduction
To investigate the relationship between postoperative changes in hip joint coverage and pelvic incidence (PI), and determines its implications in the occurrence of mechanical complications (MC), in adult spinal deformity (ASD) patients following sacral alar-iliac (S2AI) screw fixation.

Methods
A retrospective analysis was conducted on 110 cases (220 hip joints) of ASD patients who underwent long spinal fusion with S2AI fixation in our single-center from January 2016 to January 2020. Based on changes in postoperative hip joint coverage, patients were divided into group C (pre-to-post hip coverage changes in the top quartile or above) and group NC (pre-to-post hip coverage changes in the bottom quartile or below). Hip joint coverage, Cobb angle, coronal balance distance (CBD),and other sagittal parameters were taken in full-spine X-rays preoperatively, immediately postoperatively, and at the 2-year follow-up.

Results
Among 110 patients, the average postoperative hip joint coverage change was 2.9% ± 2.8%, with 54.5% experiencing changes >2%. Group C had a higher hip joint coverage change than Group NC (6.6°±2.4° vs. 0.5°±0.2°, P<0.001). Preoperative differences in LL, SVA, and PI between groups were not significant. However, Group C had smaller preoperative hip joint

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coverage and greater postoperative PI decrease. At follow-up, Group C had a lower PJK incidence (16.7% vs. 40.0%, P=0.041) and less sagittal imbalance progression. ΔPJA and PJA at 2 years were higher in Group NC. Correlation analysis showed a negative correlation between the immediate postoperative change in hip joint coverage and the follow-up ΔSVA (R=-0.880,P<0.001), follow-up ΔPJA (R=-0.849, P < 0.001), and follow-up PJA (R=-0.751, P<0.001).

Conclusion
Hip joint coverage may indicate the compensatory capacity of the hip joint in ASD patients. Those with lower preoperative hip joint coverage and prominent changes of postoperative hip joint coverage changes tend to have a higher hip compensatory capacity and reduced risk of postoperative MC following S2AI fixation.

161. Risk Factors for Surgical Complications in Patients With Early-Onset Scoliosis (EOS): Minimum 5-Year Follow-Up

Ziquan Li, MD; Nan Wu, MD; Jianguo Zhang, MD

Hypothesis
We aim to characterize the prevalence of complications associated with surgical treatment for EOS and the potential risk factors.

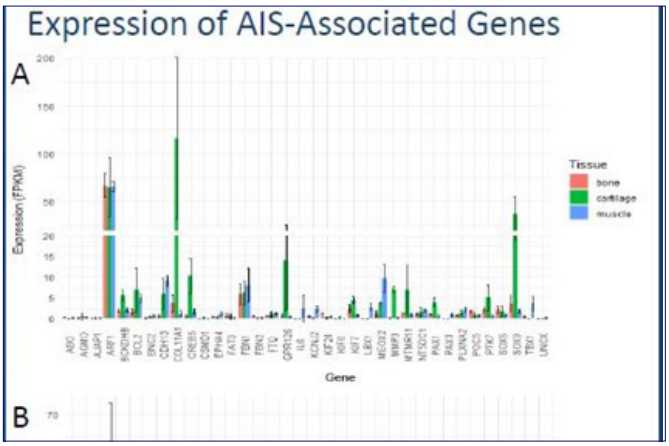
Design
Retrospective cohort study.

Introduction
Operative treatment of EOS can be challenging with a variety of complications. The identification of risk factors associated with complications is essential.

Methods
Patients with EOS who underwent spinal surgery with a minimum of five-year follow-up were included, as part of the Deciphering disorders Involving Scoliosis and COmorbidities (DISCO) study. Potential risk factors were identified by univariate analysis. Multivariate logistic regression was used to evaluate independent risk factors of surgical complications. In addition, a subgroup analysis of syndromic EOS patients was performed.

Results
A total of 319 patients were recruited. The spinal surgery performed on these patients included 251 posterior spinal fusion and 68 growing-rod implantations. For 269 of the patients, the etiology of scoliosis was congenital; for 44, syndromic; for four, idiopathic; and for two, neuromuscular. The mean postoperative follow-up was 102.4 months. Of note, patients with syndromic EOS were molecularly diagnosed by pathogenic variants in 29 genes. A total of 75(23.5%) patients developed postoperative complications. The univariate analysis revealed that the age, etiology, curvature number, and the surgical procedure were significantly associated with the development of complications (p<0.05). Multivariate analysis revealed that the age (OR,0.916; p=0.018), syndromic EOS (OR,2.320; p=0.023), fusion levels (OR,2.346; p=0.023), curvature number (OR,2.343; p=0.032), and surgical procedure (OR,2.134; p=0.048) were the independent risk factors for the complications. After subgroup analysis, we found that the incidence of complications in syndromic EOS was higher than that in the non-syndromic EOS group in all subgroups.

Conclusion
By integrative analysis of clinical information and genetic information, we found that younger age at index surgery, the diagnosis of syndromic EOS, fusion levels greater than 4, surgical procedure with growing-rod implantation, and curvature number greater than 2 were independent risk factors for complications following surgical treatment in patients with EOS. This underscores the importance that a comprehensive genetic analysis of EOS population may play a vital role in clinical care.



Subgroup analysis

162. "What Happens if I Wait?" How Fast and How Frequently Does Primary Thoracic AIS Progress to Require Lumbar Fusion?

Austin Montgomery, BS; Firoz Miyanji, MD, FRCS(C); Suken A. Shah, MD; Paul D. Sponseller, MD, MBA; Stefan Parent, MD, PhD; Peter O. Newton, MD; Burt Yaszay, MD; Craig R. Louer, MD

Hypothesis
We hypothesize that a proportion of patients with primary thoracic scoliosis who delay surgery will experience "harmful progression" of their lumbar curve, which will then require extending fusion into lumbar region.

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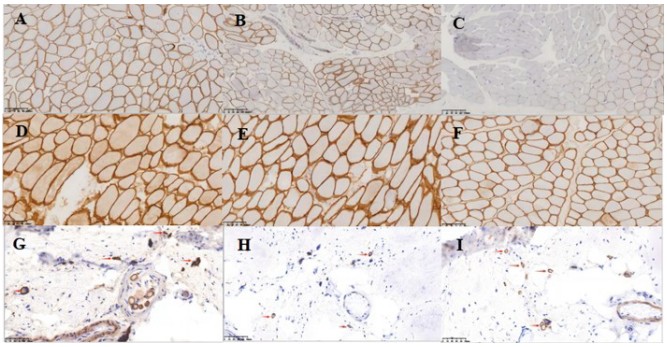
Design
Retrospective

Introduction
If not addressed, AIS patients with severe curves will experience slow curve progression into adulthood. Posterior spine fusion (PSF) halts progression but requires significant recovery time and may limit function. For these reasons, patients with specific athletic pursuits or other misgivings about PSF may inquire about the medium-term outcomes of observing a surgical curve. This study aimed to characterize the outcomes of presumed "surgical" AIS thoracic curves treated with observation.

Methods
A prospective, multicenter database of AIS patients treated non-operatively was queried for primary thoracic curves nearing surgical magnitude (≥ 40°) at baseline, who had >2 years of radiographic data without yet undergoing PSF. Bending radiographs were not obtained serially, therefore pre-determined criteria for "harmful progression" were established to suggest an emerging need for adding lumbar fusion. This criteria included: 1) patients with secondary lumbar curves whose lumbar curve magnitude surpassed the thoracic during follow-up, 2) the lumbar curve increased by 10°, or 3) the lumbar curve apical translation increased by 1.5cm. Baseline features that correlate with harmful progression of these curves were investigated.

Results
117 patients were included with average of 3.2 years follow-up. Average age was 15.9 years and thoracic curve magnitude was 46°. Seventeen (14.5%) patients met criteria for harmful progression: 6 (5.1%) at 1 year, an additional 6 at 2 years, and the final 5 (4.3%) by 5 years. Comparing baseline characteristics of the "harmful progression" and the "no progression" group showed increased lumbar cobb angle (37° vs. 29°, p=0.004), increased coronal imbalance (C7-CSVL –1.8 vs. -0.5 cm, p=0.009), and increased lumbar apical translation (-3.2 vs. -1.5, p=0.001).

Conclusion
Patients with primary thoracic scoliosis of >40° at baseline may be able to delay surgery, though 15% may experience harmful progression over 5-years. Increased coronal imbalance, lumbar curve size, and lumbar apical translation are predictive of harmful progression. This data can be used to counsel AIS patients who are deciding on ideal surgical timing.



163. Optimization and Validation of a Novel AI Framework Using NLP with LLM Integration for Clinical Data Extraction and Postoperative Billing Automation: A Study of 68,260 Records

Mert M. Dagli, MD; Hasan Ahmad, BS; Daksh Chauhan, BS; Ryan Turlip, BA; Kevin Bryan, BA; Connor Wathen, MD; Yohannes Ghenbot, MD; John Arena, MD; Joshua L. Golubovsky, MD; John Shin, MD; Ali Ozturk, MD; William C. Welch, MD; Jang Yoon, MD

Hypothesis
Integrating NLP and LLM within an AI framework will significantly enhance the accuracy, efficiency, and cost-effectiveness of clinical data extraction and postoperative billing compared to manual chart review.

Design
Retrospective Study Design

Introduction
Manual chart review (MCR) for extracting surgical data from Electronic Health Records (EHRs) is time-consuming, prone to error, and a significant bottleneck in clinical research and quality control. This study aimed to develop and validate a novel artificial intelligence (AI) framework that integrates Natural Language Processing (NLP) with a Large Language Model (LLM) to automate the extraction of relevant clinical data from spinal surgery EHRs and automate postoperative billing.

Methods
The study followed Transparent Reporting of Multivariable Prediction Models for Individual Prognosis or Diagnosis + Artificial Intelligence (TRIPOD+AI) guidelines, using three institutional databases of thoracolumbar deformity (N=646), endoscopic spinal surgery (N=182), and lumbar decompression cases

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(N=5,998). The AI framework, replicated ten times to mitigate hallucinations, analyzed 68,260 records. The primary outcome was accurate identification of surgical details (e.g., surgery type, levels operated, disks removed, levels fused, and billing), with secondary objectives on time, tokenization, and cost efficiency.

Results
The AI framework successfully extracted relevant clinical data and automated postoperative billing with high accuracy across all datasets, outperforming the human control. The NLP+LLM system achieved a sensitivity of 0.999 and an AUC-ROC of 0.997 for clinical data extraction, demonstrating similar performance in billing automation. Postoperative billing automation achieved comparable accuracy and efficiency. The use of a majority vote, utilizing data from the deduplicated (ten replications) run, eliminated errors from singular runs. Tokenization and cost analyses indicated substantial time savings (38.8 seconds per case) and cost savings ($9.04 per case) compared to manual chart reviews.

Conclusion
We found the integration of NLP and LLM within an AI framework can significantly improve the accuracy, time, and cost efficiency of clinical data extraction and postoperative billing. These results suggest the potential for widespread adoption of AI-based automation in healthcare.

164. Facet Joint Anatomy And Potential Degenerative Instability at L4-5: A Preoperative Imaging Study

Maxey Cherel, BS; Aiyush Bansal, MD; Takeshi Fujii, MD; Jack Sedwick, BS; Laura Reynolds, BS; Michael Jeffko, BS; Patricia Lipson, BS; Rafael Garcia de Oliveira, MD; Venu M. Nemani, MD, PhD; Jean-Christophe A. Leveque, MD; *Philip K. Louie, MD*

Hypothesis
There are various anatomic features of the disc and facet joint that are associated with instability observed in a degenenerative spondylolisthesis at L4-5.

Design
Retrospective evaluation of imaging studies.

Introduction
The purpose of this study was to identify anatomical features of facet joint degeneration on supine MRI that can predict the level of instability as shown on standing XRs/CTs and to assess their relative associations with indicators of instability on standing imaging.

Methods
A total of 231 cases with operations at L4-5 were analyzed, including 100 cases with spondylolisthesis, 80 with fusions, 149 with decompression, and 54 with discectomy. The mean age of the patients was 64.3 ± 12.6 years, with a mean BMI of 29.0 ± 5.9 kg/m². The cohort consisted of 55 females (23.8%). Preoperative features of facet joint anatomy were measured using radiographic measurements on MRI and X-ray. Multivariate stepwise regression was performed to predict measures of spinal instability. The outcomes measured were the change in % L4-5 slip between standing (XR) and supine (MRI), change between flexion and extension (XR), change in translation between standing (XR) and supine (MRI), and change in L4-5 disc angle between standing (XR) and supine (MRI). Univariate Pearson correlation was performed for the strongest predictors.

Results
Multivariate analysis revealed that anterior disc height was a significant predictor of % L4-5 slip change between supine (MRI) and standing (XR) ($\beta = -0.33$, $P = 0.01$), and middle disc height predicted change in L4-5 disc angle ($\beta = -1.17$, $P = 0.01$). Additionally, facet effusion width significantly predicted change in L4-5 disc angle between flexion and extension (XR) ($\beta = 0.32$, $P = 0.05$). Univariate analysis also showed that anterior disc height was significantly correlated with preoperative L4-5 slip ($r = -0.51$, $P < .001$).

Conclusion
Greater anterior and middle disc heights are associated with improved stability at the L4-5 level. Univariate analysis demonstrated that anterior disc height is strongly correlated with reduced preoperative L4-5 slip, emphasizing its potential role as a predictive marker. Facet effusion width may also be a relevant predictor of instability during motion.

165. Posterior Minimally Invasive Surgery: A New Technique for Treating Paralytic Scoliosis with Pelvic Obliquity in Children Following Spinal Cord Injury

Zezhang Zhu, PhD; Xiaodong Qin, PhD; Yi Chen, MS

Hypothesis
Both MIS and PSF techniques achieve effective correction and improve the quality of life in patients with PSPO.

Design
A retrospective study.

Introduction
The current traditional surgical method for treating scoliosis after spinal cord injury is still the posterior long-segment thoracolumbar fusion surgery. This procedure has an incision length of 40-50 cm, resulting in a large surgical wound, prolonged operation

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time, and significant blood loss. Postoperatively, patients often require ICU treatment, and the incidence of surgical complications is relatively high.

Methods
The cohort included 4 males and 21 females. Patients were divided into the MIS group (12 cases) and the PSF group (13 cases). Measurements of the scoliosis Cobb angle, pelvic obliquity, and local kyphosis angle were taken preoperatively, postoperatively, and at the final follow-up. Perioperative conditions and complications during the follow-up period were recorded. The Scoliosis Research Society questionnaires-22 (SRS-22) were used to evaluate treatment efficacy before surgery and at the last follow-up.

Results
There were no significant differences between the two groups in demographics. The MIS group had significantly shorter surgery times than the PSF group, and both intraoperative blood loss and transfusion volume were significantly lower than those in the PSF group. Hospitalization costs were also significantly lower in the MIS group. Both groups showed significant improvement in radiology characteristics. There was no significant loss of correction at final follow-up in either group, and there were no significant differences between the two groups postoperatively or at the last follow-up. In the MIS group, one patient experienced superficial incisional infection, and another had atelectasis postoperatively. In the PSF group, two patients required ICU care due to excessive intraoperative bleeding, two had deep incision infections, and one had improper screw placement. Both groups showed significant increases in SRS-22 scores postoperatively.

Conclusion
Both MIS and PSF techniques achieve effective correction and improve the quality of life in patients with PSPO. However, the MIS technique can shorten surgery time, reduce intraoperative bleeding and perioperative complications, and decrease hospitalization costs.

166. Night-Time vs. Full-Time Bracing in Thoracic AIS – Are There Differences in Curve Progression When Matching for Time-in-Brace?

Martin Heegaard, MD, PhD; Lærke C. Ragborg, MD, PhD; Amy L. McIntosh, MD; *Megan Johnson, MD*; Anne-Marie Datcu, BS; Regina Velarde, BS; Martin Gehrchen, MD, PhD; Daniel J. Sucato, MD, MS; Benny T. Dahl, MD, PhD, DMSci; Soren Ohrt-Nissen, MD, PhD

Hypothesis
We hypothesize that NTB will lead to less curve progression than FTB for patients with similar brace wear time due to the higher IBC% for NTB.

Design
Retrospective Study

Introduction
The full-time thoracolumbar sacral orthosis (FTB) treatment for thoracic adolescent idiopathic scoliosis (AIS) is well-established but compliance remains a substantial issue. The night-time brace (NTB) with a higher in-brace correction presents a viable treatment option. Whether patients with low compliance in FTB would benefit from switching to an NTB is unknown. This study aimed to compare the efficacy of FTB and NTB in patients with similar brace wear time.

Methods
In a retrospective dual center setting, we included skeletally immature AIS patients with thoracic curves of 20-45°, treated with either FTB or NTB. Patients with compliance ranging between 6-10 hours per day, Risser stage 0-3, and less than one year post-menarche were included. Radiographic measurements were collected at brace initiation and termination. A mixed effects model was used to determine significant predictors of curve progression >5°.

Results
A total of 80 FTB patients and 106 NTB patients were included in the final analysis. At baseline, the FTB patients were younger (12.4y vs. 13.1y, p<0.001) and had smaller curves (31±6° vs. 37±6°, p=<0.001). The FTB patients showed significantly lower rates of curve progression >5° (44% vs. 63%, p=0.008) as well as progression to >50° (18% vs. 41%, p<0.001). The in-brace correction percentage was 59% (±18) in the NTB group and 37% (±18) in the FTB group (p<0.001). In the mixed effects model, we found decreased odds of progression >5° for treatment with FTB (OR 0.30, 95%CI 0.13-0.72), Risser stage 3 (OR 0.23, 95%CI 0.06-0.86), and age (OR 0.67, 95%CI 0.48-0.94). The NTB, male gender, and initial major curve size were associated with increased odds of progression (NTB: OR 3.33, 95%CI 1.39-8.03; Male: OR 5.49, 95%CI 1.62-18.68; Initial curve: OR 1.07, 95%CI 1.01-1.13).

Conclusion
The FTB demonstrated lower progression rates than the NTB in thoracic AIS patients with similar brace wear times. The NTB may play a role in low-risk patients with smaller curves and higher skeletal maturity.

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Type 1A	Neutral or Kyphotic Alignment	[illegible] than Predicted CSA); CSA > 25 – T1S.	cSVA<40
Type 1B	Lordotic Cervical Alignment	Lordotic CSA (Measured CSA more lordotic than Predicted CSA); CSA ≤ 25- T1S	cSVA<40
Type 2	Primary Cervical Malalignment	T1S < 40°	cSVA ≥40
Type 3	Primary Thoracolumbar Malalignment	T1S ≥ 40°, Lordotic CSA (CSA ≤ 25- T1S)	cSVA ≥ 40
Type 4	Combined Thoracolumbar and Cervical Malalignment	T1S ≥ 40°, Neutral or Kyphotic CSA (CSA > 25 – T1S)	cSVA ≥ 40
Modifiers:	Segmental cervical sagittal alignment (sCSA)		
N (Neutral)	Any subaxial cervical segment with kyphosis < 13°		
K (Kyphosis)	Any subaxial cervical segment with kyphosis ≥ 13°		

MIxed Effects Model: Curve Progression

167. Classroom Comeback: Expectations for Post-Surgical AIS Patients Regarding Return to Full School Days

Anne Boeckmann, BS; Erica Olfson, BS; David C. Thornberg, BS; *Megan Johnson, MD*; Jaysson T. Brooks, MD; Amy L. McIntosh, MD

Hypothesis
Parents' expected return-to-school timelines for their children significantly differ from their actual timelines.

Design
Prospective

Introduction
Patients with Adolescent Idiopathic Scoliosis (AIS) who undergo posterior spinal fusion (PSF) miss significant time from school and other recreational activities. Literature exists on the impact of total levels fused on return to school time, but a gap exists when comparing the differences between AIS patients that underwent selective thoracic fusion (STF) versus those that were fused into the lower lumbar spine. The aims of this study were: 1) to compare the expected and actual timelines for returning to school as reported by patients/families 2) to determine the duration until full-time return to school between patients who underwent STF vs those who did not.

Methods
IRB approved prospective study of patients who underwent PSF for AIS. The first survey, given preoperatively, collected data on school setting, homebound program use, and expected absence duration. The second conducted postoperatively, recorded the actual return-to-school date.

Results
89 patients (mean age 14.2 ± 1.9 yrs; 73 F, 13 M) completed the preop survey. The cohort included patients with AIS (n=75), AIS-like conditions (n=9), and JIS (n=2). 79 attended public school, 5 private school, and 2 were homeschooled. Individuals reported a mean expected school absence of 4.4 weeks +/- 2.1. Regarding awareness of the homebound program, 3 reported being unaware, 23 were unsure, 58 were aware, and 2 N/A (homeschooled). Of the 58 aware, 4 reported they were not going to use it, 4 were unsure, and 50 planned on using homebound. Out of 89 patients, 55 completed the postop survey, showing a mean return-to-school time of 6.1 wks. Among them, 31 had STF and 24 had non-SFT. The mean return time was 6.2 wks for non-STF and 6.0 wks for SFT.

Conclusion
The study findings demonstrated that AIS patients who undergo PSF return to full in-person school days an average of 6 weeks from surgery. Notably, 27.1% (23 out of 85) of the sample were unaware of the homebound program, indicating a need for better family education. Additionally, there was no statistical difference in return-to-school timelines between selective and non-selective thoracic fusion cohorts. This information is helpful to set realistic expectations and guide patients and their families during the recovery process.

168. Quantifying the Importance of Upper Cervical Extension Reserve in Adult Cervical Deformity Surgery and its Impact on Baseline Presentation and Outcomes

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Hypothesis
Upper cervical extension reserve (ER) impacts postoperative disability and outcomes.

Design
Retrospective cohort study.

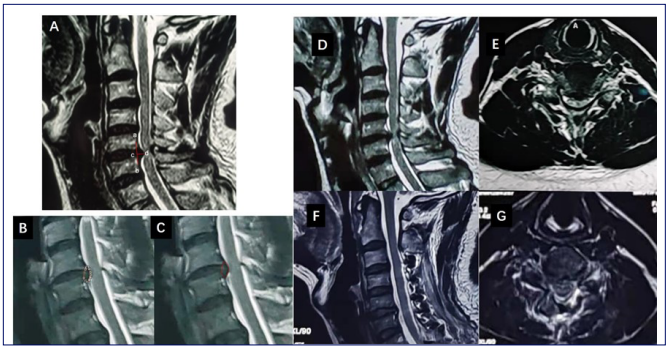
Introduction
Hyperextension of the upper cervical spine is a

prominent compensatory mechanism to maintain horizontal gaze and balance in adult cervical deformity (ACD). Relaxation of ER and its impact on post-operative outcomes is not well understood.

Methods
ACD patients undergoing subaxial cervical fusion with 2Y data were included. Upper cervical extension reserve (ER) was defined as: ΔC0-C2 sagittal Cobb angle between neutral and extension. Relaxation of ER was defined as the ER mean in those that met the ideal ACD modifiers. ANCOVA and multivariable logistic regressions were utilized, with conditional inference tree (CIT) determining thresholds.

Results
108 ACD patients met inclusion. (Age 61±12, 61% F, BMI 29±8 kg/m2, mCD-FI .24±.12, CCI 1.0±1.3). Alignment listed in Table 1. Preoperative C0-C2 ER was 8.7°±9.0°, and last follow-up was 10.3°±11.1°. ER in those meeting all ideal CD modifiers at 2Y was 12.9°±9.0°. Preoperatively 29% had adequate ER, 59.7% had improved ER postoperatively, with 50% achieving adequate ER at 2Y. Lower ER correlated with greater cervical deformity (p<.05). Preoperatively, greater ER had lower disability in NDI (p<.001). Controlled analysis found improved ER to have a 7x higher likelihood of NDI MCID (6.94 [1.37-34.96], p=.019). Isolating those with inadequate preoperative ER, found postoperative resolution having 5x odds of good clinical outcomes (p<.05). In those with inadequate ER at baseline, the preoperative C2-C7 of <-18° and TS-CL of >59° for TS-CL was predictive of ER resolution. In those with preoperative C2-C7 >-18°, a T1PA of >13° was predictive of postoperative return of ER (all p<.05). Surgical correction of C2-C7 by >16° from baseline was found to be predictive of ER return, highlighting its compensatory role in cervical deformity.

Conclusion
Increased preoperative utilization of the extension reserve in the upper cervical spine in cervical deformity was associated with worse baseline regional and global alignment while impacting health-related measures. The majority of patients had relaxation of extension reserve postoperatively, however, in those who didn't, there was a decreased likelihood of achieving good outcomes.



Radiographic Alignment

169. Evolution of Medical Complication Profiles in Adult Spinal Deformity Corrective Surgery May be Reflective of Changing Pre-operative Preparation and Intra-operative Management

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Hypothesis
Medical complication rates decreased in ASD surgery.

Design
Retrospective cohort.

Introduction
Medical complications are prevalent in adult spinal deformity surgery.

Methods
Operative ASD patients with 2Y follow-up were included. Patients were stratified into tertiles by date of surgery, with T1 from 2008-2013, T2 from 2013-2016, and T3 from 2016-2019. ANCOVA and multivariable logistic regression controlled for covariates as appropriate [age, BMI, comorbidity burden (CCI), frailty, approach, 3CO, levels fused, invasiveness].

Results
1121 patients met inclusion. (Age 61, 76% F, BMI 28.0

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

kg/m2, CCI 1.8, Frailty 3.4). Overall, 71% had complications with 21% having medical complications (2% cardiac, 5% pulmonary, 3% coagulopathy, 3% neurological, 7% GI, 5% infection, 3% MSK, 1% renal). Minor medical complications occurred in 15%, while major in 9%. Multivariable analysis depicted lower rates of medical complications before discharge between T1 and T2 (6.9% vs 3.9%, p<.05). With, pulmonary complications being substantially lower in T3 (7.2% T1, 4.3% T2, 2.4% T3, p=0.03). Those undergoing shorter segment fusion (UIV lower than T6), had nearly a 50% decrease in medical complications rate (T1 27%, T2 15%, T3 14%, p=.005), with a decrease in major medical (T1 11%, T2 8%, T3 4%, p=0.048). This was in conjunction with increasing routine cardiac clearance by 59%, stress test by 60%, echo by 64%, multidisciplinary rounds by 31%, dedicated complex spine anesthesia by 119%, and AI-guided intraoperative fluid management increasing to 9.5% from T1 to T3. Major medical complications had increased intraoperative fluid received, length of stay, SICU admission rates, and SICU length of stay (all p<.05). Although no difference at baseline, those with medical complications had worse HRQLs until 6 months, while major medical complications impacted HRQLs until 1Y (p<.05). Major medical complications decreased the likelihood of meeting MCID in ODI at 1Y by 40% (OR: .593 [.404-.869], p =.007), with no significant impact at 2Y.

Conclusion
While patient profiles became more challenging with increasing age, comorbidity burden, and frailty, those undergoing shorter segment fusions seemed to benefit the most from increased multimodal perioperative measures directed at medical optimization.

170. Do AIS Patients with Maximal Growth Potential Have Better Outcomes after Anterior Vertebral Tethering than Those with Minimal Growth Remaining?

John T. Braun, MD; Sofia Federico; David F. Lawlor, MD; Brian E. Grottkau, MD

Hypothesis
AIS patients with maximal growth potential will have better outcomes after anterior vertebral tethering than those with minimal growth remaining.

Design
Retrospective 2010-24.

Introduction
Though multiple studies have analyzed the impact of growth modulation on curve correction after anterior vertebral tethering (AVT), none have compared ultimate outcomes in AIS patients across the full range of skeletal immaturity. We compared outcomes after AVT in patients with maximal growth potential and minimal growth remaining with the goal of identifying potential differences in final curve correction and complications requiring revision surgery.

Methods
One-hundred and three consecutive AIS patients treated with AVT for curves 33-76° were divided into 2 groups based on skeletal immaturity: 1. Maximal skeletal immaturity (MAX): Risser –1 to 2; 2. Minimal skeletal immaturity (MIN): Risser 3 to 4

Results
Of 103 AIS patients with 2-10 year F/U after AVT, 49 with maximal growth potential (MAX) and 54 with minimal growth remaining (MIN) had similar initial curve corrections but MAX patients had better final curve correction. MAX patients had AVT at 13.3 years and Risser 1.1/Sanders 4.3 with thoracic curve correction from 49° pre-op to 30° post-op to 24° final and TL/L curve correction from 48° pre-op to 18° post-op to 18° final at 2.9 years and Risser 4.0 (p<0.001). MIN patients had AVT at 15.5 years and Risser 3.7/Sanders 5.9 with thoracic curve correction from 51° pre-op to 29° post-op to 29° final and TL/L curve correction from 50° pre-op to 18° post-op to 22° final at 2.9 years and Risser 4.4 (p<0.001). Complications leading to revision surgery were more common in the MAX group at 20% (10/49) with 7/10 requiring fusion. Revision surgery in MIN patients was less common at 9% (5/54) with only 2/5 requiring fusion. MIN patients did have a greater incidence of tether rupture than MAX patients (35% vs. 16%) (p<0.05).

Conclusion
In this study, AIS patients with maximal growth potential (MAX) and minimal growth remaining (MIN) had similar initial curve corrections after AVT, but MAX patients demonstrated better ultimate curve correction in both the thoracic (51% vs. 43%) and in TL/L spine (61% vs. 55%) (p<0.05). However, MAX patients also had a greater chance of revision surgery than MIN patients (20% vs. 9%) and a greater chance of conversion to fusion.

171. Progressive Curve Straightening And Overcorrection Occur In Skeletally Immature Patients After Anterior Instrumented Fusion For Thoracic Scoliosis - Is This 'The Ultimate Tether'?

Gin Way Law, MBBS; Glenys Poon, MBBS; Sunwoo Sunny Kim; John NM Ruiz, MBBS; Leok-Lim Lau, FRCS; Gabriel KP Liu, MD; Hee-Kit Wong, FRCS

Hypothesis
Curve straightening post anterior spinal fusions in adolescent idiopathic scoliosis (AIS) occur due to residual growth potential and asymmetrical growth.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Design
Retrospective clinical study

Introduction
Fusion surgeries are thought to correct spinal deformity with immediate growth cessation of the instrumented segments. Interestingly, some patients showed continued curve correction post thoracoscopic anterior fusions for AIS correction. This study investigates its incidence and influence of skeletal immaturity along with other factors related.

Methods
Thoracoscopic single-rod fusions of AIS Lenke 1 curves performed between June 2000-July 2013 in female patients aged 11-20years with at least 5 years follow-up were included. Patients with post-operative screw pullouts were excluded. Skeletally immature patients (Risser 0-3) at time of surgery (Group 1) were compared against more mature patients (Risser 4-5)(Group 2) for curve changes over time, rod angle changes, complications, and re-operation rates.

Results
19 patients were in Group 1 and 20 were in Group 2. Mean follow-up duration was 96.0months. 15 in Group 1 and 4 in Group 2 had rod straightening (>5°) ($p<0.001$). Overcorrection occurred in 3 patients, all from Group 1. Both groups had similar (i) preoperative coronal and sagittal radiological parameters including curve flexibility, (ii) perioperative data, and (iii) post-operative correction of the thoracic and adjacent curves ($p>0.05$). The instrumented main thoracic curve Cobbs angle post surgery was 10.7±4.5° in Group 1, and 10.2±5.4° in Group 2 ($p=0.745$). Group 1 had subsequent rod straightening with 6.9±2.7° mean rod angle change compared to Group 2 with 4.0±2.1° ($p<0.001$), and corresponding improvements in Cobbs angle correction over time at 5.3±2.2° versus 3.0±2.6° ($p=0.006$). Curve straightening started within 6 months post surgery in Group 1 with continued improvements up to 5 years ($p<0.05$). Group 2 had no further instrumented curve change beyond 1 year ($p>0.05$). All other radiological parameters were similar at last follow up ($p>0.05$). Complication and reoperation rates were similar between the groups ($p>0.05$).

Conclusion
Post-operative rod and curve straightening occurs progressively, and more commonly in skeletally immature patients without increase in adverse outcomes in anterior single-rod fusions for AIS correction.

172. Efficacy of the Spring Distraction System for Different Etiologies of Early Onset Scoliosis

Casper S. Tabeling, MD; *Isabelle E. Blaauw, BS*; Hilde W. Stempels; Keita Ito, MD, PhD; Tom P. Schlosser, MD, PhD; René M. Castelein, MD, PhD; Moyo C. Kruyt, MD, PhD; Justin V. Lemans, MD

Hypothesis
The spring distraction system (SDS) has with different outcomes depending on the specific etiology (congenital, neuromuscular, idiopathic) in early onset scoliosis (EOS).

Design
Retrospective analysis of two prospective study cohorts.

Introduction
EOS is a challenging condition often requiring 'growth-friendly' implants for severe cases. The SDS was designed to correct spinal deformities and to support growth without the need for repeated surgical or outpatient lengthenings. Early studies have demonstrated its efficacy in heterogeneous patient populations. The aim of the current study was to compare the performance of the SDS between patients with different etiologies of EOS.

Methods
Skeletally immature EOS patients treated with the SDS with a minimum of two-year follow-up were included. Radiographic outcomes included Cobb angles and spinal growth. Serious adverse events (SAEs) and unplanned returns to the operating room (UPRORs) were recorded. Outcomes were compared between different etiologies using linear mixed models.

Results
Sixty-one patients were included: 14 congenital, 37 neuromuscular and 10 idiopathic. Mean age at surgery was 8.5±1.9 years with a follow-up 3.8±1.4 years. SDS insertion reduced the main curve from 74°±20° to 39°±16° (46%). Correction loss was greater in idiopathic patients (3.4°/year), than in congenital (0.4°/year) and neuromuscular (0.7°/year) patients ($p=0.002$). T1-T12 growth was 5.1 mm/year with no significant differences between groups. T1-S1 growth was 8.7 mm/year in congenital, 9.7 mm/year in neuromuscular ($p=0.05$) and 7.2 mm/year in idiopathic patients. There were 61 SAEs (0.25/patient/year), with rates of 0.20/patient/year in congenital, 0.26/patient/year in neuromuscular, and 0.33/patient/year in idiopathic patients. Most SAEs were implant-related (73%), mostly from 4.5 mm rod fractures and excessive kyphosis in the system. There were 43 UPRORs (0.18/patient/year), with neuromuscular patients having the highest rate (0.23/patient/year).

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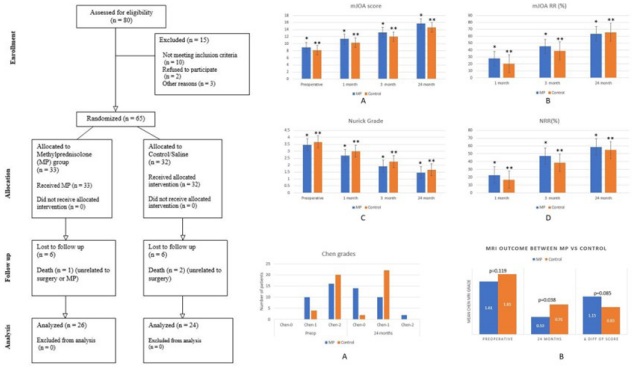
Conclusion
The SDS is effective with a relatively low failure rate compared to other systems, but complication rates, especiallyy in neuromuscular and idiopathic patients, remain a concern. Despite the continuous distraction force, idiopathic scoliosis could not be controlled satisfactory. These findings highlight SDS potential and suggest iterations, like increasing the rod diameter and spring force, which show promising early results.



173. Postoperative Procollagen type 1 N-Propeptide (P1NP) Increase is Associated with Pseudarthrosis at One-Year After Anterior Cervical Discectomy and Fusion (ACDF).

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Hypothesis
Serum P1NP and CTX levels will be associated with fusion after ACDF.

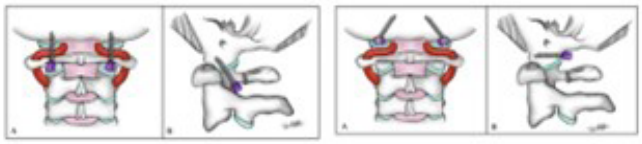
Design
Prospective cohort study

Introduction
Bone turnover markers P1NP and CTX represent metabolic bone activity and are directly modifiable with anabolic agents. The purpose of this study was to evaluate whether BTM predict pseudarthrosis after cervical spine surgery.

Methods
Patients undergoing 1-3 level ACDF for degenerative pathology were enrolled. Exclusions included the use of BMP during fusion, metabolic bone disease, treatment for osteoporosis, inflammatory arthritis, chronic steroid use, chronic kidney disease. Serum collagen type 1 C-telopeptide (CTX) and procollagen type 1 N-propeptide (P1NP) were used as markers of bone resorption and formation, respectively. Labs were collected preoperatively and at six weeks postoperatively. Outcome of interest was lack of radiographic fusion of any level at 1 year, defined as an interspinous distance change >1 mm on lateral flex/ext (Song et al 2014). BTMs, demographics, comorbidities, surgical factors, vitamin D, calcium, and PTH levels were evaluated for association with pseudarthrosis.

Results
58 consecutive patients were enrolled, 23 were excluded for failure to collect 6-week labs, leaving 60 levels for analysis. 30% of patients had at least one level of pseudarthrosis. Baseline demographics, surgical factors, and lab values were similar between cohorts (Table 1). 6-week P1NP in the pseudarthrosis group was 95.0 ±85.0 vs 55.1 ±23.0 in the fused cohort (p=0.074), and a larger 6-week increase in P1NP was associated with pseudarthrosis (38.5 ±71.0 vs -14.8 ±104, p=0.035).

Conclusion
Patients at risk for pseudarthrosis after ACDF show a larger early increase in P1NP compared to their fused counterparts. Considering that these changes occur early after surgery, there may be a role for early post-operative intervention with anabolic agents.



174. Intraoperative Neuromonitoring Alerts During Surgery for Congenital Spinal Deformity: Prevalence, Risk Factors, and Outcome

Anuj Gupta, MD; Brett Shannon, MD; Petya Yorgova; Paul D. Sponseller, MD, MBA; Oheneba Boachie-Adjei, MD; Jennifer M. Bauer, MD, MS; Burt Yaszay, MD;

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Purnendu Gupta, MD; Kwadwo Poku Yankey, MD; Munish C. Gupta, MD; Suken A. Shah, MD

Hypothesis
CSD has higher neuromonitoring alerts

Design
Retrospective

Introduction
Congenital spinal deformity (CSD) is given distinct recognition due to its early presentation and rapid progression. The surgical goal is to stop progression and correct deformity without affecting neurological function. Historically, CSD has a higher incidence of intraoperative neuromonitoring (IONM) alerts, and potential post-operative neurological deficits. We aimed to investigate the incidence and risk factors leading to IONM alerts and postop outcomes.

Methods
A prospective pediatric database was queried for patients with CSD managed surgically. The demographic,surgical & IONM details were recorded and analyzed. Cases with IONM alerts were followed & neurological status was reported in the perioperative period.

Results
100 consecutive patients with CSD were reviewed: 63 females and 37 males with an average age of 11.6 years (1.8- 19.6 years). Categories included scoliosis (n=59), kyphosis (n=13) and kyphoscoliosis (n=28). Mean curvature in the coronal and sagittal plane was 53° (range 2°- 125°) and 51° (range 9°- 128°) respectively. Most cases (n=77) had hemivertebra as one of the anomalies. Neuromonitoring alerts were reported in 19% of cases: TcMEP alone (11), and both TcMEP and SSEP (8), and of these, 16 patients had osteotomies and 3 had PSF alone. Risk factors with positive correlation were male gender (0.042), amplitude of curvature (0.030), % blood loss (0.041) and presence of osteotomy (0.128, odds ratio 2.3). In total, there were 27 alerts, and 6 patients had>1 alert. Most of the alerts were seen during hemivertebrae excision/VCR (9/64) and rod/correction maneuvers (8). Less common events with alerts were osteotomy closure and hypotension. The most common intra-operative measure taken to regain neuromonitoring was to increase MAP (8 responses). Correction was reduced for 3 alerts. Out of 19 cases, four cases were had a neurological deficit on immediate post-op assessment, and all 4 cases had both TcMEP and SSEP alerts.

Conclusion
This study highlights the incidence of IONM alerts and outcomes of neurologic deficit in congenital deformity in a prospective series. Different measures adopted by spine surgeons intra-operatively during alerts are described. Though most of alerts can revert to baseline and do not culminate in clinical deficit, combined loss of TcMEP and SSEP should be considered threatening.

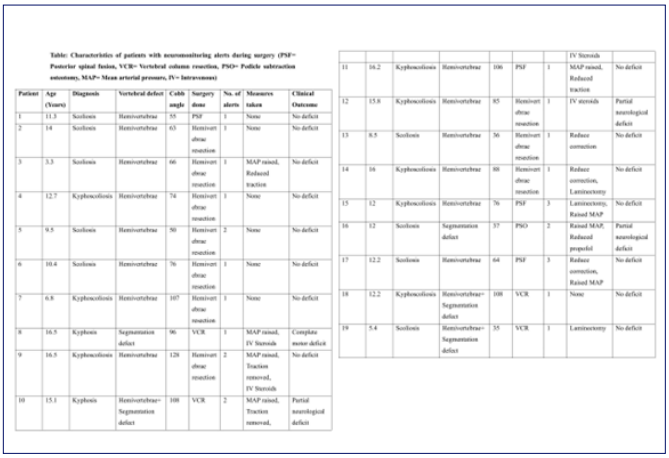


Table: Characteristics of patients with neuromonitoring alerts during surgery (PSF= Posterior spinal fusion, VCR= Vertebral column resection, PSO= Pedicle subtraction osteotomy, MAP= Mean arterial pressure, IV= Intravenous)

Patient	Age (Years)	Diagnosis	Vertebral defect	Cobb angle	Surgery done	No. of alerts	Measures taken	Clinical Outcome
1	11.3	Scoliosis	Hemivertebrae	55	PSF	1	None	No deficit
2	14	Scoliosis	Hemivertebrae	63	Hemivert ebrae resection	1	None	No deficit
3	3.3	Scoliosis	Hemivertebrae	66	Hemivert ebrae resection	1	MAP raised, Reduced traction	No deficit
4	12.7	Kyphoscoliosis	Hemivertebrae	74	Hemivert ebrae resection	1	None	No deficit
5	9.5	Scoliosis	Hemivertebrae	50	Hemivert ebrae resection	2	None	No deficit
6	10.4	Scoliosis	Hemivertebrae	76	Hemivert ebrae resection	1	None	No deficit
7	6.8	Kyphoscoliosis	Hemivertebrae	107	Hemivert ebrae resection	1	None	No deficit
8	16.5	Kyphosis	Segmentation defect	96	VCR	1	MAP raised, IV Steroids	Complete motor deficit
9	16.5	Kyphoscoliosis	Hemivertebrae	128	Hemivert ebrae resection	2	MAP raised, Traction removed, IV Steroids	No deficit
10	15.1	Kyphosis	Hemivertebrae+ Segmentation defect	108	VCR	2	MAP raised, Traction removed,	Partial neurological deficit
11	16.2	Kyphoscoliosis	Hemivertebrae	106	PSF	1	MAP raised, Reduced traction	No deficit
12	15.8	Kyphoscoliosis	Hemivertebrae	85	Hemivert ebrae resection	1	IV steroids	Partial neurological deficit
13	8.5	Scoliosis	Hemivertebrae	56	Hemivert ebrae resection	1	Reduce correction	No deficit
14	16	Kyphoscoliosis	Hemivertebrae	88	Hemivert ebrae resection	1	Reduce correction, Laminectomy	No deficit
15	12	Kyphoscoliosis	Hemivertebrae	76	PSF	3	Laminectomy, Raised MAP	No deficit
16	12	Scoliosis	Segmentation defect	57	PSO	2	Raised MAP, Reduced propofol	Partial neurological deficit
17	12.2	Scoliosis	Hemivertebrae	64	PSF	3	Reduce correction, Raised MAP	No deficit
18	12.2	Kyphoscoliosis	Hemivertebrae+ Segmentation defect	108	VCR	1	None	No deficit
19	5.4	Scoliosis	Hemivertebrae+ Segmentation defect	35	VCR	1	Laminectomy	No deficit

175. Impact of Patient Income Differences on Surgical Outcomes: Analysis of Income Stratification by Zip Code on Outcomes after Adult Spinal Deformity Surgery

Ankita Das, BS; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Jamshaid Mir, MD; Anthony Yung, MMSc; Aleksandra Qilleri, BS; *Peter G. Passias, MD*

Hypothesis
Income status affects patient outcomes after ASD surgery.

Design
Retrospective cohort.

Introduction
With new healthcare reform and greater emphasis on public health practice, socioeconomic status of patients undergoing surgery has played a bigger role for health equity. Socioeconomic status by income stratification on outcomes within adult spinal deformity (ASD) surgery is poorly understood and studied.

Methods
Operative ASD patients ≥18 years with up to 2 year data were included. Using zip code, median household income was determined from publicly available data. The cohort was ranked into 3 groups by median income: Low, Middle, and High. Highest quartile set as H, Lowest quartile set as L. Social depravity score (SDI), composite measure of area level deprivation based on seven demographic characteristics, calculated from 1 to 100 by standardized data collected by American Community Survey and census.gov. Depraved score set as greater than 90. The impact of median income was assessed by ANCOVA

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and logistic regression analysis while accounting for covariates as appropriate. Multivariate logistic regression (MVA) was used to assess the effect on outcomes and associated baseline predictive factors to improved outcome.

Results
170 included: 58.8Y, 50.6%F, BMI 31.5kg/m2, CCI 3.9. Median income: H $79,834, L $28,465. L had a significantly higher CCI than H (4.4 v 3.1;p=.019). SDI: L 88.5, H 42 (p<.05). MVA controlling for age, CCI, levels fused and osteotomies found L had significantly longer length of stay (L 8.7, M 6.5, H 6.1;p=.010). L had significantly lower rates of SICU stay (OR: 0.293;[0.091,0.938];p=.039) and higher BL frailty (4.2 vs 2.9;p=.02). H had significantly lower EBL (1614mL v 2697mL;p=.027) and lower rates of discharge to rehabilitation center (29.1% v 49.6%;p=.004). H were 66% more likely to have lower SDI (OR: 1.34;[1.33, 1.78];p<.05). Greater SDI score correlated to increased odds of reoperation and length of stay (OR: 1.93;p<.001).

Conclusion
Patients from high income zip codes were significantly less likely to experience unplanned return to the OR in the postoperative period, along with lower social depravity score. These data demonstrate differences in outcomes in adult spinal deformity patients by income group, further elucidating the impact of socioeconomic factors on patient care.

176. Radiographic Severity of Knee Osteoarthritis in Adult Spinal Deformity: The Effect on Rod Fracture After Long Spinal Fusion in Deformity Correction

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Gil Han, MD; Cheol-Hyun Jung, MD; *Hong-Sik Park, MD*; Woo-Jae Jang, MD

Hypothesis
Despite ideal deformity correction in adult spinal deformity (ASD), complications such as rod fracture (RF) may still occur if lower-extremity joint pathologies are not resolved.

Design
A retrospective study

Introduction
Instrumentation failure, notably rod fracture (RF), may occur even after ideal spinal deformity correction in adult spinal deformity (ASD). As RF is the major reason behind a revision surgery, various risk factors of RF are reported in literature. However, whether hip and knee joint pathologies serve as another risk factor for RF remains unexplored.

Methods
89 consecutive ASD patients (mean age 71.2 years) who underwent deformity correction through pedicle subtraction osteotomy (PSO) and long-segment fixation from T10 to S1 were analyzed. Patients were classified into two groups: RF (n=36) and non-RF (n=60). Coronal and sagittal spinopelvic parameters, lower-extremity osteoarthritis (OA) parameters and clinical outcomes (ODI and VAS) were analyzed at preoperative, postoperative, and last follow-up. Radiographic factors were assessed, correlations between parameters were examined, and multivariate logistic regression analysis was performed to evaluate risk factors for RF.

Results
Patients in both groups showed severe preoperative sagittal imbalance. There were no significant intergroup differences in patient factors, sagittal and coronal spinopelvic parameters, and osteoarthritis (OA) grade of the lower-extremity joints. However, preoperative structural and functional leg length discrepancy (LLD) and pelvic obliquity (PO) had significantly differed between the groups (p = 0.001, 0.002, and 0.002, respectively). The between-knee differences in the extent of OA, the incidences of both structural and functional LLD, and the frequency of knee angular deformity were significantly greater in the RF group than in the non-RF group (p = 0.008, 0.000, 0.020, and 0.012, respectively).

Conclusion
ASD in the elderly often presents alongside degenerative changes in the lower-extremities, and even with ideal spinal deformity correction, RF may still occur if pre-existing joint pathologies are not resolved. In the deformity correction of ASD, it is essential that we not only pursue the restoration of spinopelvic harmony, but also apply perioperative measures for lower-extremity degenerative joint diseases.

Acute Postoperative Opioid Use and Perioperative Data After Two-to-One Propensity Matching

	MIS (n = 30)	Open (n = 60)	p-value
PCA duration, d (mean ± sd)	1.2 ± 0.7	1.4 ± 0.6	0.382
PCA total, mg (mean ± sd)	3.68 ± 2.61	4.50 ± 5.31	0.922
PCA POD0	1.33 ± 1.87	1.40 ±1.31	0.248
PCA POD1	0.65 ± 1.00	2.28 ± 2.83	**0.019**

Two representative cases

177. Decoding the No-Show: What Predicts Postoperative Visit Cancellations in AIS? §

Sydney Lee, BA; Shanika De Silva, PhD, MS; M. T. Hresko, MD; Craig M. Birch, MD; Ata Kiapour, PhD, MS; Erin Trousdale, BS; Nazgol Tavabi, PhD; *Grant D. Hogue, MD*

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Hypothesis
Driving distance to the clinic and neighborhood-level socioeconomic factors are associated with postoperative visit cancellations in AIS patients.

Design
Retrospective cohort study

Introduction
Despite high surgical correction success rates for Adolescent Idiopathic Scoliosis (AIS), patient-related cancellations and no-shows for postoperative follow-up visits remain a challenge. This study investigates the predictors of cancellations and no-shows in AIS patients.

Methods
Patient demographics, visit characteristics, and neighborhood factors were summarized. Generalized estimating equations were used to identify factors associated with visit cancellations. Factors were compared among patients who completed, cancelled, or discontinued their 2-year follow-up using Kruskal-Wallis, chi-squared or Fisher's exact tests.

Results
The study analyzed 3,459 postoperative visits from 647 patients (median 15 years at surgery, 82% female, 71% White), with 57% living within 50 km of the clinic. Cancellation risk varied across factors. Visits for patients living 50-100 km away versus within 50 km (p=0.04), those over 18 versus younger (p=0.03), and those with public versus private insurance (p=0.01) were each 1.2 times more likely to be canceled. Cancellation likelihood increased with follow-up duration, from 1.3 times at 6 months to 2.3 times at 5 years versus 1-month visits (p=0.002). Winter visits had 1.2 times higher cancellation risk than summer visits (p=0.01). Visits from areas with lower Child Opportunity Index (COI) showed 20-22% higher cancellation risk, while those from areas where ≥50% of carless households had 54% higher risk (p=0.04). Follow-up rates were 73%, 74%, and 44% for 6-month, 1-year, and 2-year visits, respectively. Compared to those who completed their 2-year appointments, patients who cancelled or dropped-out were older at surgery (15 vs. 14 years, p<0.001), more likely to have public insurance (46% and 25% vs. 17%, p=0.003), lived farther (43 and 48 km vs. 42 km, p=0.0014), came from areas with lower COI (29% and 14% vs. 12%, p=0.005), and carless households (10% and 5% vs. 4%, p=0.013).

Conclusion
Cancellation risk increased with driving distance, age, insurance, longer follow-up, season, and neighborhood characteristics. Patients from lower socioeconomic areas, particularly those with limited access to transportation, face higher cancellation risks.

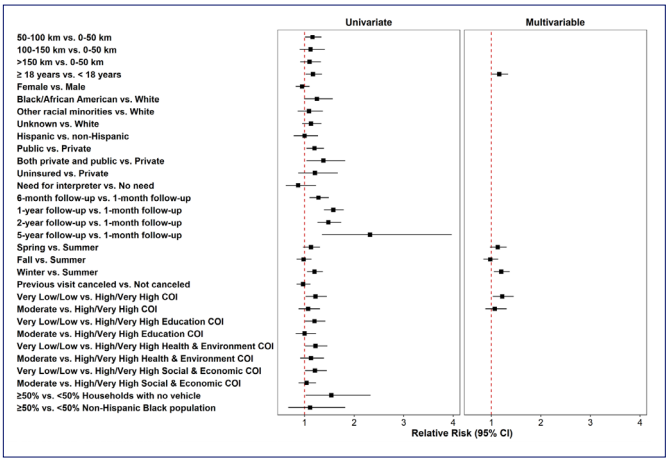


Figure 1. Forest plot of relative risks of visit cancellation

178. Comparison of Accuracy of In-House vs Commercial Patient-Specific Pedicle Guide 3D Printing: A Cadaveric Safety Study ‡

Peter P. Lafranca, MD; Jules Cool, BS; Joëll Magré, MS; Johannes G. Dobbe, PhD; Geert J. Streekstra, PhD; Moyo C. Kruyt, MD, PhD; Barend J. Van Royen, MD, PhD; *Tom P. Schlosser, MD, PhD*

Hypothesis
Patient-specific, 3D-printed pedicle drill guides (3DP) designed by an in-house 3D lab, using MRI-based synthetic CT and regular CT as input, allow for similar safe breach rates as commercially designed 3DP.

Design
Investigator-initiated, cadaveric safety study.

Introduction
Patient-specific, 3DP, allow for accurate screw placement for complex anatomy in pediatric spinal deformity patients. As compared to navigation techniques, 3D printed guides are designed to uniquely fit the patients anatomy. Moreover, they can decrease operative time and the need for intra-operative imaging. Furthermore, pre-operative MRI-based synthetic CTs allow for radiation-free design of 3DP. These 3DP can be designed and produced large-scale by commercial companies, as well as by in-house 3D labs that rely on close collaboration between surgeons and engineers.

Methods
In this investigator-initiated study, 71 pedicle guides were designed on synthetic CTs and conventional CTs of four cadaveric spines (C7-S1). In a randomized way, 36 of the guides were in-house designed, and 35 commercially designed. Two surgeons used the

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

pedicle guides to place 2.0mm k-wires in the pedicles. Pedicle breaches were assessed on postoperative CTs using the Gertzbein-Robbins classification, grade A (no breach) and B (breach <2mm) were considered clinically satisfactory.

Results

142 k-wires were placed, with no differences between sCT and conventional CT and no pedicle breaches grade C,D or E. From the in-house designed guides, 67 were grade A and 5 grade B, and for the commercially available guides, 69 were grade A and 1 grade B. One in-house guide, planned on the wrong level, was made at the day of the surgery within 2 hours, which was impossible for commercial guides.

Conclusion

In-house designed guides as well as commercially-available 3DPs both provide safe pedicle screw placement, with CT as well as MRI-based CT as the input. As compared to commercial large-scale 3DP production, in-house 3D design relies on more close collaboration between surgeons and engineers backed by logistic specialists, and can be used for complex cases. In-house guides have the advantage they can be designed and produced relatively quickly.

Figure 1: Outcomes Between Patients With Expandable and Static Cage Placement in LLIF

		Expandable (N=21)	Static (N=68)	p-value
Demographics	Age	65.76±7.93	63.24±9.69	0.230
	Gender (%F)	61.90%	64.70%	0.801
	BMI	31.74±6.19	30.40±6.48	0.405
	Current Smoker	0.00%	8.80%	0.329
	ASA	2.52±0.51	2.53±0.53	0.966
Surgical Characteristics	Levels Fused	4.10±2.64	3.05±2.48	0.103
	LLIF cages placed	1.57±0.60	1.46±0.63	0.461
	Hyperlordotic Cage?	4.80%	2.90%	0.559
	L1/L2	33.30%	16.20%	0.119
	L2/L3	61.90%	52.90%	0.617
	L3/L4	47.60%	47.10%	1.000
	L4/L5	19.00%	27.90%	0.571
Perioperative Outcomes	EBL (ml)	710.48±720.87	374.82±556.66	**0.027**
	Length of Stay (days)	5.40±3.19	4.29±2.24	0.077
	Post Op Complication	7(33.3%)	19(28.4%)	0.785
	Cardiac	1(4.8%)	7(10.4%)	0.674
	Pulmonary	2(9.5%)	6(9.0%)	1.000
	Neurological Deficit	1(4.8%)	2(3.0%)	0.563
	Ileus	1(4.8%)	4(6.0%)	1.000
	Urinary	2(9.5%)	5(7.5%)	0.670
	90 Day Readmission	3(14.3%)	9(13.6%)	1.000
1 Year Outcomes	Recurrent Radiculopathy at 1 yr	5(26.3%)	23(35.4%)	0.584
	Subsidence at 1 Yr	3(17.6%)	12(20.7%)	1.000
	Return to OR Within 1 Yr	3(14.3%)	3(4.5%)	0.149
	Psuedoarthrosis	1 (4.8%)	0 (0.0%)	0.236
	Mechanical Failure	2(6.5%)	0 (0.0%)	0.054
	Adjacent Segment Disease	1 (4.8%)	2 (2.9%)	0.559

Figure 2: Radiographic Analysis Between Expandable and Static Cage Placement in LLIF

	Expandable (N=21)	Static (N=68)	p-value
Number of Cages	33	99	
Baseline Average Disk Height (mm)	6.71±2.94	5.35±2.07	**0.030**
Δ Average Disk Height Post Op (mm)	5.40±2.55	4.30±2.38	0.095
Δ Average Disk Height Post Op to 1 Year (mm)	-1.04±1.86	-0.44±1.39	0.163
Baseline Average Segmental Lordosis °	7.85±5.43	6.35±4.58	0.299
Δ Average Segmental Lordosis Post Op °	2.30±3.65	3.37±4.83	0.446
Δ Average Segmental Lordosis Post Op to 1 Year °	0.31±2.99	-1.97±4.26	0.058
Baseline Lumbar Lordosis °	51.24±11.88	43.40±15.53	0.087
Δ Lumbar Lordosis Post Op °	2.75±11.16	3.47±9.66	0.812
Δ Lumbar Lordosis Post Op to 1 Year °	2.07±6.36	-1.32±7.92	0.147

One of the cadaveric species with all guides and k-wires in place. White guides are in-house designed, grey are the commercial alternatives.

179. Immediate Chest Tube Removal at the Completion of Anterior Vertebral Tethering is Well Tolerated With No Increase in Pulmonary Complications

John T. Braun, MD; Sofia Federico; David F. Lawlor, MD; Brian E. Grottkau, MD

Hypothesis

Immediate chest tube removal at the completion of anterior vertebral tethering (AVT) will be well tolerated without increased risk of pulmonary complication.

Design

Retrospective 2012-24.

Introduction

Though chest tube removal at the completion of endoscopic thoracic procedures is well accepted in the pediatric and adult general surgery literature, this practice has never been studied in pediatric patients treated with AVT for AIS. This study analyzed 211 consecutive AIS patients treated with AVT over 11 years after immediate removal of the chest tube in the majority of patients. While the rate of pulmonary complication has been reported as high as 10% after AVT in patients with post-op chest tube retention, this study found a pulmonary complication rate of only 3.6% after chest tube removal at completion of AVT.

Methods

Two-hundred eleven consecutive AIS patients (203 primary/8 revision) with 273 curves were treated with AVT. Of 273 chest tubes placed intra-op, 253 were removed at procedure completion and 20 retained for 2-5 days post-op. Charts and X-rays were reviewed to identify pulmonary complications.

Results

In 211 AIS patients treated with AVT, 193 had chest tube removal at completion of AVT with 2 immediate (1%) and 5 delayed pulmonary complications (2.6%): 1 intra-op PTX required chest tube reinsertion in OR and 1 static PTX post-op resolved without intervention; 4 delayed pleural effusions at 2 weeks post-op and 1 chylothorax at 1 week post-op required drainage but subsequently resolved. In 18 remaining patients, 20 chest tubes were retained for 2-5 days post-op for air leak/presumed parenchymal injury (11), revision with significant adhesions (6), bleeding disorder (2), or diaphragm repair related to renal eventration (1) with no pulmonary complications. Pulmonary complications were not related to lung deflation, laterality, or the number of curves treated.

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Conclusion
This study demonstrated the relative safety of immediate chest tube removal in AIS patients at the completion of AVT. The rate of pulmonary complication in 193 patients with chest tube removal at the completion of AVT was 3.6% which compared favorably with a reported rate of 10% pulmonary complication after chest tube retention. In 18 patients with an indication for chest tube retention at the completion of AVT, chest tube retention for 2-5 days resulted in no pulmonary complication.

180. Evaluation of Robotic Navigation Assistance in Spine Surgery: A Single-Institution Study of 1001 Pedicle Screws

Fedan Avrumova, MS; Samuel Goldman, BS; Celeste Abjornson, PhD; Darren R. Lebl, MD

Hypothesis
Although previous studies have explored Robotic Navigation Assistance (RNA), limited data exist on clinical series with over 1000 screws using current-generation RNA. We hypothesize that RNA improves screw placement accuracy and reliability in spinal surgery with a low complication rate.

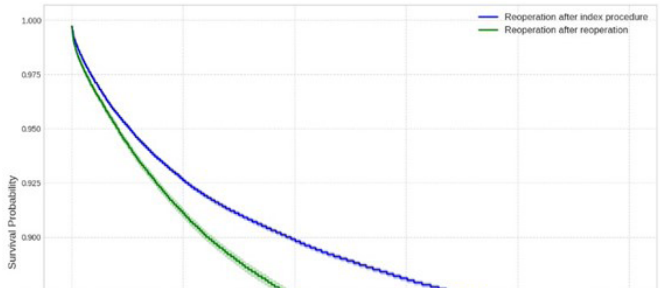
Design
Prospectively collected data

Introduction
In recent years, there has been increased use of RNA with the aim of maximizing efficiency while minimizing the risk of surgical complications. Technical advances have integrated navigation and robotics into a single platform and the introduction of 3D optical systems now allow real-time image guidance.

Methods
This single-center study prospectively collected data from consecutive patients undergoing RNA posterior spinal fusion (2019–2022). Intraoperative 3D fluoroscopy was used to compare screw positioning with the preoperative plan, evaluating accuracy, reliability, and malposition risk factors. Clinical data, radiation time, and exposure were recorded.

Results
A total of 1129 pedicle screws were implanted in 196 adult patients over the 3-year study period. Screws were placed robotically in 1001(89%), converted from robotic placement to k-wire or freehand technique in 68(6%), and planned and inserted freehand in 60(5%) patients. Of the robotically placed screws, 94.1% were determined to be GRS Grade A with median deviation from preoperative planning templates of 1.1±1.2 mm. Breaches(≥2 mm exceeding pedicle cortex) were registered in 19(5.1%) of screws. Skive events were noted in 20 screws(1.8%) due to hypoplastic pedicles, unfavorable morphology of screw starting point, and soft-tissue pressure on the robotic cannula. The most common skive level was L5(11 screws). Complete robot abandonment was recorded in three patients(1.5%). In cases with suboptimal screw position noted on intraoperative 3D scans, implants were repositioned in all cases uneventfully. Mean fluoroscopic time per screw was 5.2±4.4s. There were no durotomies, neurological deficits, or returns to the operating room related to implant positioning in any patient.

Conclusion
RNA enables highly accurate and reliable screw placement in the thoracic and lumbar spine with minimal complications. Identifying patient anatomical factors linked to suboptimal screw positioning will support further advancements in robotic surgery.



Real-time RNA workflow for pedicle screw insertion.

181. Prior Shoulder Surgery Predicts Prolonged Length of Stay After Surgery for Cervical Myelopathy

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Hypothesis
We theorized that machine learning models could successfully predict which patients would require a prolonged length of stay and identify significant predictive factors.

Design
This is a retrospective analysis of the prospectively-collected Quality Outcomes Database to develop predictive models for prolonged length of stay after cervical spondylotic myelopathy surgery.

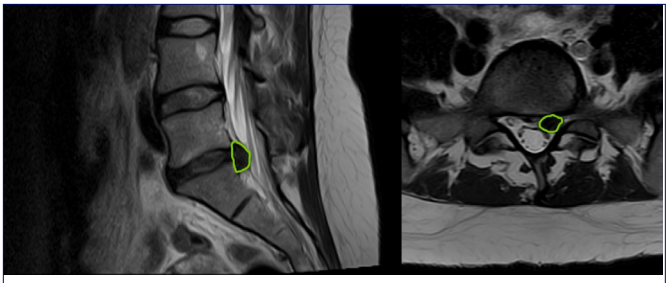
Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Introduction
Cervical spondylotic myelopathy (CSM) is the most common type of spinal cord disease in adults. Identifying patients at risk for prolonged postoperative length of stay (LOS) can help optimize perioperative care and resource utilization. This study aims to develop predictive models for prolonged LOS after CSM surgery.

Methods
Data was obtained from the Quality Outcomes Database CSM dataset, a prospective registry of 1141 patients from 14 sites. Prolonged LOS was defined as 3 days or more (75th percentile). Patients with missing data were excluded. Remaining patients were partitioned into training (n=728) and test sets (n=182). Logistic Regression, XGBoost, and Random Forest models were trained to predict prolonged LOS after surgery for CSM.

Results
Overall, 910 patients met inclusion criteria with mean age of 60.5 ± 11.6 years, 47.5% female, mean BMI 30.0 ± 6.4, and mean ASA grade 2.5 ± 0.6. Logistic Regression, XGBoost, and Random Forest models demonstrated excellent performance with mean AUROCs of 0.868 (±0.028), 0.855 (±0.027), and 0.864 (±0.026), respectively. Significant predictors of prolonged LOS were older age (OR 1.03, 95% CI: 1.03–1.04, p=0.041), past shoulder surgery (OR 2.86, 95% CI: 2.54-3.17, p=0.043), and more fused levels (OR 1.92, 95% CI: 1.86-1.97, p<0.001). In contrast, radicular motor deficits (OR 0.32, 95% CI: 0.28–0.37, p=0.004) and anterior surgical approach (OR 0.07, 95% CI: 0.06–0.08, p<0.001) were associated with shorter hospital stays.

Conclusion
In this large CSM registry cohort, prior shoulder surgery emerged as a key predictor of prolonged LOS, along with older age and more extensive, posterior fusions. Prior shoulder surgery may lead to functional impairment and increased pain from surgical positioning and taping, which may in turn impair postoperative mobility, delay rehabilitation, and increase the risk of complications. These findings suggest that patients with prior shoulder surgery may be considered a distinct entity with regards to potential resource utilization.



182. Development of a Multimodal Machine Learning Model for Predicting Second Osteoporotic Vertebral Compression Fractures

Sung Hyun Noh, MD, PhD; *Hoyeon Cho*

Hypothesis
This study developed a multimodal machine learning model to predict the occurrence of a second osteoporotic vertebral compression fracture (OVCF) in patients following an initial fracture.

Design
Retrospective study

Introduction
Osteoporosis is a frequent health condition among older adults. It is characterized by low bone mineral density among men and women over 50 years. Osteoporosis increases the probability of Osteoporotic vertebral compression fracture (OVCF) which causes pain that severely limits physical activity, increases mortality and morbidity. Therefore, preventing OVCF is a crucial factor. We focus on predicting secondary OVCF which occurs after the first OVCF.

Methods
A retrospective study was conducted on electronic medical record of one hundred seventy-eight patients from a single institution who had their first OVCF between January 1, 2000, and December 31, 2019. Clinical dataset included 18 columns of preoperative data, encompassing demographic factors, medication information, comorbidities, bone mineral density (BMD), body mass index (BMI), fat and muscle amount of the trunk using dual X-ray absorptiometry (DEXA). Image datasets were comprised of sagittal MRI and Xray photos of patients. We used feature level fusion multi modal approaches on combining image data and clinical factors.

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Results
We developed a predictive model combining a pre-trained convolutional neural network (EfficientNet B0) with principal component analysis (PCA) and a random forest algorithm. The model's mean accuracy, F1-score, Recall, Precision, AUROC was 0.966, 0.972, 0.980, 0.963, 0.994 respectively. Feature importance analysis revealed that gynoid fat and tissue were the most critical factor in predicting 2nd OVCF, with android and trunk fat/tissue also being significant contributors. Along with clinical factors, image features represented as PCA components emerged as important predictors. Visualization of important PCA components showed that the CNN focused on gynoid and android fat/tissue, as well as vertebral structures, in MRI images.

Conclusion
This study developed a multimodal machine learning model to predict the occurrence of a second osteoporotic vertebral compression fracture (OVCF) in patients following an initial fracture. The model achieved excellent performance metrics and were effectively interpreted using feature importance analysis and visualization methods.

Table 1. Patients with no Hip OA versus patients with Hip OA

			No Hip OA(n=5647)	Hip OA (n=160)	p-value
	Revision for Adjacent Segment Disease		**434(7.7%)**	**30 (18.8%)**	**<.001**
Demographics	**Age**		**58.97 ± 13.798**	**66.16 ± 9.289**	**<.001**
	Gender (% Female)		2940(47.9%)	70(43.8%)	.296
	BMI		**29.47 ± 6.28**	**30.34 ± 6.06**	**.008**
	Smoker (% Non-Smoker)		519(90.8%)	15 (9.4%)	.937
	ASA		**2.44 ± 2.09**	**3.03 ± 3.46**	**.001**
	CCI		**2.41 ± 2.07**	**3.46 ± 1.91**	**<.001**
	Levels Fused		2.09 ± 2.127	2.26 ± 1.26	.305
Surgical Characteristics	Operative Time (min)		265.6 ± 121.7	277.1 ± 117.8	.42
	EBL (mL)		418.06 ± 641.03	449.58 ± 621.26	.539
	LOS (days)		6 ± 38.95	9.85 ± 43.75	.219
Complications	Intra-Operative	Any Intraoperative Complication	294(5.2%)	13(8.1%)	.104
		Mass Blood Loss (≥2L)	**21(0.4%)**	**3(1.9%)**	**.003**
		Neuromonitoring	**235(4.2%)**	**14(8.8%)**	**.005**
		Durotomy	227(4%)	10(6.3%)	.16
	Post-Operative	Any Post-Operative Complication	1150 (20.4%)	51 (31.9%)	<.001
		Cardiac	312(5.5%)	14(8.8%)	.081
		Neuro	228(4%)	11(6.9%)	.075
		DVT/PE	65(1.2%)	3(1.9%)	.401
		Pulmonary	155(2.7%)	1(0.6%)	.102
		Airway Edema	2(0.0%)	0(0.0%)	.812

183. If Not Now, When?: A Comparative Analysis of Early-Term Versus Late-Term Complication Rates Following Adult Spinal Deformity Surgery

Max R. Fisher, MD; Anthony Yung, MMSc; Oluwatobi O. Onafowokan, MBBS, MS; Alexander Parsons, MD, MSc; Iryna Ivasyk, MD, PhD; Isabel Prado, MD, MS; Caroline Wu, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Pawel Jankowski, MD; Khoi D. Than, MD; *Peter G. Passias, MD*

Hypothesis
To compare the rates of certain complications before and after two years following ASD surgery

Design
Retrospective cohort

Introduction
It remains to be established which complications are more prevalent after two years following ASD surgery

Methods
ASD patients with minimum 3-year and up to 5-year data were included. Complication groups were defined as follows: 1) any complication,2) major,3) medical [cardiac event,ileus,etc.],4) mechanical [implant failure,rod fracture,etc.], 5) radiographic [proximal junctional kyphosis(PJK),pseudarthrosis,adjacent segment disease], and 6)reoperation. Complications were stratified by occurrence before or after two years(2Y) postoperatively. Multivariable logistic regression analysis adjusting for age and invasiveness determined likelihood of the occurrence for certain complications before or after two years

Results
481 ASD patients included, with an average age of 59±15 years, predominantly female(77%) and a high CCI(1.7±1.7). By 2Y, complication rates: 74% ≥1 complication,19% major,17% medical,13% neurological,46% radiographic,15% mechanical, and 20% required reoperation. After 2Y, complication rates: 19% ≥1 complication,3% major,0.4% medical,1% neurological,17% radiographic,3% mechanical, and 1.5% required reoperation. Radiographic and mechanical complications had the highest proportional rates after 2Y at 23% and 18%, respectively. This translated to 75% of all complications occurring after 2Y to be mechanical- or radiographic-related. The cause of major complication after 2Y was more likely mechanical(OR: 148,[37-598];p<.001), in addition to the indication for reoperation after 2Y(OR: 51,[10-255];p<.001). Patients suffering radiographic complications after 2Y were less likely to have suffered radiographic complications before 2Y(OR: 5,p<.001). Patients suffering major complications or reoperations before 2Y were not more likely to develop any certain complication after 2Y(all p>.05). Patients developing major complications after 2Y had higher rates of each complication prior to 2Y(all p<.05), but those undergoing reoperation after 2Y were only predicted by PJF(OR: 6,[1.1-37.1]) prior to 2Y.

Conclusion
This study increases our understanding of the complications occurring later in the postoperative course, along with early-term correlates, to better aid the spine deformity surgeon during postoperative monitoring and management

Key: § = Whitecloud Award Nominee – Best Clinical Paper † = Whitecloud Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

E-POINT PRESENTATION ABSTRACTS

184. Long-Term Clinical and Radiologic Outcomes of Semi-constrained Lumbar Total Disc Replacements (More Than 15 Years Follow-up)

Baris Peker, MD; Hamisi M. Mraja, MD; Mehmet Zamanoglu, MD; Inas Daadour, MD; Sepehr Asadollahmonfared, MD; Onur Levent Ulusoy, MD; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Hypothesis
Lumbar total disc replacement provides long-term (> 15yrs) preservation of motion at the index level while limiting adjacent segment degeneration

Design
Retrospective

Introduction
The purpose of this study was to evaluate the long-term of clinical and radiologic outcomes of pts whom underwent total disc replacement surgery for lumbar degenerative disc disease.

Methods
Lumbar degenerative disc disease patients who underwent total disc replacement surgery and had complete radiological data with more than 15 years f/up were included. All patients were evaluated with preop and final f/up standing AP/LAT, dynamic x-rays, lumbar low dose CT and MRIs, analyzed by two radiologists. The range of motion of index and adjacent levels were measured with dynamic x-rays. Facet joint degeneration of index and adjacent level (preop vs f/up) were classified according to Pathria classification with CT. Disc degeneration of adjacent levels was classified according to Phirmann classification on preop and f/up MRIs. Marginal homogeneity test was used for statistical analyses. ODI and VAS scores were used for clinical assessment.

Results
16 pts (12F,4M), mean age 42(34-54) yrs, f/up 17.4 (15-19) yrs were included. Total disc replacements were 29 levels; single level in 6 pts, two levels in 8 pts, three levels in 1 and four levels in 1 pt. Mean preop range of motion was 12,2°(6-18) and f/up range of motion was 11,8° (8-16) at index levels. Comparison of preop and f/up CT scans showed one grade increase in FJD at index levels in 10 pts (62,5%) ($p<0.05$) and at the adjacent levels in 5 pts (31,3%) (3 cranial, 2 caudal). Comparison of preop and f/up MRI scans showed one grade increase in DD at adjacent levels in 7 pts (43,8%). None of total disc replacements showed any loosening, subsidence, dislocation or heterotopic ossification. Mean NRS score improved from 7,4 to 2,2 and mean ODI score was 13 at the final f/up.

Conclusion
Semiconstrained total disc replacement showed satisfactory clinical and radiological results after min 15 yrs f/up. CT scan evaluation showed facet joint degeneration progressed one grade at index (62,5%) and adjacent levels (31,3%). Comparison of preop and f/up MRI scans showed mild adjacent level disc degeneration (grade 1) in 43,8% of the cases. Semi-constrained total disc replacement preserves range of motion of the index levels without any mechanical failure even 15 years after surgery

185. When is Staging Complex Adult Spinal Deformity Advantageous? Identifying Subsets of Patients Who Benefit from Staged Interventions

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Hypothesis
To identify baseline patient and surgical factors predictive of optimal outcomes in staged versus same-day combined-approach surgery.

Design
Retrospective cohort

Introduction
There remains no definitive consensus on which patiets benefit most from staged surgery for ASD correction

Methods
ASD patients were stratified based on single-stage (Same-Day) or multistage (Staged) surgery, excluding planned multi-hospitalization. Means comparison analyses assessed baseline demographic, radiographic, and surgical differences between cohorts. Backstep logistic regression and conditional inference tree (CIT) analysis identified variable thresholds associated with study-specific definitions of an Optimal Outcome in each cohort, defined as no intraoperative or surgery-related in-hospital adverse event.

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Results
There were 439 complex ASD patients in the dataset (64.0±9.3yrs, 68% F, 28.7±5.5kg/m2). 58.7% of patients were Same-Day, while 41.3% were Staged. Demographically, cohorts were not significantly different, (p>.05) but staged patients were more frail per total Edmonton Frailty (p=.043). Staged patients also reported greater NRS-Back pain versus Same-Day patients (p=.002). Cohorts were comparable in magnitude of planned correction of C7-S1 SVA, PI-LL, and T4-T12 kyphosis (all p>.05). Controlling for BL age, frailty, and levels fused, Staged patients reported significantly higher PROMIS-Discretionary Social Activities (DSA) scores by 6W (p=.029). Radiographic outcomes by 6W were comparable between cohorts, both in terms of magnitude of change from baseline and overall result (all p>.05). Same-Day patients were significantly more likely to experience in-hospital complications (p=.013). When considering frailty thresholds for staging, only CCI ≤ 1.0 was associated with Optimal Outcome in Same-Day patients, while Edmonton Frailty total ≥ 7 (p=.036), ≥ 9 levels fused (p=.016), and baseline PI-LL ≥ 15.3° (p=.028) were associated with Optimal Outcome for Staged patients. Yet, staging alone was not significantly associated with an Optimal Outcome peri-operatively (p=.056).

Conclusion
Individuals with increased frailty, moderate-severe PI-LL mismatch, and increased anticipated number of levels fused may experience a lower risk of perioperative adverse events if they undergo a staged procedure

186. Segmental Trans-endplate Pedicle Screws do not Induce Scoliotic or Kyphotic Deformity in a Porcine Model ‡

Taylor R. Johnson, MD; Christine L. Farnsworth, MS; Amishi Jobanputra, MS; Jonathan Wen; Austin Stoner, BS; Vivian Ho, NP; Vidyadhar V. Upasani, MD; John S. Vorhies, MD

Hypothesis
We hypothesize that unilateral trans-endplate screws—referred to as spinal epiphysiodesis trajectory (SET) screws—can induce partial anterior spinal growth arrest, inducing scoliotic deformity in a porcine model.

Design
This study explores a new area of mechanical fixation across spinal growth centers using SET screws.

Introduction
Growth modulation is an effective method for limb deformity correction and is increasingly popular in spinal deformities. While posterior distraction/compression-based and anterior compressive techniques for spinal growth modulation have been explored, mechanical fixation across growth centers to arrest growth has been less studied.

Methods
A pilot study was conducted using four male piglets (two experimental, two control) at 8 weeks of age. Unilateral posterior spinal instrumentation at 4 levels in the lower thoracic spine was performed under sterile conditions. The experimental group received trans-endplate SET screws (Fig 1A) and the control group received pedicle screws (Fig 1B) Radiographs before and after surgery assessed vertebral height and coronal and sagittal Cobb angles. At 3 months postoperatively, radiographs, magnetic resonance imaging (MRI) and computed tomography (CT) were used to evaluate for coronal and sagittal vertebral wedging, disc and facet degeneration, physeal bar presence, and endplate irregularities.

Results
Three months postoperatively, no significant differences in coronal or sagittal curve magnitudes were observed between the SET and pedicle screw groups. Neither screw type caused coronal or sagittal segmental vertebral wedging (Figure 1C,D). Neither SET screws nor pedicle screws limited vertical growth, with mean vertebral height gains of 40%, 27%, and 27% in the SET group, pedicle screw group, and adjacent uninstrumented segments, respectively. No significant changes in disc or facet health were observed, based on the Pfirrmann and Fujiwara classifications. No physeal bars were detected, though one experimental specimen exhibited endplate irregularities.

Conclusion
In this porcine model, SET screws as applied did not induce scoliotic or kyphotic deformity. As other methods of neurocentral synchondrosis and endplate epiphysiodesis have resulted in deformity, further investigation is warranted to define mechanisms and timing of spinal growth to facilitate modulation and deformity correction.

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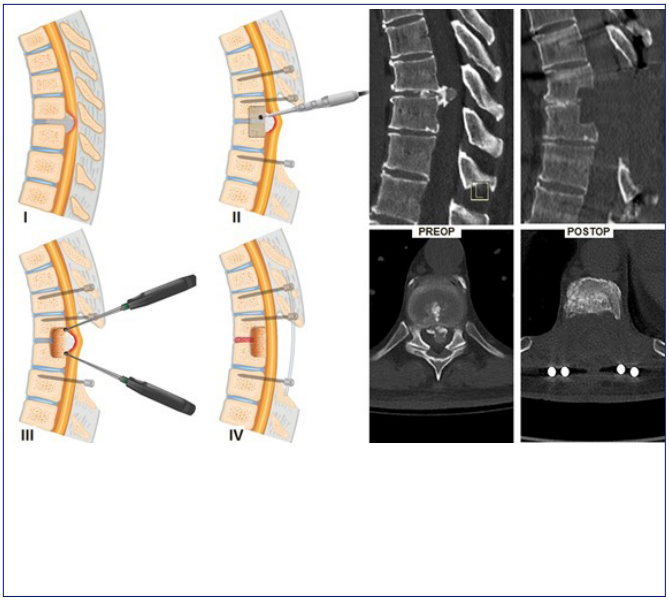

SET and pedicle screws No difference in wedging.

187. Bipolar Fixation Technique Versus Traditional Posterior Fusion in Underweight Pediatric Patients With Neuromuscular Scoliosis §

Carlos Huaiquilaf, MD; Karen A. Weissmann, MD; Francoise Descazeaux, MD

Hypothesis
Neuromuscular scoliosis undergoing bipolar technique posterior fixation is more effective than classic long posterior fixation

Design
A retrospective study in Cohorts groups

Introduction
Neuromuscular Scoliosis surgery is associated with severe complications and high mortality rates. Less invasive techniques have emerged to reduce complications in Spinal Deformity Surgery. Bipolar technique has shown favorable results and decrease in complications in adult patients with cerebral palsy (CP). We focused this case series on underweight pediatric patients with neuromuscular scoliosis undergoing bipolar technique posterior fixation.

Methods
A retrospective study comparing 17 patients in two cohorts of underweight non-ambulatory patients with Neuromuscular scoliosis operated on between 2018 and 2024. 9 cases (Group A) underwent traditional posterior fusion and 8 cases (Group B), Bipolar fixation. Demographics, operative time, invasiveness, Length of Stay (LOS) in both critical patient unit (CPU) and Total LOS ,complications where recorded. Statistical analysis was performed using two-tailed t-student with 95% confidence interval.

Results
Group A (Mean age 13.1 years) had a mean weight of 26.8 kg Group B (13.0 years) a mean weight of 26.8 kg. surgical time was 196 minutes for Group A and 81 minutes for Group B ($p<0.05$). Mean blood loss was 455 cc (24% volemia) in Group A and 172 cc (9.9% volemia) in Group B ($p<0.05$). CPU LOS was 3.7 days in Group A and 1.25 days in Group B, with Total LOS of 9.8 and 2.75 days respectively ($p<0.05$; $p<0.05$). Mean instrumented levels was 18.7 in Group A, and 9.5 in Group B ($p<0.05$). Mean Cobb angle of the main curve in Group A was 82° a 42% correction rate: Group B averaged 59° Cobb, with 48% correction rate ($p>0.05$). Regarding complications, Group A had 2 patients with unspecific fever that resolved itself in a couple of days without antibiotic therapy and 4 patients with severe ileum, Group B had no postoperative complications.

Conclusion
There is statistically significant reductions in surgical time, blood loss, number of implants used, LOS and complication rates in underweight patients undergoing bipolar fixation versus traditional posterior fusion in patients with Neuromuscular Scoliosis; while maintaining similar correction rates. Despite a small sample size, these results are encouraging for this complex group of patients. Long-term follow-up is needed to evaluate fusion rates in these cases. Cost analysis also needs to be performed.

188. Prediction of Patient Satisfaction after Lumbar Fusion Surgery Based on Machine Learning

Sung Hyun Noh, MD, PhD; *Hoyeon Cho*; Dain Lee; Su Hyeon Kim, PhD; Min K. Joo, MD

Hypothesis
The machine learning model successfully predicts patient satisfaction after lumbar fusion surgery

Design
Retrospective study

Introduction
The indications and number of lumbar fusion surgery has been increasing. Patient satisfaction is a valuable measure that effects overall patient outcomes and gives valuable insight on patient care. Traditional statistical methods do have a limited aspect on prediction of patient satisfaction in this context. Machine learning methods are an assuring alternative that can be developed continuously as new conditions appear. This study aims to develop a machine learning model that can predict patient satisfaction after lumbar fusion surgery by using only preoperative factors. This model development will benefit in clinical decision making and patient well-being.

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Methods
A retrospective analysis was conducted using electronic medical data (EMR) data of 359 patients who underwent lumbar fusion surgery between January 2021 and December 2023. This study employed a multi-label classification method to predict improvements in short form 36 mental component summary (SF-36 MCS) and SF-36 physical component summary (SF-36 PCS) scores after lumbar fusion surgery. 22 preoperative variables and six machine learning approaches were used. Model performance was evaluated using 5-fold cross validation and seven evaluation metrics, while prioritizing F1-score and area under the receiver operating characteristics curve (AUROC). SHAP analysis and waterfall plots were utilized for model interpretation.

Results
The Extra trees model in multi-class classification showed best performance among the models, with F1-score of 0.850 and AUROC of 0.835. Key predictors among preoperative variables identified using SHAP analysis were Hypertension, Diabetes mellitus, BMI, bone mineral density, and revision status.

Conclusion
The machine learning model successfully predicts patient satisfaction after lumbar fusion surgery. Identified key predictors and the model itself can be used as a practical tool for clinicians and patients, aiding their decision-making process before lumbar fusion surgery.

Table 1	Post-Operative Cognitive Dysfunction		
	No	Yes	
Total	496	70	
Age	59.64 (15.83)	68.68 (9.05)	<.001
BMI	29.8 (6.43)	31.95 (5.94)	0.007
ASA	2.73 (0.55)	2.91 (0.40)	0.004
Diabetes	81 (16%)	22 (31%)	0.002
Lung disease	152 (31%)	29 (41%)	0.076
Heart disease	100 (20%)	19 (27%)	0.209
Liver disease	9 (2%)	4 (6%)	0.065
Alcohol Use	83 (17%)	9 (13%)	0.491
Sleep Apnea	138 (28%)	33 (47%)	0.002
CPAP	74 (15%)	17 (24%)	0.053
Hearing Impairment	60 (12%)	11 (16%)	0.439
Vision Impairment	252 (51%)	38 (54%)	0.611
Mobility			0.101
Independent	319 (64%)	35 (50%)	
Cane	73 (15%)	11 (16%)	
Walker	63 (13%)	15 (21%)	
Wheelchair	35 (7%)	7 (10%)	
Benzodiazepines	78 (16%)	14 (20%)	0.387

189. Evaluation of the Utility of Morphological Alignment in Revision Adult Spinal Deformity Corrective Surgery: Do Revisions Obscure Recognition, Implementation, and Outcomes?

Jamshaid Mir, MD; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Max R. Fisher, MD; Anthony Yung, MMSc; Aleksandra Qilleri, BS; Matthew Galetta, MD; Nathan Lorentz, MD; Jordan Lebovic, MD, MBA; Pawel Jankowski, MD; *Peter G. Passias, MD*

Hypothesis
Prior lumbar spine fusion challenges restoration of Roussouly spinal morphology.

Design
Retrospective cohort.

Introduction
Surgical correction for adult spinal deformity (ASD) is a complex and multifaceted challenge, further intensified by the need for revision surgery. Determination of optimal spinal alignment and shape is complicated by the presence of existing implants.

Methods
ASD patients undergoing revision surgery w/ a minimum of 2-year (2Y) follow-up undergoing fusion from at least L1 to sacrum included. Patients stratified based on prior fusion from L1 and proximal to sacrum (PF) or not (NPF). Roussouly morphotype based on SS "current" was defined as: Type 1 (T1): SS<35° and ≤3 lordotic vertebra (kyphosis-lordosis inflection point was caudal to L2/3); Type 2 (T2): SS<35° and ≥4 lordotic vertebrae (inflection point was cranial to L2); Type 3-AP (T3A): 35°≤SS<45°, PI<50, and PT<5°; Type 3 (T3): 35°≤SS<45°, PI≥50°, or PT≥5°; and Type 4 (T4): SS≥45°. Subanalysis conducted on postoperative match of Roussouly based on theoretical PI: Type 1 (T1): PI<45°, LL apex<L4; Type 2 (T2): PI<45°, LL apex>L4-L5 space; Type 3 (T3PI): 45°<PI<60°; Type 4 (T4PI): PI>60°.

Results
334 included: Age 63±10, 77%F, BMI 27.6±5.1kg/m2, frailty 3.5±1.5, CCI 1.9±1.7. 9.0% had PF. Roussouly categories preoperatively: 40% T1, 26% T2, 24% T3, 1% T3AP, 9% T4. 48% met Roussouly targets postoperatively, with 35% of those in T1 meeting the correct target type, 60% in T2, 49% in T3, 0% in T3AP, and 72% in T4. Evaluation of PF depicted no difference in rates of matching overall and by type. No difference in PF and NPF rates by type was found when assessing only those who were mismatched at BL. This was also seen utilizing PI-based theoretical targets. In those matched preoperatively (54% of cohort), 40% lower rate of remaining matched in PF (PF 29% v NPF 49%;p=.14), which was most prominent in T2 (NPF 59% v 17%;p=.03). Becoming mismatched when matched preoperatively was associated with 11x likelihood of not achieving MCID for ODI in those with prior fusion (OR 11.928[1.081-131.614];p=0.043).

Conclusion
Prior lumbar fusion affected rates of matching ideal spinal morphological targets for Type 2 who were matched preoperatively, which indicates that significant pelvic retroversion, in the setting of low

PI, was more challenging to identify and correct in revision surgery.

191. A Multicenter Evaluation of Pre and Postoperative Malalignment in Fusions from L4-S1 – How Well Are Spine Surgeons Doing at Hitting Segmental Alignment Targets?

Venu M. Nemani, MD, PhD; Aiyush Bansal, MD; Takeshi Fujii, MD; Jerry Y. Du, MD; Jean-Christophe A. Leveque, MD; Philip K. Louie, MD

Hypothesis
Spine surgeons do not consistently achieve appropriate postoperative alignment using global vs segmental alignment criteria.

Design
Retrospective analysis of a multicenter, multi-surgeon database.

Introduction
Increasing awareness has emerged regarding the need to restore appropriate spinal alignment during spinal fusions at L4-5 and L5-S1 to optimize patient-reported outcomes and reduce the risk of adjacent level degeneration. As most degenerative spine surgeries occur at L4-5 and L5-S1, we focused on patients undergoing spinal fusion surgery at these levels. Our goal was to determine how well surgeons achieved appropriate postoperative alignment using global vs segmental alignment criteria.

Methods
We performed a retrospective analysis of a multicenter, multi-surgeon database of patients who had spinal fusions at either L4-5 alone, L5-S1 alone, or L4-S1. Pre-op and 6-month post-op radiographs were measured using two alignment criteria: Criteria A (global) defined as PI – LL ≤ 10°, and Criteria B (segmental). For L4-5 fusions, segmentally aligned was L4-5 lordosis ≥ 15°; for L5-S1 fusions, segmentally aligned was L5-S1 lordosis ≥ 20°; for L4-S1 fusions, segmentally aligned was L4-S1 lordosis ≥ 35° and L5-S1 lordosis ≥ 20°.

Results
525 cases were analyzed: 282 L4-L5 fusions, 125 L5-S1 fusions, and 125 L4-S1 fusions. There was a significant discordance between the percentage of patients aligned vs. malaligned postoperatively when applying global vs. segmental alignment criteria. For L4-5 fusions, 72% of patients were aligned post-op according to global criteria and 70% were aligned according to segmental criteria (P = 0.58). For L5-S1 fusions, 85% of patients were aligned post-op according to global criteria, whereas only 30% were aligned according to segmental criteria (P < 0.001). For L4-S1 fusions, 74% of patients were aligned post-op according to global criteria, whereas only 31% were aligned according to segmental criteria (P < 0.001).

Conclusion
In a large database of one or two-level spinal fusions from L4-S1, a significant percentage of L5-S1 and L4-S1 fusion patients were deemed aligned postoperatively based on PI-LL global criteria, but malaligned based on segmental criteria. This suggests upper lumbar compensation can hide subtle segmental malalignment after spinal fusion.

192. Sarcopenia Among Elderly Adults with Spinal Deformity Undergoing Correction

Tim Bui, BS; Karan Joseph, BS; Sam Vogl, BS; Miguel Ruiz Cardozo, MD; *Camilo A. Molina, MD*; Daniel Hafez, MD, PhD; John Ogunlade, DO; Wilson Z. Ray, MD; Jacob Greenberg, BS

Hypothesis
Patients undergoing deformity correction, and those experiencing complications post-op will have a lower psoas index (PX).

Design
Retrospective Cohort Analysis

Introduction
One of the most common causes of spinal deformity in older populations is degenerative scoliosis. Prior studies have offered general sarcopenia, represented by PX as a predictor of negative outcomes with mixed results. We sought to verify if PX was related to these outcomes, or if further study in spine-specific sarcopenia would be more productive.

Methods
We retrospectively reviewed radiographic and outcome data of 105 thoracolumbar fusion patients over 65 years of age at an academic tertiary care center between 2015 and 2023 with at least 1 year follow-up. Demographic information and postop outcomes were collected. Preop PX was calculated as averaged bilateral surface area of the psoas at L3, via axial imaging, divided by height^2.

Results
Our cohort included 73 females (69.5%). Average cohort age and BMI was 71.1 years and 28.9. 25 patients (24.3%) developed proximal junction kyphosis (PJK), 26 (25%) reported persistent back pain, 11 (10.5%) experienced pseudoarthrosis or rod-fracture (PRF), and 24 (22.9%) underwent reoperation. The average PX among this cohort was 6.14 cm2/m2 (7.18 cm2/m2 for males, p=0.001; 5.74 cm2/m2 for females, p<0.001). Among males, no significant differences in PX were found when comparing patients who did and did not develop the following outcomes: PJK (7.23 non-PJK vs 7.12 PJK, p=0.749),

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surgical reoperation (7.29 no reoperation vs 6.90 reoperation, p=0.564), persistent back pain (7.17 no back pain vs 7.67 back pain, p=0.611), and development of PRF (7.39 no-PRF vs 6.28 PRF, p=0.264). Among females, no significant differences in PX were found when comparing patients who did and did not develop the following outcomes: PJK (5.81 non-PJK vs 5.51 PJK, p=0.686), surgical reoperation (5.73 no reoperation vs 5.77 reoperation, p=0.790), persistent back pain (5.82 no back pain vs 5.50 back pain, p=0.458), and development of PRF (5.75 no-PRF vs 5.65 PRF, p=0.574).

Conclusion

Average PX was different in our data than a healthy cohort of the same age. Global sarcopenia was not shown to be a significant predictor of negative outcomes; while further studies are needed, more attention should be directed to evaluating spinal sarcopenia in spinal deformity.

HARMS SK vs MEANS normative comparison			p-value	Notes
Study population	**HARMS**	**MEANS**		
Population description	**Scheuermann's kyphosis**	**normative sample**		
Cohort name	**preSK**	**MEANS**		
Timepoint	**preoperative**	**baseline**		
Total n	53	53		
Baseline demographics				
Age (years) [mean±SD]	15.9 (±1.8)	28.9 (±6.2)	*<0.00001	
Sex [n,%]			0.742	
Male	36 (67.9%)	20 (37.7%)		
Female	17 (32.1%)	33 (62.3%)		
BMI (kg/m^2) [mean±SD]	26.7 (±7.2)	24.9 (±5.5)	0.395	preSK n=49; MEANS n=38
Radiographic parameters (°) [mean±SD]				
Cervical sagittal angle (CSA; C2-C7)	-18.1 (±10.9)	2.7 (12.3)	*<0.00001	preSK n=19; MEANS n=53
T1 vertebral slope (T1S)	37.7 (±9.2)	22.0 (±6.9)	*<0.00001	preSK n=45; MEANS n=53
Thoracic kyphosis (TK; T1-T12)	74.1 (±12.4)	41.6 (±9.1)	*<0.00001	preSK n=45; MEANS n=53
Distal thoracic kyphosis (dTK; T4-T12)	73.5 (±12.6)	34.7 (±8.1)	*<0.00001	preSK n=48; MEANS n=53
Lumbar lordosis (LL; L1-S1)	-69.6 (±14.5)	-52.8 (±10.8)	*<0.00001	preSK n=49; MEANS n=53
Proximal lumbar lordosis (pLL; L1-L4)	-25.5 (±11.3)	-15.6 (±8.0)	*<0.00001	preSK n=49; MEANS n=53
Distal lumbar lordosis (dLL; L4-S1)	-44.1 (±10.6)	-37.1 (±6.4)	*0.0002	preSK n=49; MEANS n=53
Pelvic incidence (PI)	40.2 (±11.6)	41.8 (±9.9)	0.366	preSK n=53; MEANS n=53
Pelvic tilt (PT)	6.7 (±7.3)	6.3 (±6.3)	0.587	preSK n=53; MEANS n=53
Sacral slope (SS)	33.4 (±9.6)	35.4 (±8.3)	0.220	preSK n=53; MEANS n=53
Cohort name	**postSK**	**MEANS**		
Timepoint	**2-year postoperative**	**baseline**		
Total n	53	53		
Baseline demographics				
Age (years) [mean±SD]	18.5 (±1.8)	28.9 (±6.2)	*<0.00001	
BMI (kg/m^2) [mean±SD]	27.4 (±7.5)	24.9 (±5.5)	0.167	postSK n=44; MEANS n=38
Radiographic parameters (°) [mean±SD]				
Cervical sagittal angle (CSA; C2-C7)	-8.0 (±16.3)	2.7 (12.3)	*0.0009	postSK n=21; MEANS n=53
T1 vertebral slope (T1S)	34.1 (±9.9)	22.0 (±6.9)	*<0.00001	postSK n=45; MEANS n=53
Thoracic kyphosis (TK; T1-T12)	56.5 (±13.5)	41.6 (±9.1)	*<0.00001	postSK n=45; MEANS n=53
Distal thoracic kyphosis (dTK; T4-T12)	44.4 (±11.4)	34.7 (±8.1)	*<0.00001	postSK n=48; MEANS n=53
Lumbar lordosis (LL; L1-S1)	-53.3(±13.5)	-52.8 (±10.8)	0.930	postSK n=48; MEANS n=53
Proximal lumbar lordosis (pLL; L1-L4)	-16.6 (±10.6)	-15.6 (±8.0)	0.603	postSK n=48; MEANS n=53
Distal lumbar lordosis (dLL; L4-S1)	-36.7 (±10.0)	-37.1 (±6.4)	0.780	postSK n=48; MEANS n=53
Pelvic incidence (PI)	43.2 (±11.0)	41.8 (±9.9)	0.578	postSK n=53; MEANS n=53
Pelvic tilt (PT)	7.9 (±7.7)	6.3 (±6.3)	0.189	postSK n=53; MEANS n=53
Sacral slope (SS)	35.5 (±10.0)	35.4 (±8.3)	0.884	postSK n=53; MEANS n=53

Boxplots of Psoas Index by Outcome (female top, male below)

193. Early Onset Scoliosis Questionnaire (EOSQ-24) Variation Amongst Parents/Caregivers

Alastair W. Sterns, BS; Tishya Wren, PhD; Tiffany N. Phan; Michael J. Heffernan, MD; Tyler A. Tetreault, MD; Brandon A. Ramo, MD; Pediatric Spine Study Group; *Lindsay M. Andras, MD*

Hypothesis

Significant variability will be encountered in answers provided by different caregivers on the EOSQ-24 completed at the same timepoint.

Design

Prospective Cohort Study

Introduction

The EOSQ-24 is a validated questionnaire that measures health-related quality of life for patients with early-onset scoliosis(EOS), as well as evaluate the impact of treatment on patients and their families. This study aims to evaluate variability in caregivers' responses to the EOSQ-24.

Methods

Included were EOS patients with two caregivers, each of whom was administered the EOSQ-24 and asked to respond independently. If one caregiver was unavailable during the patient's visit, the questionnaire was requested electronically. If the caregivers completed the study more than 4 weeks apart, it was excluded. Differences between caregiver responses were examined.

Results

Two caregivers of 87 patients both completed the EOSQ-24. 73 respondents identified as mother, 69 as father, and 32 as other. The mean difference between caregivers for standardized total EOSQ scores was 7.5 points (range: 0 – 38.6) on a 100-point scale. 26.4% (23/87) of caregivers had a difference of >10 points. Fathers gave slightly higher scores than mothers, and the difference was significant (mean 74.1 vs. 71.6, p=0.03). The subdomain with the highest mean difference was Daily Living with a difference of 15.7. The subdomain with the lowest mean difference was Parental Impact with a difference of 10.5 (Table 1). At the time the survey was administered, the patients were being treated as follows: 18 patients (20.7%) with magnetically controlled growing rods (MCGR), 20 patients (23.0%) with bracing, 12 patients (13.8%) with fusion, 11 patients (12.6%) with elongation derotation flexion (EDF) casting, 5 patients (5.7%) with HALO, and 19 (21.8%) patients with monitoring/observation alone. Those treated with MCGR's had mean EOSQ scores nearly 6.3 points higher than those who had not had instrumentation (77.7 vs 71.4, p=0.16). Notably, 40% (35/87) of patients had a caregiver response with a difference greater than 7 points.

Conclusion

While EOSQ provides important insight into the impact of EOS, there is often variability between caregiver-responses. Nearly half of patients had a greater difference in caregiver response than was found between treatment types. The difference between caregivers completing surveys is a factor that warrants consideration when interpreting EOSQ results.

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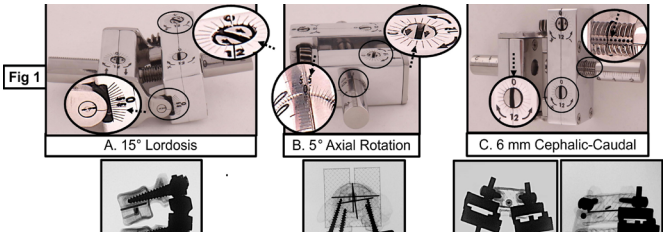

Table 1

194. Cobalt-chrome Multidirectional Slide Growing-rod versus Traditional Growing Rods: Better Cobb Angle Correction and Less Surgeries.

You Du, MD; Jianguo Zhang, MD

Hypothesis
Cobalt-chrome Multidirectional Slide Growing-rod has the ability to correct the scoliosis and preserve the growth potential of the spine with less surgeries.

Design
Retrospective Study

Introduction
Cobalt-chrome multidirectional slide growing-rod(CMSG) is an emerging growth guidance system, which is modified based on the traditional Shilla technique: The cobalt-chrome rods were used, and the interface of the sliding part of the rods and screws were polished, in order to avoid the metal debris and reduce fraction force. A buttress were used between the fixed screws and sliding screws in concave side, to maintain the concave distraction force.

Methods
Between 2004 and 2019, a retrospective study of EOS patients underwent CMSG and TDGR was conducted in in two center in China. Patients were divided into 2 groups according to the different treatment approaches: the CMSG group and the TDGR group. Demographic information, radiographic parameters, complications and revisions were compared among three groups.

Results
Sixty-four EOS patients were enrolled: 15 in the CMSG group and 49 in the TDGR group. Average follow-up was similar between groups (CMSG, 5.0 years; TDGR, 6.1 years; p 0.114). Average Cobb angle improvement of index surgery was 45.0°(range, 69.8 to 24.9) in the CMSG group versus 32.8° (range, 61.9° to 29.1°) in the TDGR group (p < 0.001). Average Cobb angle improvement pre-operatively to latest follow-up was 41.5°(range, 69.8 to 28.3) in the CMSG group versus 31.8° (range, 61.9° to 30°) in the TDGR group (p 0.042). T1-T12 length increased 5.4cm in patients treated with CMSG, compared with 5.3cm in TDGR patients (p 0.959). At latest follow-up T1-T12 length reached 21.6cm in CMSG group and 20.7cm in TDGR group. CMSG patients had fewer surgeries (1.3) than patients in the TDGR group (6.9) (p < 0.001) and similar rate of unplanned surgeries for complications (CMSG, 0.40; TDGR, 0.42; p 0.846). The overall complication rate were comparable between groups (CMSG, 0.73; GR, 0.82; p 0.673). The main complication of the CMSG were screws loosening, due to the irregular follow-up and untimely replace the rods.

Conclusion
CMSG demonstrates powerful ability on scoliosis correction while preserving spinal growth potential. Compared to TDGR, CMSG exhibits stronger correction with less surgeries, and does not increase the incidence of complications, although spinal growth rate is lower.

Logistics regression model to discern effect of CS:EBL on development of pulmonary embolisms in the early postoperative period

Characteristic	Unadjusted Regression [OR (95% CI)]	p-value	Adjusted Regression [OR (95% CI)]	p-value
Age	1.06 (0.99 – 1.13)	0.0968	1.01 (0.96 – 1.05)	0.7819
EBL	1.00 (1.00 – 1.00)	0.4761	1.00 (1.00 – 1.00)	0.9557
CS:EBL ≥ 0.33	7.34 (1.89 – 28.49)	**0.0039**	6.57 (1.75 – 24.66)	**0.0053**
PCO Performed	0.13 (0.03 – 0.49)	**0.0028**	0.32 (0.10 – 1.08)	0.0655
TIV	0.89 (0.74 – 1.08)	0.2298	1.00 (0.86 – 1.17)	0.9461
Colloids Transfused	1.00 (1.00 – 1.00)	0.7967	1.00 (1.00 – 1.00)	0.9687
PRBC Units Transfused	1.12 (0.86 – 1.46)	0.3862	1.39 (0.93 – 2.08)	0.1100
Platelet Units Transfused	1.11 (0.53 – 2.35)	0.7802	1.18 (0.55 – 2.53)	0.6799
FFP Units Transfused	0.90 (0.53 – 1.54)	0.7123	0.75 (0.55 – 2.53)	0.2989
Δ Max Coronal Cobb	1.13 (1.05 – 1.22)	**0.0018**	1.04 (1.00 – 1.09)	0.0658

AUC=0.92, Model p=0.0031, Hosmer and Lemeshow Goodness-of-Fit Test p-value = 0.7264

CMSG

195. Optimizing Modifiable Health Conditions Prior to Adult Cervical Deformity Surgery Associated with Fewer Complications

Anthony Yung, MMSc; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Alexander Parsons, MD, MSc; Ankita Das, BS; Aleksandra Qilleri, BS; Caroline Wu, MD; Iryna Ivasyk, MD, PhD; Isabel Prado, MD, MS; Matthew Galetta, MD; Nathan Lorentz, MD; Ethan Cottrill, MS; Khoi D. Than, MD; Pawel Jankowski, MD; *Peter G. Passias, MD*

Hypothesis
To determine the effects of optimizing modifiable health conditions on periop and postop outcomes in cervical deformity patients

Design
Retrospective

Introduction
While benefits to surgical outcomes from optimizing comorbidities prior to surgical adult cervical deformity correction (ACD) is hypothesized, this has not yet been studied

Methods
ACD patients 2-year data included. Preoperative optimization for osteoporosis assessed by treatment

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with an FDA approved drug prior to surgery. Patients divided into 2 groups: those who had preoperative rehabilitation [Prehab] and those who did not [no Prehab]. Prehab consisted of cognitive behavioral therapy and physical therapy with core, paraspinal and leg strengthening. Nutritional status assessed by ranking patients into quartiles (Q1-Q4) by baseline BMI. Q1 (low BMI) and Q4 (high BMI) were considered not optimized. Patients stratified by optimization in all three groups (Opt) or non-optimized. ANCOVA and logistic regression analyses assessed outcomes while accounting for surgical and demographic differences between groups.

Results

347 patients (age 57.9±12.1 years, 48% female, 29.0±6.82 kg/m2) included. Optimized patients were significantly less female (43% vs. 52%, p=.038) and had fewer levels fused (4.14±3.50 vs. 5.21±4.15, p=.002), shorter length of stay (3.96±3.94 vs. 5.12±8.18 days, p=.044), less operative time (261.9±166.6 vs. 315.8±189.7 mins, p=.002), and lower EBL (502.8±950.6 vs. 679.0±965.5 mL, p=.039). Optimized patients trended towards being younger (p=.199) and having fewer osteotomies (p=.314) but this was not significant. When comparing means for perioperative outcomes and cost, optimized patients experienced fewer minor complications (9.12% vs. 16.5%, p=.010. However, optimized patients were similar to not optimized patients when comparing mean rate of reoperations and reaching MCID for mJOA at 2 years (all p>.05). A stepwise regression model was significant higher odds of reaching MCID for NDI for optimized patients when controlling for gender, levels fused, operative time, and EBL (OR: 1.406 [1.169-1.691], p<.001. Optimized patients had lower odds of overall complications at 2 years (OR:.45 [1.02, 1.89], p=.009) with lower rates of DJK and DJF development (p<.05).

Conclusion

Patients undergoing corrective cervical deformity surgery benefit from preoperative optimization, emphasizing its importance in surgical planning

196. Preoperative Optimization of Modifiable Patient-Related Factors Reduces the Risk of Distal Junctional Kyphosis (DJK): A Virtual Analysis of a Novel Multicenter Complex Adult Cervical Deformity Database

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Hypothesis

Modifiable baseline patient-related factors may predicting increased virtual risk of DJK after complex ACD surgery.

Design

Multicenter Retrospective

Introduction

Potentially modifiable patient-related factors have not been well studied in complex adult cervical deformity (ACD) surgery, especially in the context of distal junctional kyphosis (DJK).

Methods

Complex ACD patients with baseline (BL) data were included, excluding those indicated for DJK revision surgery. Virtual risk of DJK was assessed per Passias et al. BL-only factors: 1) prior diagnosis of diabetes, hypertension, or depression 2) presence of BL neurological impairment 3) BL C2-T3 angle >31º). Pre-operative data correlating to a virtual risk was assessed via backstep logistic regression. CIT determined thresholds for significant factors. A score based on number of optimized variables was created, with CIT determining threshold associated with DJK risk. Means comparison assessed groups differences in BL patient-reported outcomes and frailty [Edmonton, Adult Cervical Frailty Index (ACFI)] in patients considered Optimized (Opt) vs not optimized (nOpt).

Results

52 ACD patients were included (mean age: 60.4±15.4, sex: 68.8% female, BMI: 27.5±5.8, CCI: 0.95± 1.4). Based upon Passias et al. criteria, 30.8% of patients were predicted to suffer DJK by 2Y post-operatively. Logistic regression revealed significant modifiable demographic, nutritional and metabolic factors predictive of DJK were: BMI <18.5 or >30, bone health per total spine DEXA T-score < 1.1, HgA1C > 7.0%, ESR > 15.7 mm/hr, INR > 0.9, Albumin > 4.2 g/dL, Hematocrit > 41.7% (model p=.010). CIT analysis revealed that optimization of a minimum of 3 variables was associated was protective against development of

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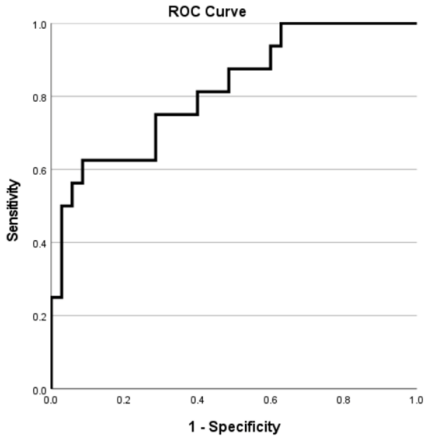
DJK [.727 (.591-.895), p=.003]. Of the total cohort, 73.1% were considered Opt.

Conclusion

Through virtual risk analysis, the present study demonstrates that empiric and potentially modifiable metabolic and nutritional factors, as well as pre-operative bone health, are significantly associated with predicted risk of distal junctional kyphosis by 2Y. As such, surgeons should consider reduction of >3 risk factors pre-operatively to expedite recovery, enhance peri-operative course, and reduce complications in complex adult cervical deformity patients.

Figure/Table (Max 1): JPEG

Fig 1. ROC Curve of Virtual DJK Risk Prediction



Area Under the Curve

Test Result Variable(s): Predicted probability

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.816	.065	.000	.689	.943

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

197. Optimizing Mental Health Conditions Prior to Adult Cervical Deformity Surgery: Does Preoperative Optimization Improve Surgical Outcomes? §

Anthony Yung, MMSc; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Oliver Menken, BS; Caroline Wu, MD; Alexander Parsons, MD, MSc; Isabel Prado, MD, MS; Iryna Ivasyk, MD, PhD; Nathan Lorentz, MD; Matthew Galetta, MD; Ethan Cottrill, MS; Khoi D. Than, MD; *Peter G. Passias, MD*

Hypothesis

To determine the long-term effectiveness of brief psychological intervention on psychological outcomes in cervical spine surgery.

Design

Prospective, blinded

Introduction

More studies ared needed to address CBT's impact on postoperative outcomes in cervical deformity correction

Methods

Patients administered 4 instruments: Distress and Risk Assessment Method (DRAM), Fear-Avoidance Beliefs Questionnaire (FABQ), Pain Catastrophizing Scale (PCS), Outcome Expectation question (OEQ). Patients randomized using matched pairs: Sham (placebo educational group receiving six sham treatments then surgery); CBT (treatment by licensed professional prior to surgery). Thresholds were set >17 DRAM, >49/66 FABQ, >30/52 PCS. Subjects who did not meet cutoff were assigned into control group. Those who are above any thresholds placed into either the Sham or CBT group based on a 1:1 randomization. Any who exceeded psychological distress criteria were assigned to DRAM observation only group

Results

48 patients enrolled (53.6yrs±10.7yrs, 49% female, 29.6±5.9kg/m2), and underwent surgical correction (levels fused 2.2±1.5, EBL: 111mL, operative time: 177min). At baseline, mean PCS was 27.4 and mean FABQ was 40. 57.1% of patients had a severe FABQ score, 40.8% had a severe PCS score, and 27.7% had a severe NDI score. By randomization group: 17 (35.4%) CBT, 12 (25.0%) Sham, 10 (20.8%) Control, and 9 (18.8%) DRAM. 33 patients (68.8%) completed 2Y follow-up. Overall, the greatest number of patients improved from baseline to 2Y within the CBT group according to NRS Back score (63% vs. 38%, p=0.014). Compared to CBT, those without intervention in the DRAM and Control groups had greater levels of psychological distress measured by FABQ (44 vs 14.3, p<.001). Similarly, without intervention had higher odds of reoperation (50% vs. 28%, OR:1.23, p=0.03), and DJK (69% vs. 45%, OR 1.44, p=0.012). Those optimized with CBT therapy preoperatively had comparatively lower NDI scores and lower EQ5D Pain scores at baseline (p<.05). Additionally, patients in the CBT group trended toward a higher rate of improvement in PCS (56% vs. 41%, p=0.058), VAS (63% vs. 38%, p=0.064), and NRS Back (56% vs. 38%, p=0.13)

Conclusion

We found clear trends in our cohort of operative cervical spine patients with improved psychological and functional outcomes after preoperative CBT intervention.

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E-POINT PRESENTATION ABSTRACTS

198. What Drives Cost during Adult Cervical Deformity Surgery?: Identifying High Cost Surgical Components and their Effect on Outcomes

Anthony Yung, MMSc; Max R. Fisher, MD; Ankita Das, BS; Oluwatobi O. Onafowokan, MBBS, MS; Iryna Ivasyk, MD, PhD; Isabel Prado, MD, MS; Caroline Wu, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Oliver Menken, BS; Ethan Cottrill, MS; Pawel Jankowski, MD; Khoi D. Than, MD; *Peter G. Passias, MD*

Hypothesis
To define which high-cost components of ACD surgery drive positive outcomes

Design
Retrospective

Introduction
Adult cervical deformity (ACD) surgery can carry significant cost burden. It is necessary to further study what high-cost components have greatest utility to patient outcomes

Methods
Operative ACD patients up to 2Y data included. Components: Percutaneous screws, robotics with nav, DJK prophylaxis, BMP, approach (Anterior, Posterior), rods, distal screws, epidural, and kyphoplasty. Component cost was gathered by CMS.gov and published item rates, then totaled based on surgical technique. Utility data was calculated using ODI converted to SF-6D using published conversion methods. QALYs utilized a 3% discount rate to account for decline to life expectancy (78.7 years)

Results
131 were included (56.5yrs, 72%F, BMI: 29.5kg/m2, CCI: 1.8). Greatest cost came from DJK prophylaxis ($34,189) and from BMP ($53,023), both p<.05. 21.2% (28) had robotic assistance, 28.6% (38) had BMP (1% small, 4% medium, 59% large). BMP cost differs by kit: small - 4.2 mg ($21,800), medium – 8.4 mg ($23,667), large – 12 mg ($25,617). Mean cost without robotics was higher ($18,666 Non-Robotic vs. $27,189 Robotic), equating to superior cost utility for robotics ($48,647 Non-Robotic vs. $66,858 Robotic, p<.05). Cost was greater for BMP vs without (BMP $53,023 vs Non-BMP $41,145, p<.05), with no significant difference in utility ($80,337 BMP vs $85,718 non-BMP, p=.076). Patients without DJK prophylaxis had lower cost at index, but lower cost utility at 2 years ($59,600 Non-Prophylaxis vs $45,099 Prophylaxis, p<0.001). For approach, mean cost was lower for posterior ($1,836.90 P vs $2,367.75 A, p=.072). Kyphoplasty had average cost of $13,100 and provided significantly lower cost utility with increasing levels ($23,135.75 vs $28,871.89, p=.043). Percutaneous screws (mean cost $878), rods ($258), distal screws ($282), and epidural ($980) had no significant difference in utility. Overall, greatest utility was found in BMP, robotic assistance, and DJK prophylaxis, with approaches through posterior offering higher cost benefit.

Conclusion
Certain surgical components, such as BMP, robotics, and DJK prophylaxis, improve postoperative risk and cost utility despite increase in total cost. Thus, higher cost surgeries can result in better clinical, radiographic, and patient reported outcomes

199. Impact of Increased Component Utilization in Adult Cervical Deformity Surgery: Identifying Differences in Outcomes based on Cost Utility of Individual Surgical Components

Anthony Yung, MMSc; Max R. Fisher, MD; Oluwatobi O. Onafowokan, MBBS, MS; Nathan Lorentz, MD; Matthew Galetta, MD; Isabel Prado, MD, MS; Iryna Ivasyk, MD, PhD; Caroline Wu, MD; Alexander Parsons, MD, MSc; Ethan Cottrill, MS; Khoi D. Than, MD; *Peter G. Passias, MD*

Hypothesis
To define increased components utilizers of corrective adult cervical deformity surgery and its influence on positive surgical outcomes

Design
Retrospective

Introduction
With increasing focus on value-based healthcare, it is necessary to further study whether high cost component utilizers influence patient outcomes

Methods
Components included: Interbody fusion, percutaneous screws, robotic equipment with navigation, DJK prophylaxis, BMP usage, approach (Anterior, Posterior, Combined), number of rods used, distal screws, epidural, and kyphoplasty. Cost for each component was gathered by published item rates, then totaled based on surgical technique. Utility data was calculated using NDI converted to SF-6D. QALYs utilized a 3% discount rate to account for decline to life expectancy (78.7 years). Cohort was ranked into 3 groups by component usage and total cost: Low, Middle, and High. Multivariate regression (MVA) was used to assess the effect of high cost utilizer (HU) compared to low cost utilizer (LU) on outcomes.

Results
163 were included (60.5yrs, 76%F, BMI: 28.0kg/m2, CCI: 1.8). Once ranked, 56 in HU and 56 LU. Average cost for LU was $53,632 vs. $99,273 in HU, p<.001. Within HU, greatest cost came from DJK prophylaxis ($34,189) and from BMP ($53,023), both p<.05. HU had a higher mean BMI and was more often male

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(both p<.001). HU had a significantly higher CCI than patients in LU (4.4 vs. 3.1, p=.019). HU was more deformed at baseline by radiographics: cSVA (69.6 vs. 52.9), C2-C7 (18.4 vs. 12.3), TS-CL (25.3 vs. 22.0, all p<.001). LU had significantly longer length of stay (8.7 vs 6.1, p=.01), with lower rates of SICU (OR: 0.293 [0.091, 0.938], p=.039) and higher baseline frailty scores (4.2 vs. 2.9, p=.02). HU patients had significantly lower EBL (914mL vs. 1197mL, p=.02) and were 32.3% less likely to undergo reoperation (OR: 0.677, [0.487, 0.942], p=.02). HU patients were 66.3% more likely to reach MCID in NRS Back (OR: 1.663, [1.273, 2.173], p<.001) and had overall improved NRS Neck and EQ5D scores by 2 years (all p<.05).

Conclusion
Patients in the highest tertile for surgical cost had superior patient reported outcomes. This data suggest that greater utilization of surgical components during intraoperative period can result in long term improvements to clinical, radiographic, and patient reported outcome.

200. History of Primary Fragility Fracture Predicts Adverse Postoperative Complications and Revision in Patients Undergoing Short-Segment Lumbar Fusion for Degenerative Lumbar Disease

Rachel Baum, BA; *Neil V. Shah, MD, MS*; Chibuokem P. Ikwuazom, MD; Juhayer Alam, BS; David Kim, MD; Chadi Tannoury, MD; Tony Tannoury, MD; Jad Bou Monsef, MD; Bassel G. Diebo, MD; Carl B. Paulino, MD

Hypothesis
History of fragility fracture(s) (FFx) is associated with increased postoperative complications following short-segment fusion for degenerative lumbar disease (DLD).

Design
Retrospective multicenter cohort study

Introduction
A history of FFX can be indicative of reduced bone density and metabolic bone disorders, such as osteoporosis, which can influence complications following short-segment lumbar fusion in patients with DLD. This relationship remains inadequately understood. We aimed to investigate the association between a history of FFX and occurrence of adverse postoperative outcomes in patients undergoing short-segment posterior lumbar fusion (≤3-level).

Methods
The Mariner10 PearlDiver database was queried to identify pts aged ≥50Y who underwent ≤3-level posterior spinal fusion (PSF) for DLD from 2010-2022. Pts with a hx of primary FFX (hip, proximal humerus, distal radius, vertebral body, and pelvis) were further stratified. Cases w/ surg indics for trauma, infection, and tumor were excluded. Univariate and multivariate analyses were conducted to assess risk of postoperative medical (90D and 1Y) and surgical complications (6mos and 1Y) controlling for age, sex, CCI, and obesity.

Results
Among the 828,332 DLD pts who underwent short-segment PSF, 6.5% (n=53,477) had prior FFX hx. A baseline history of FFx was associated with increased 1Y odds of all med complics (OR=1.82) and indiv complics, including surgical infection (OR=1.99), blood transfusion (OR=1.88), DVT (OR=1.81), PE (OR=1.72), and pneumonia (OR=1.92), all p<0.001. FFx history also predicted higher 1Y odds of all surgical complics (OR=1.38), as well as peri-implant fracture (OR=5.14), revision/extension (OR=3.78), pseudarthrosis (OR=3.28), implant loosening (OR=2.68), I&D and explantation (OR=2.11), and decompressive laminectomy (OR=1.40), all p<0.001 (Table).

Conclusion
Patients with a history of primary FFX were at significantly higher odds of incurring both both medical and surgical complications following short-segment lumbar fusion for DLD. A history of FFX identified during preoperative screening may assist in improving optimization and risk stratification for such patients to potentially improve outcomes in patients planned for short-segment fusion for DLD.

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E-POINT PRESENTATION ABSTRACTS

Complications post-LF	Odds Ratio	P-value
Surgical Infection		
90 days	2.62 [2.17-3.13]	<0.001
1 year	1.99 [1.82-2.16]	<0.001
Wound Disruption		
90 days	2.24 [1.98-2.51]	<0.001
1 year	2.06 [1.88-2.24]	<0.001
Blood Transfusion		
90 days	2.14 [1.96-2.33]	<0.001
1 year	1.88 [1.76-2.00]	<0.001
DVT		
90 days	1.95 [1.83-2.08]	<0.001
1 year	1.81 [1.73-1.90]	<0.001
PE		
90 days	1.81 [1.68-1.95]	<0.001
1 year	1.72 [1.62-1.82]	<0.001
Pneumonia		
90 days	2.09 [2.01-2.17]	<0.001
1 year	1.92 [1.87-1.98]	<0.001
Acute Kidney Failure		
90 days	1.87 [1.79-1.94]	<0.001
1 year	1.74 [1.69-1.80]	<0.001
Respiratory Failure		
90 days	2.26 [2.16-2.37]	<0.001
1 year	2.09 [2.02-2.16]	<0.001
Myocardial Infarct		
90 days	1.66 [1.54-1.79]	<0.001
1 year	1.63 [1.55-1.72]	<0.001
Cerebrovascular Infarction		
90 days	1.63 [1.54-1.72]	<0.001
1 year	1.53 [1.47-1.59]	<0.001
Irrigation & Debridement Explantation		
6 months	2.09 [1.83-2.39]	<0.001
1 year	2.11 [1.88-2.36]	<0.001
Posterior Revision/Extension		
6 months	3.78 [3.00-4.71]	<0.001
1 year	3.78 [3.06-4.64]	<0.001
Decompressive Laminectomy		
6 months	1.39 [1.33-1.46]	<0.001
1 year	1.40 [1.33-1.46]	<0.001
Loosening of Implant		
6 months	2.80 [2.24-3.46]	<0.001
1 year	2.68 [2.23-3.21]	<0.001
Pseudarthrosis		
6 months	3.27 [2.79-3.81]	<0.001
1 year	3.28 [2.86-3.74]	<0.001
Peri-implant Fracture		
6 months	6.62 [4.75-9.16]	<0.001
1 year	5.14 [3.90-6.74]	<0.001
All Medical Complications	1.82 [1.78-1.85]	<0.001
All Surgical Complications	1.38 [1.32-1.44]	<0.001

Table 1. Odds Ratios for Complications following lumbar fusion (LF), Multivariable analyses.

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EXHIBIT HALL FLOOR PLAN

We encourage you to visit the exhibits throughout the meeting to learn more about the technological advances.

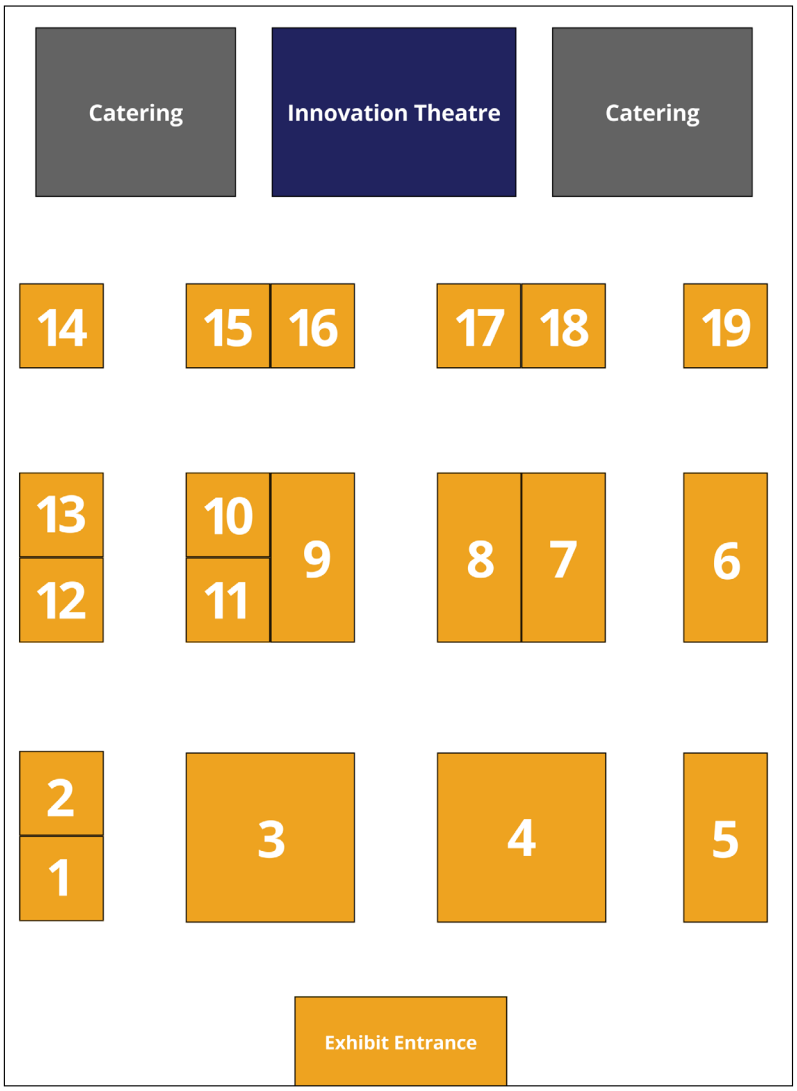
The IMAST Exhibit Hall is located in Hall 2 in the Scottish Event Campus (SEC).

Exhibit Hall Hours:

Wednesday, April 2 18:00 - 20:00 *(Welcome Reception 18:00 - 20:00)*
Thursday, April 3 09:00 - 17:30
Friday, April 4 08:30 - 16:00

VISIT THE SRS MEMBERSHIP BOOTH

Stop by the SRS Booth (#13) in the Exhibit Hall for information about becoming an SRS member, upcoming meetings, and more.



BOOTH #	COMPANY
1	Isto Biologics
2	Silony Spine Corp
3	Medtronic
4	Globus Medical
5	Johnson & Johnson MedTech
6	Orthofix
7	Highridge Medical
8	ATEC Spine
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19	MRIguidance

EXHIBITOR DESCRIPTIONS

ISTO BIOLOGICS | BOOTH #1

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Established in 2013 by the internationally renowned Schoen Clinic hospital group, Silony Spine is a market disrupter aiming to change the status quo of how product manufacturers partner with hospital systems. Silony Spine curates and designs spinal hardware and tools that provide surgeons and hospitals with high-value product solutions that are highly compatible with enabling technologies.

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We lead global healthcare technology, boldly attacking the most challenging problems. Our Mission — to alleviate pain, restore health, and extend life — unites a global team of 90,000+ people, and our technologies transform the lives of two people every second, every hour, every day. Expect more from us. Medtronic. Engineering the extraordinary.

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Globus Medical, Inc. is a leading musculoskeletal technology company based in Audubon, PA. The company was founded in 2003 by an experienced group of engineers and business leaders who believed that significantly better patient outcomes in spine surgery were possible. Today Globus Medical is committed to creating products that enable surgeons to promote healing in patients with musculoskeletal disorders. At Globus Medical, listening to customers and responding with action is paramount, and the company is relentlessly focused on solving unmet customer and patient needs with world class engineering and technology.

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ORTHOFIX | BOOTH #6

Orthofix is a global medical technology company headquartered in Lewisville, Texas. By providing medical technologies that heal musculoskeletal pathologies, we deliver exceptional experiences and life-changing solutions to patients around the world. Orthofix offers a comprehensive portfolio of spinal hardware, bone growth therapies, specialized orthopedic solutions, biologics and enabling technologies, including the 7D FLASH™ Navigation System. To learn more, visit Orthofix.com and follow Orthofix on LinkedIn.

HIGHRIDGE MEDICAL | BOOTH #7

Highridge Medical is proud to be a Triple Diamond Sponsor of SRS in 2025 as this marks our continued and expanding support of this wonderful society and its members. We are driven by our dedication to restoring daily life for patients through comprehensive spinal solutions with a focus on education, training, and clinical support for surgeons. With both vertebral body tethering and spinal fusion solutions, Highridge is eager to meet you at IMAST.

EXHIBITOR DESCRIPTIONS

ATEC SPINE | BOOTH #8

ATEC is a medical device company dedicated to revolutionizing the approach to spine surgery through innovation. ATEC's Organic Innovation Machine™ is the greatest concentration of spine knowhow in the industry and committed to the creation of clinical distinction. Leveraging 100% spine focus and expertise, we seek to improve spine surgery by rethinking, redesigning and seamlessly integrating the technologies required from the ground up. The innovation that results from that process is being rapidly adopted because, like us, spine surgeons covet informatic and procedural sophistication that enables more predictable, more reproducible care. Our vision is to be the standard bearer in spine. Visit our website for more information: www.atecspine.com

STRYKER | BOOTH #9

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RIWOspine - advanced product solutions for minimally invasive spine procedure.

TRIA SPINE | BOOTH #11

Tria Spine®, founded in 2009, is a Turkish company, specialising in the production of spine implants. More than 25 years of experience in the design, manufacture and supply of spinal implants are brought together.

The main goal of Tria Spine® is to provide quality with sustainability and user-friendly solutions to our surgeons, patients and global partners with an excellent R&D process and professional teams in spine surgery.

Tria Spine® serves nearly 30 countries globaly with a growing penetration quickly. Tria Spine® and its products have MDR Confirmation and ISO 13485:2016 international certificates. More over to international certificates, Tria Spine® has its own patents, including US approval for the design and mechanisms of the products.

As Tria Spine®, our primary priority is to ensure the satisfaction of our doctors and the health of our patients by producing high quality products.
As one of those who always create, develop and use advanced technologies, we focus on providing our doctors with the best products based on simplicity, creativity and quality.

As Tria Spine we are honored to mention that we are one of three manufacturer of Vertebral Body Tethering System worldwide.

At Tria Spine® WE SERVE LIFE.

CARLSMED INC. | BOOTH #12

Carlsmed is a high-growth medical technology leader and pioneer in the personalized spine surgery market. The company is transforming spine surgery to improve outcomes and decrease the cost of healthcare for spine surgery and beyond. Carlsmed's mission is to revolutionize the standard of care in spine surgery by providing cutting-edge solutions tailored to the unique needs of each patient. The Company's innovative aprevo® Technology Platform combines proprietary AI-driven software is an end-to-end integrated platform with patient-specific fusion devices designed for better surgical results, reduced revisions and improved long-term outcomes. aprevo® empowers surgeons to personalize procedures to align with their unique preferences while addressing each patient's individual needs. The platform supports a broad spectrum of surgical techniques, offering precision solutions for anterior, posterior, and lateral approaches.

EXHIBITS & WORKSHOPS

SRS MEMBERSHIP | BOOTH #13

Stop by for information about becoming an SRS member, upcoming meetings, and more.

E-POINT PRESENTATION KIOSKS | BOOTH #14

Visit the E-Point Kiosk located in Hall 2, Booth #14 to view all E-Point presentations.

MOMENTUM HEALTH | BOOTH #15

Momentum Health – Advancing AI-Powered 3D Imaging for Spine Care

Momentum Health is transforming spine care with Momentum Spine, the first FDA-cleared AI-powered mobile 3D imaging and monitoring platform for spine deformity. By leveraging computer vision and AI, our technology creates true-to-scale 3D models from a simple 45-second smartphone video, providing radiation-free, objective assessment of spinal alignment, disease progression, and functional mobility. Momentum Health is a proud partner of the Harms Study Group, collaborating on research to advance innovation in spine deformity care.

Pediatrics: Remote Scoliosis Monitoring
Momentum Spine enables radiation-free, continuous monitoring of scoliosis progression, improving early detection and brace adherence. The platform provides AI-predicted Cobb Angle measurements from surface topography, allowing clinicians to track progression over time. Integrated brace sensors enhance treatment by tracking brace compliance in real time, supporting non-operative management. Patients and families gain insights through an engaging, mobile-first experience, reducing reliance on frequent X-rays while enabling remote, data-driven care.

Adults: Objectively Quantifying Functional Status and Outcomes
For adult spine deformity, preoperative and postoperative assessments are critical to optimizing patient outcomes. Momentum Spine provides dynamic, functional insights by capturing gait, balance, and postural changes over time. The whole-body 3D model offers objective measurement of alignment and aesthetics, supporting surgical planning, risk stratification, and long-term monitoring. By integrating wearables and passive activity tracking, the platform enables continuous mobility assessment, allowing clinicians to optimize treatment and detect complications early.

Momentum Spine is trusted by leading spine centers, bringing hospital-grade assessments to any clinical setting—without radiation or specialized equipment.

B.BRAUN | BOOTH #16

As one of the world's leading medical technology companies, B. Braun protects and improves the health of people around the world. For over 180 years, the family-owned company has been accelerating progress in health care with pioneering spirit and groundbreaking contributions. This innovative strength continues to be the foundation of B. Braun's success today—always with the goal of improving clinical outcomes, cost of care and patient benefits.

More than 65,000 employees live Sharing Expertise worldwide, they make B. Braun a true partner that develops smart solutions and sets new standards. By linking products, services and consulting, the company improves treatment processes and supports medical staff. In doing so, B. Braun always acts with future generations in mind, which is why responsibility for sustainable growth is embedded into all business processes. In 2022, the B. Braun Group generated sales of € 8.5 billion.

SI-BONE | BOOTH #17

SI-BONE, Inc. is a global leading medical device company specializing in Sacropelvic Solutions™. SI-BONE utilizes its iFuse Technology® to develop products to treat SI joint dysfunction, spinopelvic fixation, and pelvic trauma. The iFuse Implant System®, a proprietary minimally invasive surgical implant system to fuse the sacroiliac joint, was launched in 2009 to treat sacroiliac joint dysfunction. The iFuse Implant System portfolio has expanded to include iFuse Bedrock Granite® to provide a solid foundation in spinal deformity surgery, and iFuse TORQ® for treatment of pelvic trauma including sacral fragility and insufficiency fractures.

With more than 100,000 procedures worldwide performed by 3,600+ surgeons, and 160+ publications, iFuse is the leading choice in the surgical treatment of sacropelvic disorders.

EXHIBITS & WORKSHOPS

CRESCO SPINE | BOOTH #18

Cresco Spine is a pioneering medical device company, dedicated to revolutionizing the treatment of spinal deformities through innovative dynamic implant solutions to optimize treatment outcomes for patients suffering from scoliosis.

Our current focus is on pediatric and adolescent scoliosis patients, aiming to establish a new treatment standard based on temporary and dynamic implants, designed to cure spinal deformities rather than merely salvage spinal alignment.

Our flagship technology, the Spring Distraction System™ (SDS™), is a proprietary, growth-friendly, dynamic spinal implant designed to continuously and physiologically guide spinal growth while correcting scoliosis three-dimensionally and supporting thoracic development. Unlike conventional growth systems that require repeated surgical or non-surgical abrupt lengthening interventions, SDS™ provides integrated corrective, continuous, dynamic distraction, preserving spinal mobility and promoting normal spinal growth and thoracic expansion. And the good thing is, all this is also possible in the most extreme and complex scoliosis cases.

Supported by extensive clinical evidence, SDS™ outperforms existing systems by providing superior spinal growth, significantly reducing complications and lowering the surgical burden and number in hospital visits throughout the treatment period, while also offering an improved quality of life to these young, unfortunate patients. All these improvements also reduce substantially the health care costs associated with this intensive treatment. Industry recognition highlights Cresco Spine's innovative approach, with the FDA granting Breakthrough Device Designation and Orthopedics This Week awarding SDS™ the Best Technology in Spine Award.

Cresco Spine's mission is to set a new standard in scoliosis care, significantly improving the clinical outcome and quality of life, as well as lowering the burden of disease for these young patients and their parents. For more information, visit www.cresco-spine.com or connect with us on LinkedIn @CrescoSpine.

MRIGUIDANCE | BOOTH #19

MRIguidance is a Dutch MedTech company pioneering radiation-free bone imaging with BoneMRI, the world's first software that generates 3D CT-like visualizations of bone structures from MRI data. By eliminating the need for harmful radiation exposure, BoneMRI enhances diagnostic accuracy and supports more effective treatment planning for medical professionals.

HANDS-ON WORKSHOPS

IMAST delegates are encouraged to attend the Hands-On Workshops (HOWs). Each workshop is programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company. Catering will be served at each Workshop.

Please note: CME credits are not available for Hands-On Workshops.

	Thursday, April 3, 2025	Friday, April 4, 2025
MORNING	**08:00 - 09:00**	
Alsh 1&2	Highridge Medical	
LUNCH	**12:00 - 13:00**	**11:30 - 12:30**
Alsh 1&2	Medtronic	Highridge Medical
Boisdale 1&2	Johnson & Johnson MedTech	Johnson & Johnson MedTech
Carron 1&2	Globus Medical	ATEC Spine

meeting room locations are subject to change

THURSDAY, APRIL 3 | 08:00 - 09:00

HIGHRIDGE MEDICAL

Alsh 1&2

Spinal Alignment: Concepts and Principles

Workshop will highlight core principles for restoring and maintaining spinal alignment. Presenters will share cases and outline their decision-making process with consideration to pelvic incidence, lumbar spine distribution, T4-L1 pelvic alignment, and age-adjusted alignment goals.

Faculty: Han Jo Kim, MD & Venu Nemani, MD

THURSDAY, APRIL 3 | 12:00 - 13:00

MEDTRONIC

Alsh 1&2

Three-Column Osteotomies in adult and pediatric spine surgery: Decisions, challenges, and the impact on new techniques

Join our esteemed faculty, Dr. Lenke, Dr. Samdani, Professor de Kleuver and Professor Pumberger, for a workshop featuring in-depth case discussions on the role of Three-Column Osteotomies in both adult and pediatric spine surgery. We'll tackle the unique challenges of these procedures, review the decision-making process, and examine how emerging technologies and innovative surgical approaches are transforming complex surgeries and enhancing patient outcomes

Faculty: Lawrence Lenke, MD, Amer Samdani, MD, Prof Matthias Pumberger, MD, Prof Marinus de Kleuver, MD, PhD

JOHNSON & JOHNSON MEDTECH

Boisdale 1&2

Next-Gen Spine Surgery: Redefining Enabling Technology | Fireside Chat

Join us for a captivating Fireside Chat where cutting-edge enabling technology meets real-world impact. From groundbreaking advancements to practical adoption. This session will inspire, educate, and spark meaningful conversations that is shaping the future of MedTech.

Faculty: Christopher Ames, MD (Moderator), Safdar Khan, MD, W.G. Stuart Mackenzie, MD

GLOBUS MEDICAL

Carron 1&2

Beyond the Basics: Overcoming challenges in deformity correction surgery with Enabling Technologies

Please join us for an interactive case-based discussion on the advanced applications of enabling technology in adult and pediatric deformity correction surgery.

Faculty: Richard A. Hynes, MD, FACS, Roland S. Kent, MD, Mr. Nicolas Beresford-Cleary, MBChB, BEng, FRCS (Tr and Orth), David L. Skaggs, MD

HANDS-ON WORKSHOPS

FRIDAY, APRIL 4 | 11:30 - 12:30

HIGHRIDGE MEDICAL
Alsh 1&2

VBT: A Decade of Learning and Understanding of Growth Modulation

Initial research identified patients who might not benefit from VBT. Following the FDA's HDE approval in 2019, second-generation data is better patient selection criteria are becoming more refined, offering a greater understanding of growth modulation. Join a panel of surgeons to review the clinical progress of VBT and how current data collection could shape future applications.

Faculty: A. Noelle Larson, MD, Laurel Blakemore, MD, Amer Samdani, MD

JOHNSON & JOHNSON MEDTECH
Boisdale 1&2

Surgical Techniques in Complex Reconstruction for Adults

Dive deep into real-world cases with seasoned thought leaders covering topics on cervicothoracic deformity, coronal deformity, VCR, PSO, and more. Engage in lively discussions and exchange insights on surgical techniques for complex reconstruction in adults.

Faculty: Munish Gupta, MD, MBA (Moderator), Amit Jain, MD, MBA, Alekos Theologis, MD, Eric Klineberg, MD

ATEC SPINE
Carron 1&2

Precision in Correction: Optimizing Procedure Selection with EOS Insight

Join us for an insightful discussion on how EOS Insight leverages AI-driven alignment data and 3D surgical planning to support procedure selection, bridging the gap between planned and achieved correction. Discover how this advanced platform is designed for data collection and continuous improvement in clinical decision-making and patient outcomes.

Faculty: Chris Ames, MD, Robert Eastlack, MD, Han Jo Kim, MD

AUTHOR DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
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Christopher P. Ames, MD	United States	Stryker Spine (g); Biomet Zimmer Spine (g); DePuy Synthes (a, b, g); NuVasive (g); Next Orthosurgical (g); K2M (b, g); Medicrea (b, g); Medtronic (b); Agada Medical (b); Carlsmed (b); Titan Spine (a); ISSG (a, g); Operative Neurosurgery, Neurospine (g); SRS (a); Global Spinal Analytics (g); SRS Safety and Value Committee Chair (g)
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AUTHOR DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Todd J. Albert, MD	United States	DePuy Synthes (g); ZIMMER Biomet (g); JP Medical Publishers (Book Royalties) (g); Thieme Medical Publishers (Book Royalties) (g); Springer (Book Royalties) (g); Elsevier, Inc. (Book Royalties) (g); NuVasive (b); Innovative Surgical Designs, Inc. (c); Care Equity (c); InVivo Therapeutics (c); Spinicity (c); CytoDyn Inc. (c); Paradigm Spine, LLC (c); Strathspey Crown (c); Surg.IO LLC (c); Augmedics (c); Morphogenesis (c); Precision Orthopedics (c); Pulse Equity (c); Physician Recommended Nutriceuticals (c); Back Story LLC (Board of Directors) (e); Socrates Health Solutions (c); Hospital for Special Surgery (Board of Directors) (e); Parvizi Surgical Innovations (PSI) (c); HS2, LLC (c); DermQ (c); See All Surgical (c, e); Spine Stabilization Technologies (c); Socrates Health Solutions (c); Discure Technologies (c); OrthoMond (c); Discure Technologies (c)
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Douglas C. Burton, MD	United States	DePuy Synthes (a, b, g); Globus (b, g); Blue Ocean (b, g); Progenerative Medical (c)

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NAME	COUNTRY	DISCLOSURE(S)
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Claudius Thomé, MD	Austria	DePuy Synthes (a, b); NuVasive (d); Intrinsic Therapeutics (a, b); Signus Medical (a, b); NEOS Surgery (a, b); Medacta (d); Icotec (a, d); BrainLab (a, b); Pfizer (a); Stryker Spine (b); Zeiss (b)
Eeric Truumees, MD	United States	Medtronic (a); Orthofix (a); Relievant Medsystems (a); Stryker Spine (g); NASS (e)
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Cheerag D. Upadhyaya, MD, MSc	United States	BK Medical (b, d)
Vidyadhar V. Upasani, MD	United States	DePuy Synthes (a, b); Stryker Spine (b); Indius (b); nView (a); OrthoPediatrics (a, b, g); Orthofix (b)
Anand Veeravagu, MD	United States	Alphatec Spine (b, c, g); Globus Medical (b, c, g); Osteocentric (c); surgical theater (c)
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Michael Y. Wang, MD	United States	Globus Medical (b); Stryker Spine (b); DePuy Synthes (b, g); Spineology (b); ISD (c); Medical Device Partners (c); Kinesiometrics (c); Pacira (b); Medtronic (b)
Roger F. Widmann, MD	United States	SpineGuard (b); OrthoPediatrics (b)
Hee-Kit Wong, FRCS	Singapore	SpineGuard (e); Highridge Medical (b)
Burt Yaszay, MD	United States	Stryker Spine (b, g); DePuy Synthes (b); NuVasive (b, g); Globus Medical (g); OrthoPediatrics (g); Biogen (b); Medtronic (b); Pacira (b)
Jang Yoon, MD	United States	Kinesiometrics, INC (c, g); DePuy Synthes (a, b); TrackX (b, c); RIWOSpine (b, d); Pacira (b); MedCyclops, LLC (c); Medyssey (b); Amplify (b)
Hong Zhang, MD	United States	Globus Medical (g)
Teng G. Zhang, PhD	China	Conova Medical Technology (g)

All of the relevant financial relationships listed for these individuals have been mitigated.

All other planners, faculty, and others in control of content (either individually or as a group) have no relevant financial relationships with ineligible companies.

If noted, the relationships disclosed are as follows: a – grants/research support; b – consultant; c – stock/shareholder (self-managed); d – speaker's bureau; e – advisory board or panel; f – employee, salary (commercial interest); g – other financial or material support (royalties, patents, etc.)

AUTHOR INDEX

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ABOUT SRS

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 37 orthopaedic surgeons to an international organization of more than 1,600 health care professionals.

DEI STATEMENT

The SRS recognizes the benefit of bringing the knowledge, perspectives, experiences, and insights of a diverse membership to our society. We are committed to including outstanding members from the broad spectrum of human ethnicities, genders, sexual orientations, national origins, geographic backgrounds, abilities, disabilities, religious beliefs, and ages. We will create a culture that is equitable and inclusive, where everyone has a voice and differences are celebrated. By building a membership and leadership who better reflect the diverse communities we study and care for, we foster better and more equitable care for patients with spinal disorders.

MISSION STATEMENT

The purpose of the Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers, and allied health professionals who have a practice that focuses on spinal deformity. Visit https://www.srs.org/Membership/Become-a-Member for more information on membership types, requirement details, and to apply online.

PROGRAMS AND ACTIVITIES

SRS is focused primarily on education and research that include the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Worldwide Courses, the Research Education Outreach (REO) Fund, which provides grants for spine deformity research, and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities, and membership please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible, and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public, and SRS members.

SOCIETY OFFICE STAFF

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Rachel Davis - *Administrative Manager*
Erica Ems - *Membership & Development Manager*
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Leah Skogman, CMP - *Senior Meetings Manager*
Sarah Slagle - *Program Manager, Education*

SOCIAL MEDIA

Join the conversation surrounding IMAST by including **#SRSIMAST25** in your social media posts.

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SCOLIOSIS RESEARCH SOCIETY

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33rd International Meeting on Advanced Spine Techniques

IMAST 2026

TORONTO, ON, CANADA

Powered by Scoliosis Research Society

SRS Scoliosis Research Society

April 15-17, 2026 | www.srs.org/imast26

60th Annual Meeting

September 16-20, 2025

CHARLOTTE

North Carolina, USA

WWW.SRS.ORG/AM25

Scoliosis Research Society

CORPORATE SUPPORTERS

We are pleased to acknowledge and thank those companies that **provided financial support to SRS in 2024**. Support levels are based on total contributions throughout the year and include the Annual Meeting, IMAST, Global Outreach Scholarships, Edgar Dawson Memorial Scholarships, SRS Traveling Fellowships, and the Research Education (REO) Fund.

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Spinal Elements
SI-BONE

MEETING OVERVIEW

WEDNESDAY, APRIL 2, 2025	
12:30 - 18:30	Registration Open | Hall 1
15:00 - 18:00	Speaker Ready Room Open | Hall 1
18:00 - 20:00	Exhibits Open | Hall 2
16:00 - 18:00	Spine & Scotch: Cases on the Rocks Sessions *(concurrent sessions)*
18:00 - 20:00	Welcome Reception & Exhibitor Viewing* | Hall 2
THURSDAY, APRIL 3, 2025	
07:00 - 18:30	Registration Open | Hall 1
08:00 - 18:30	Speaker Ready Room Open | Hall 1
09:00 - 17:30	Exhibits Open | Hall 2
08:00 - 09:00	Hands-On Workshop* *(includes breakfast)*
09:00 - 09:30	Refreshment Break & Exhibit Viewing* | Hall 2
09:30 - 11:45	Abstract Session 1 | Lomond Auditorium
11:45 - 12:00	Lunch Pick-Up | Hands-On Workshop Rooms*
12:00 - 13:00	Hands-On Workshops*
13:00 - 13:30	Break & Exhibit Viewing* | Hall 2 Award Nominated E-Point Presentations* | Innovation Theatre (Hall 2)
13:30 - 15:00	Sessions 2A & 2B *(concurrent sessions)* Abstract Session 2A | Lomond Auditorium Session 2B | M1
14:30 - 16:30	SRS-POSNA Kids Forum* | Alsh 1&2
15:00 - 15:30	Refreshment Break & Exhibit Viewing* | Hall 2 Award Nominated E-Point Presentations* | Innovation Theatre (Hall 2)
15:30 - 17:00	Sessions 3A & 3B *(concurrent sessions)* Abstract Session 3A | Lomond Auditorium Session 3B | M1
17:00 - 17:30	Break & Exhibit Viewing* | Hall 2
17:30 - 18:30	Session 4 | Lomond Auditorium

**Denotes Non-CME Session or Event*

MEETING OVERVIEW

FRIDAY, APRIL 4, 2025	
07:00 - 16:30	Registration Open | Hall 1
07:00 - 16:00	Speaker Ready Room Open | Hall 1
08:30 - 16:00	Exhibits Open | Hall 2
07:30 - 08:45	Abstract Sessions 5A, 5B, 5C & 5D *(concurrent sessions)* Abstract Session 5A | Alsh 1&2 Abstract Session 5B | Boisdale 1&2 Abstract Session 5C | Carron 1&2 Abstract Session 5D | Dochart 1&2
08:45 - 09:00	Refreshment Break & Exhibit Viewing* | Hall 2
09:00 - 11:00	Abstract Session 6 & Keynote Speaker | Lomond Auditorium
11:15 - 11:30	Lunch Pick-Up | Hands-On Workshop Rooms* Award Nominated E-Point Presentations* | Hall 2
11:30 - 12:30	Hands-On Workshops*
12:45 - 14:15	Sessions 7A & 7B *(concurrent sessions)* Session 7A | Lomond Auditorium Session 7B | M1
14:30 - 15:30	Medical Device Regulations: What You, As A Surgeon, Should Know Worldwide Impact on Your Practice and Your Patients*
15:30 - 16:00	Refreshment Break & Exhibit Viewing* | Hall 2 SRS Member Information Session* | Innovation Theatre (Hall 2)
16:00 - 17:30	Session 8* | Lomond Auditorium
17:30 - 19:00	Innovation Celebration* *(pre-registration required)* Radisson RED Hotel Glasgow Sky Bar Lounge

**Denotes Non-CME Session or Event*