SRS
Scoliosis Research Society

57TH ANNUAL MEETING
STOCKHOLM SWEDEN

SEPTEMBER 14-17, 2022 • Stockholm Waterfront Congress Centre

FINAL PROGRAM

www.srs.org • www.srs.org/am22

SRS-0722-416

CORPORATE PARTNERS

We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2022. 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.

DOUBLE DIAMOND LEVEL SUPPORT

DePuy Synthes
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SeaSpine
Spinal Elements
Spineology
SI-Bone

★ = ASLS II Supporter

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ANNUAL MEETING VENUE

Stockholm Waterfront Congress Centre
Nils Ericsons Plan 4, 111 64 Stockholm, Sweden

VIRTUAL MEETING PLATFORM

http://srs.brightspace.com

All information as of August 25, 2022.

Scoliosis Research Society

SRS Executive Office 555 East Wells Street, Suite 1100 Milwaukee, WI 53202
P: 414.289.9107 F: 414.276.3349 info@srs.org www.srs.org

MEETING INFORMATION

The Scoliosis Research Society gratefully acknowledges
Globus Medical, OrthoPediatrics and ZimVie
for their support of the Annual Meeting Welcome Reception.

WELCOME LETTER

On behalf of the Scoliosis Research Society, it is my great pleasure to welcome you to the 57th SRS Annual Meeting in Stockholm, Sweden. I am looking forward to celebrating another wonderful year for our Society with all of you in this lovely city.

This year there were 1,086 abstracts submitted from around the globe. Shay Bess, MD and the Program Committee have done outstanding work in reviewing all of the submissions and putting together a truly outstanding scientific program.

The Education Committee, led by Justin S. Smith, MD, PhD, has put together an excellent program, beginning on Wednesday morning with the Pre-Meeting Course titled, Evolution of Research for the Scoliosis Research Society: Defining the R in Our SRS. After the Pre-Meeting Course, there are three concurrent lunchtime symposia; two abstract sessions, one focusing on AIS papers, the other on adult spinal deformity; and finishing with three concurrent case discussions before heading into the evening festivities.

Wednesday evening will begin with the Opening Ceremonies which will include a welcome by our local hosts, Acke Ohlin, MD, PhD & Paul Gerdhem, MD, PhD; presentation of the Walter P. Blount Humanitarian Award; and this year's Howard Steel Lecturer, Tobias Degsell,the founder and CEO of COMBINER and creativity expert. Following the Opening Ceremonies will be the Welcome Reception, our first formal opportunity to connect with colleagues, many of whom we have not seen in many years due to the COVID-19 pandemic.

Thursday morning commences with sessions from the scientific program, followed by presentation of the Harrington Lecture given by Jürgen Harms, MD, and the Lifetime Achievement Award presented to Michael McMaster, MD, DSc, FRCS.

Industry Workshops, highlighting topics and technologies selected by the supporting companies take place on Thursday during lunch. Delegates are encouraged to attend one of the five concurrent workshops. Half-Day Courses on the topics, Current Updates in Understanding and Management of Intraoperative Neuromonitoring Alerts and Pediatric Syndromic Scoliosis: How to Safely Manage AMC to SED & Everything in Between follow the workshops.

Friday will be a full day of scientific sessions beginning with the Hibbs Award-Nominated Papers for Best Basic/ Translational and Clinical Research. The Members Business Meeting will be held during lunch from 12:05-13:35. During this time, there will also be a lunch session on, MIS Deformity Surgery State of the Art: How to Avoid and Manage Complications.

The Farewell Reception will take place Friday evening at the Historical Hotel Berns, in the eye-catching and original designed Salonger Ballroom. Tickets to the reception are required; if you have not purchased a ticket with your registration, please check at the registration desk, as there may be tickets still available. Cocktail attire is appropriate for the Farewell Reception.

We close the 57th Annual Meeting with a half-day of scientific sessions on Saturday, September 17 from 8:00-11:55, including the Transfer of the Presidency, where I will be joyfully passing the torch to our first female President, Serena S. Hu, MD. I encourage everyone to spend their afternoon exploring all of the wonderful sites that Stockholm has to offer.

A new event for our calendar this year, is a Major Donor Event, following the conclusion of the Annual Meeting. All donors who have reached Founders Level and above will be participate in a special event with the SRS Executive Committee.

The SRS staff, led by Executive Director, Ashtin Neuschaefer deserve special recognition for their countless efforts. They make the work of being SRS President so much easier. I also want to thank my fellow Presidential Line colleagues who have made this year significant for me and have advanced our Society; Past President, Muharrem Yazici, MD; President Elect, Serena S. Hu, MD; and Vice President, Marinus de Kleuver, MD, PhD.

It has been a pleasure and an honor to serve this year as your President of our extraordinary Society.

Best wishes to all for a great meeting!

Christopher I. Shaffrey, MD
Scoliosis Research Society President 2021-2022

ANNUAL MEETING COMMITTEES

SRS PRESIDENT

Christopher I. Shaffrey, MD

LOCAL HOSTS

Paul Gerdhem, MD, PhD
Acke Ohlin, MD, PhD

SRS EDUCATION COUNCIL CHAIR

Suken A. Shah, MD

PROGRAM COMMITTEE

Shay Bess, MD, Chair
Michael P. Kelly, MD, Past Chair
Amy L. McIntosh, MD, Co-Chair-Elect
Rajiv K. Sethi, MD, Co-Chair-Elect
Ivan Cheng, MD, Co-Vice Chair
Mitsuru Yagi, MD, PhD, Co-Vice Chair
Michael C. Albert, MD
Patrick J. Cahill, MD
Satoru Demura, MD, PhD
Mostafa H. El Dafrawy, MD
Jeffrey L. Gum, MD
Steven W. Hwang, MD
Megan Johnson, MD
Khaled M. Kebaish, MD
Deniz Konya, MD
David E. Lebel, MD, PhD
Joseph H. Perra, MD

EDUCATION COMMITTEE

Justin S. Smith, MD, PhD, Chair
Amer F. Samdani, MD, Past Chair
Mark A. Erickson, MD, Co-Chair-Elect
Charla R. Fischer, MD, Co-Chair-Elect
Brian Hsu, MD, Co-Vice Chair
Javier Pizones, MD, PhD, Co-Vice Chair
Ricardo B. Fontes, MD, PhD
Paul Gerdhem, MD, PhD
Arvindera Ghag, MD, FRCSC
Munish Chandra Gupta, MD
Hamid Hassanzadeh, MD
Steven W. Hwang, MD
Kenneth D. Illingworth, MD
Sharif Ahmed Jonayed, MS, FCPS (BD)
David Lazarus, MD
Marissa M. Muccio, PT
Luiz Müller Avila, MD
Ibrahim Obeid, MD
Rafael G. Oliveira, MD
Stefan Parent, MD, PhD
Yong Qiu, MD
Brett Rocos, MD, FRCS
Byron F. Stephens, MD

PROGRAM REVIEWERS

Paloma Bas Hermida, MD
Saumyajit Basu, MBBS, MS, DNB, FRCS
Keith R. Bachmann, MD
Junseok Bae, MD
Michael S. Chang, MD
David B. Cohen, MD, MPH
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Jeffrey L. Gum, MD
Judson W. Karlen, MD
David Lazarus, MD
Darren R. Lebl, MD, MBA
Charles Ledonio, MD
Scott J. Luhmann, MD
Kamran Majid, MD
Md Yousuf Ali, MBBS, MS
Ahmad Nassr, MD
Stefano Negrini, MD
Colin Nnadi, MBBS, FRCSI, FRCS (Orth)
Masayuki Ohashi, MD, PhD
Yong Qiu, MD
Surya P. Rao Voleti, MS, DNB
Karl E. Rathjen, MD
Juan Carlos Rodriguez-Olaverri, MD, PhD
Byron F. Stephens, MD
Fernando Techy, MD
Khoi D. Than, MD
ZeZhang Zhu, MD, PhD

GENERAL INFORMATION

MEETING DESCRIPTION

The Scoliosis Research Society (SRS) Annual Meeting is a forum for the realization of the Society's mission and goals: the improvement of patient care for those with spinal deformities. Nine faculty-led instructional course lectures, case discussions, 167 abstract papers, and 50 E-Posters will be presented on an array of topics, including adolescent idiopathic scoliosis, neuromuscular scoliosis, growing spine, kyphosis, adult defor-mity, minimally invasive surgery, and machine learning.

LEARNING OBJECTIVES

Upon completion of the Annual Meeting, participants should be able to:

- Apply and interpret current best practice guidelines in intraoperative neuromonitoring to improve the safety of care for spinal deformity surgical treatment
- Apply innovative research strategies
- Correctly identify and manage pediatric syndromic scoliosis conditions
- Recognize MIS strategies and how to apply them for adult spinal deformity surgery

TARGET AUDIENCE

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

ACCREDITATION STATEMENT

The 57th Annual Meeting have been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the sponsorship of the Scoliosis Research Society (SRS). SRS is accredited by the ACCME to provide continuing medical education for physicians.

CREDIT DESIGNATION

SRS designates this other (hybrid) activity, 57th SRS Annual Meeting, for a maximum of 43 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in each activity.

ATTIRE

Business (suits) or business casual attire (polo or dress shirt, sport coat) are appropriate for all Annual Meeting sessions; ties are not required. Cocktail attire is appropriate for the Farewell Reception.

LANGUAGE

Presentations and meeting materials will be provided in English.

WIRELESS INTERNET

Wireless Internet access is available throughout the meeting space.

Network: SRS2022
Password: SCOLIOSIS

Wireless Internet is supported, in part, by ZimVie.

REGISTRATION DESK HOURS

Location: Level 4, Foyer

Tuesday, September 13	12:00-17:00
Wednesday, September 14	06:30-20:30
Thursday, September 15	07:00-18:00
Friday, September 16	07:00-17:00
Saturday, September 17	07:30-11:00

SPEAKER READY ROOM

Location: Level 5, Foyer

Presenters may upload their presentations onsite in the Speaker Ready Room. Presentations should be uploaded no later than 24 hours before the session is scheduled to begin.

Tuesday, September 13	12:00-17:00
Wednesday, September 14	06:30-19:00
Thursday, September 15	07:00-18:00
Friday, September 16	07:00-17:00
Saturday, September 17	07:30-11:00

SRS MEMBERSHIP DESK

Location: Level 4, Foyer

Hours: Same as Registration Desk

Stop by the SRS Membership Desk for more information about becoming an SRS member, application status, upcoming meetings, and more. SRS members can pick up Active Fellow certificates and request a printed 2022 Membership Directory to be mailed after the conclusion of the meeting (advance request only).

SRS COMMUNICATIONS DESK

Location: Level 4, Foyer

Visit the Communications Desk to learn more about the SRS podcast, social media, and meeting app. It makes the perfect spot to get an AM22 selfie.

SRS DEI TABLE

Location: Level 4, M1

Learn more about the SRS Diversity, Equity and Inclusion Task Force's efforts and connect with similarly minded individuals at the new DEI table. Content will include summaries of past and on-going SRS DEI efforts, DEI related surgical organizations, and an opportunity for non-members to make their voices heard. Gathering at the DEI table during breaks is encouraged.

GENERAL INFORMATION

SRS HISTORICAL DISPLAY

Location: Level 4, M1

Explore the unique spine history of Sweden at a new SRS feature, the local host Historical Display. The SRS Historical Committee, in conjunction with Acke Ohlin, MD, PhD, have created a timeline of noteworthy Swedish contributions to spine and spine deformity surgery.

ABSTRACT VOLUME

All abstracts accepted for presentation at the 57th Annual Meeting are published in the Final Program. All in person meeting attendees will receive one copy of the program along with their registration materials. Abstracts are also available online on the Program page of the SRS Annual Meeting website (https://www.srs.org/am22/program) and in the Annual Meeting mobile app.

E-POSTERS

There are 50 E-Posters available for your review on the virtual meeting platform in the E-Poster module. E-Posters are also available on the USB included with in-person meeting registration materials.

NAME BADGES

Official name badges are required for admission to all Annual Meeting sessions, breaks, and lunches. Meeting attendees will receive a name badge with their registration materials. Name badges are required to be worn while inside the meeting venue, as badges will be used to control access to sessions and activities. Attendees are cautioned against wearing their name badges while away from the venue, as badges draw unwanted attention to your status as visitors to the city.

SRS MEETING BAGS

SRS has decided to take a greener approach in 2022 and not produce meeting bags in order to save resources.

EVALUATIONS

Please take time to complete the evaluations for each session you attend. Session evaluations and the overall meeting evaluation are available online on the AM22 Meeting App. Your input and comments are essential in planning future Annual Meetings.

VIRTUAL MEETING ACCESS

Online Platform: https://srs.brightspace.com/

The Annual Meeting online platform is available to in-person and virtual-only meeting delegates beginning September 9 through December 31, 2022. If you were unable to attend a concurrent session, don't forget to watch it on-demand after the meeting. To access the virtual content, go to https://srs.brightspace.com, select "I have an account on the SRS website", enter your SRS username and password, click "Continue", and select 57th Annual Meeting listed under "My Courses".

LOST & FOUND

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

CELL PHONE PROTOCOL

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

NO SMOKING POLICY

Smoking is not permitted during any Annual Meeting activity or event.

PHOTOGRAPHY POLICY

SRS will be taking photographs throughout the Annual Meeting. SRS will use these photos in publications and to produce related literature and products for public release. Individuals photographed will not receive compensation for the use and release of these photos and will be deemed to have consented to the use and release of photos in which they appear. If you are opposed to being photographed, please immediately notify the photographer or a SRS staff member if your picture is taken. Thank you for your cooperation.

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 recordings taken of any of the presentations. All session rooms will be recorded and will be available to delegates after the meeting on the Annual Meeting virtual platform.

SPECIAL NEEDS

If you have any health issues for which you may require special accommodations or assistance, please notify a SRS staff member. SRS will make every effort to accommodate any special needs.

EMERGENCY & FIRST AID

The Stockholm Waterfront Congress Centre 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.

GENERAL INFORMATION

DISCLOSURE OF CONFLICT OF INTEREST

It is the policy of SRS to insure balance, independence, objectivity and scientific rigor in all educational activities. In accordance with this policy, SRS identifies conflicts of interest with instructors, content managers, and other individuals who are in a position to control the content of an activity. Conflicts are resolved by SRS to ensure that all scientific research referred to, reported, or used in a CME activity conforms to the generally accepted standards of experimental design, data collection, and analysis. Complete faculty disclosures will be included in the final program.

FDA STATEMENT (UNITED STATES)

Some drugs and medical devices demonstrated during this course have limited FDA labeling and marketing clearance. It is the responsibility of the physician to be aware of drug or device FDA labeling and marketing status.

INSURANCE/LIABILITIES AND DISCLAIMER

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

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

The materials presented at this Continuing Medical Education activity are made available for educational purposes only. The material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement, or opinion of the faculty that may be helpful to others who face similar situations.

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

JOIN THE CONVERSATION

Join the conversation surrounding the SRS Annual Meeting by using #SRSAM22 in your social media posts.

@srs_org @ScoliosisResearchSociety @srs_org @Scoliosis Research Society

SESSION AND EVENT INFORMATION

HIBBS SOCIETY MEETING - $50

Tuesday, September 13 • 13:00-17:00

Available to in-person meeting delegates for an additional fee of $50

Over the years, the Russell A. Hibbs Society, formed in 1947 as an international travel club for continuing medical education and furthering orthopaedic knowledge, has held an educational meeting at the SRS Annual Meeting. These meetings address difficult and complex issues that do not lend themselves to the usual kind of scientific presentations. The meeting encourages interaction among international participants and highlights new ideas, new concepts, and reports on personal experience.

OPENING CEREMONIES AND WELCOME RECEPTION

Wednesday, September 14

Opening Ceremonies • 18:50-20:00
Welcome Reception • 20:00-22:00

Available at no charge to in-person meeting delegates, $100 for registered guests

The Annual Meeting will officially begin with the Opening Ceremonies and this year's Howard Steel Lecturer. The evening will include an introduction of the SRS officers, the presentation of the Walter P. Blount Humanitarian Award, and highlights from 2022.

A hosted reception featuring hors d'oeuvres, cocktails, and reunions with colleagues and friends will follow the Opening Ceremonies.

The Welcome Reception is supported, in part, by Globus Medical, OrthoPediatrics, and ZimVie.

EARLY CAREER SURGEON SESSION

Thursday, September 15 • 17:50-18:50

Available at no charge to in-person meeting delegates

The Early Career Surgeon Session is a part of SRS's recently developed Early Career Surgeon Program. This session features tips and tricks for the early career surgeon and offers a unique opportunity for SRS members and non-members to interact closely with a panel of experts through didactic case-based discussions. This session is open to all registered delegates, including those who are residents and fellows, and is followed by an early career surgeon social.

The Early Career Surgeon Session is supported, in part, by Globus Medical, Medtronic, NuVasive, and ZimVie.

EARLY CAREER SURGEON SOCIAL

Thursday, September 15 • beginning at 18:50

Immediately following the Early Career Surgeon Session is an Early Career Surgeon Social hosted by Medtronic. The social will include light refreshments, beverages, and an opportunity to connect with colleagues and friends.

INDUSTRY WORKSHOPS

Thursday, September 15 • 12:50-14:20

Delegates are encouraged to attend the industry workshops. Each workshop is programmed by a single-supporting company and features presentations on topics and technologies selected by the company. Lunch will be available during the workshops. CME credits are not available for workshops.

Industry workshops at the Annual Meeting will be hosted by: DePuy Synthes, Globus Medical, Medtronic, NuVasive and Stryker. Please see page 221 for program information.

MEMBERS BUSINESS MEETING

Friday, September 16 • 12:05-13:35

All SRS members are invited to the Member Business Meeting. Agendas will include reports from the various SRS committees, updates on SRS activities and programs, and voting (online).

LIVE WEBCAST

Friday, September 16 • 12:05-13:35

On Friday, September 16 from 12:05-13:35, *LTS 4: MIS Deformity Surgery State of the Art: How to Avoid and Manage Complications*, will be webcast live. More information about the webcast is available on the AM22 website: www.srs.org/am22.

The webcast is supported, in part, by DePuy Synthes.

FAREWELL RECEPTION - $50

Friday, September 16 • 19:30-22:00

Open to all registered delegates and registered guests. Tickets are $50 for registered delegates and $175 for registered guests and must be purchased in advance. A limited number of tickets may be available onsite, please stop at the registration desk for information and ticket availability.

ANNUAL MEETING 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 AM 2022*.
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, www.eventmobi.com/am22 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.

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.

LIVE SESSION POLLS

Session polls can be found at the top of session pages. If prompted by the moderator or speaker, click Polls at the top of the page. Once you have started a session poll, you can move from question to question by selecting your answers and clicking Submit or by clicking on the navigation arrows to the left and right of the Submit button. Moderators can display the poll results live on screen for the entire audience to view.

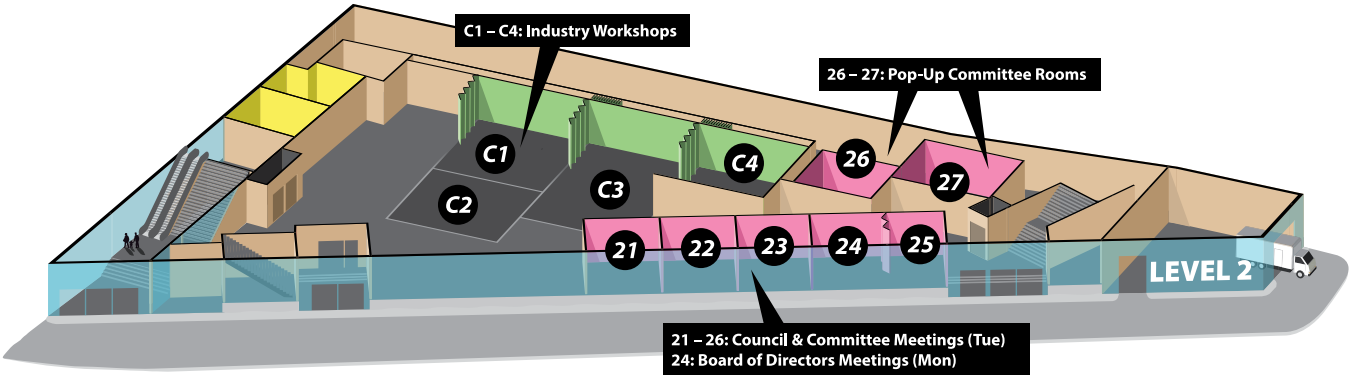
GAME ON!

Gamification within the SRS Annual Meeting app is a unique way to interact with your peers and engage with the presenters by collecting codes to earn points. Download the app and, on the first screen, you will get your first code. Pick up a second code at the registration desk. Are you on Facebook, Twitter or Instagram? Share our content and earn another code. To get you started, enter **program** 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 Communications Hub to learn more about gamification and the Annual Meeting app.

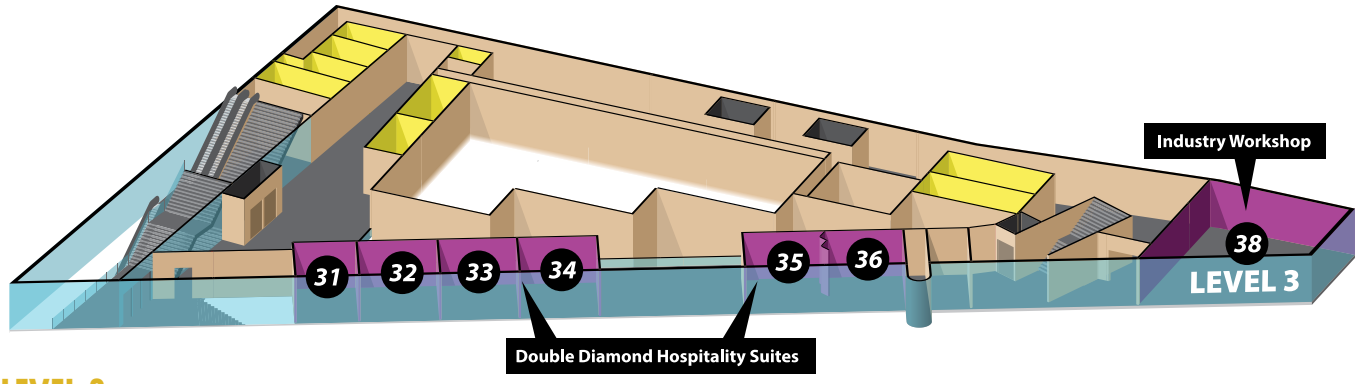
MEETING SPACE FLOORPLANS

- Hibbs Society Meeting, General Session, Concurrent Sessions
- Refreshment Breaks, Lunch, Historical Display & DEI Table
- Industry Workshops
- Double Diamond Hospitality Suites
- Elevators
- Restrooms
- Committee Rooms



LEVEL 2

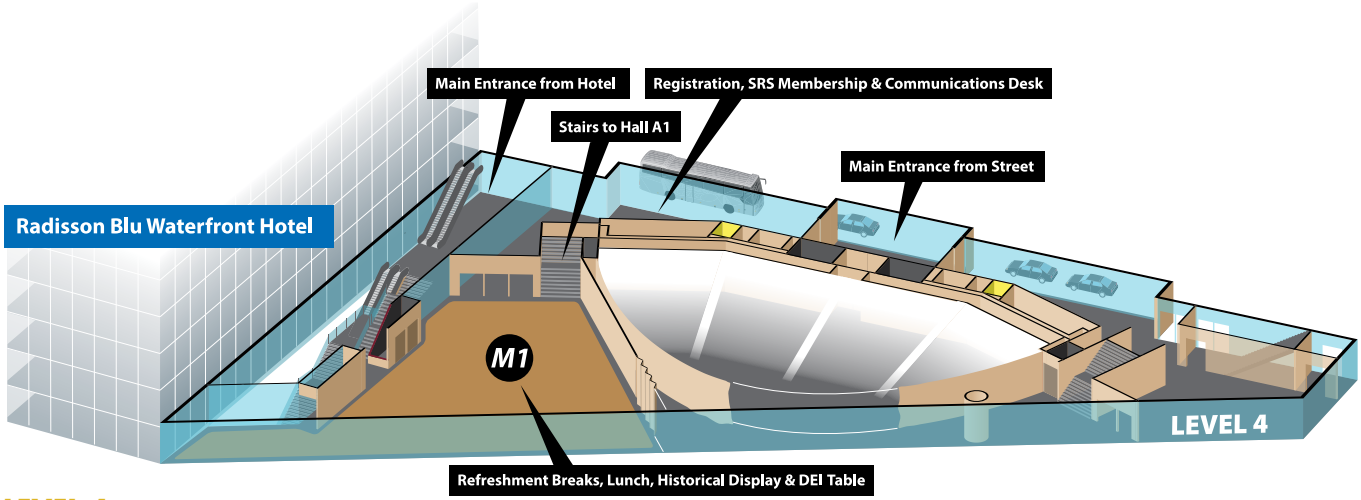
ROOM	FUNCTION
Room 21 - 25	Committee & Council Meetings (Tuesday)
Room 24	Board of Directors Meeting (Mon)
Room 26	Pop-Up Committee Room
Room 27	Pop-Up Committee Room
Hall C1	Industry Workshop
Hall C2	Industry Workshop
Hall C3	Industry Workshop, Early Career Surgeon Session, Journal Editorial Board Meeting
Hall C4	Industry Workshop



LEVEL 3

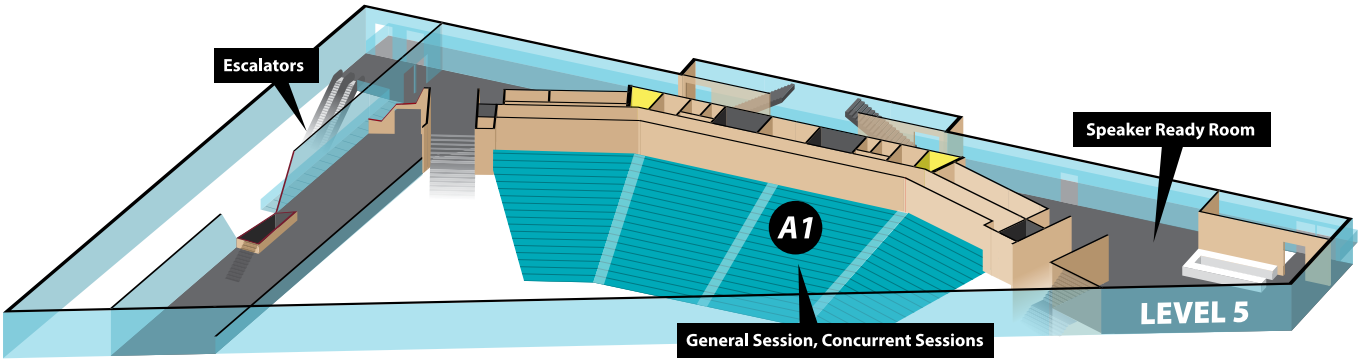
ROOM	FUNCTION
Room 31	Double Diamond Hospitality Suite: ZimVie
Room 32	Double Diamond Hospitality Suite: Stryker
Room 33	Double Diamond Hospitality Suite: NuVasive
Room 34	Double Diamond Hospitality Suite: Medtronic
Room 35	Double Diamond Hospitality Suite: Globus Medical
Room 36	Double Diamond Hospitality Suite: DePuy Synthes
Room 38	Industry Workshop

MEETING SPACE FLOORPLANS



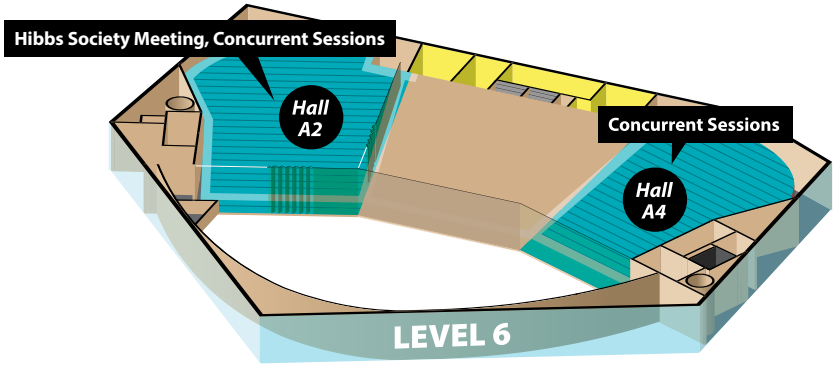
LEVEL 4

ROOM	FUNCTION
Foyer	Registration, SRS Membership Desk, SRS Communications Desk
M1	Refreshment Breaks, Lunch, DEI Table, Historical Display



LEVEL 5

ROOM	FUNCTION
Foyer	Speaker Ready Room
Hall A1	General Session, Concurrent Session



LEVEL 6

ROOM	FUNCTION
Hall A2	Hibbs Society Meeting, Concurrent Session
Hall A4	Concurrent Session

MEETING OUTLINE

MONDAY, SEPTEMBER 12, 2022			
08:00-14:00	SRS Board of Directors Meeting*	Room 24	Level 2
TUESDAY, SEPTEMBER 13, 2022			
07:00-17:00	Committee and Council Meetings*	Rooms 21-25	Level 2
12:00-17:00	Registration Open*	Foyer	Level 4
12:00-17:00	Speaker Ready Room Open*	Foyer	Level 5
13:00-17:00	Hibbs Society Meeting	Hall A2	Level 6
18:30-21:30	SRS Leadership Dinner (by invitation only)	Offsite	
WEDNESDAY, SEPTEMBER 14, 2022			
06:30-20:30	Registration Open*	Foyer	Level 4
06:30-19:00	Speaker Ready Room Open*	Foyer	Level 5
07:30-12:00	Pre-Meeting Course (PMC): Evolution of Research for the Scoliosis Research Society: Defining the R in Our SRS	Hall A1	Level 5
	The Pre-Meeting Course is supported, in part, by Globus Medical, NuVasive, and ZimVie		
12:00-12:20	Lunch Pick-Up*	M1	Level 4
12:20-13:20	Lunchtime Symposia (3 Concurrent Sessions)		
	- LTS1: Tweeners: To Fuse or Not To Fuse? Treatment of Early Onset Scoliosis in Patients Who Are Not Yet Skeletally Mature	Hall A2	Level 6
	- LTS2: From Alignment to Balance, There is More Than One Step	Hall A1	Level 5
	- LTS3: Cervical Spine: Deformity and Instability Case Controversies	Hall A4	Level 6
	Lunchtime Symposia are supported, in part, by Globus Medical and OrthoPediatrics		
13:20-13:40	Break*		
13:40-15:10	Abstract Session 1: Adolescent Idiopathic Scoliosis	Hall A1	Level 5
15:10-15:30	Refreshment Break**	M1	Level 4
15:30-17:15	Abstract Session 2: Adult Spinal Deformity I	Hall A1	Level 5
17:15-17:35	Break*		
17:35-18:35	Case Discussions (3 Concurrent Sessions)		
	- Case Discussion 1: Peds 1 - Dislocations, Coronal and Sagittal Decompensation	Hall A1	Level 5
	- Case Discussion 2: Peds 2 - Cardiac, Neurofibromatosis, and Growth Preservation	Hall A4	Level 6
	- Case Discussion 3: Adult	Hall A2	Level 6
18:35-18:50	Break*		
18:50-20:00	Opening Ceremonies*	Hall A1	Level 5
20:00-22:00	Welcome Reception*	M1	Level 4
	The Welcome Reception is supported, in part, by Globus Medical, OrthoPediatrics and ZimVie		
THURSDAY, SEPTEMBER 15, 2022			
07:00-18:00	Registration Open*	Foyer	Level 4
07:00-18:00	Speaker Ready Room Open*	Foyer	Level 5
08:00-09:50	Abstract Session 3: Quality/Safety/Value/Complications I	Hall A1	Level 5
09:50-10:10	Refreshment Break**	M1	Level 4
10:10-12:15	Abstract Session 4: Quality/Safety/Value/Complications II and Harrington Lecture	Hall A1	Level 5
12:15-12:50	Lunch Pick-Up*	M1	Level 4

**Denotes non-CME Session/Activity **Refreshment breaks are supported, in part, by ZimVie*

MEETING OUTLINE

THURSDAY, SEPTEMBER 15, 2022, CONTINUED			
12:50-14:20	Industry Workshops* (5 Concurrent Sessions) *Workshops from DePuy Synthes, Globus Medical, Medtronic, NuVasive and Stryker*	Halls C1 - C4 Room 38	Level 2 Level 3
14:20-14:40	Refreshment Break**	M1	Level 4
14:40-17:20	Half-Day Courses (2 Concurrent Sessions)		
	- HDC 1: Pediatric Syndromic Scoliosis: How to Safely Manage AMC to SED & Everything in Between	Hall A1	Level 5
	- HDC 2: Current Updates in Understanding and Management of Intraoperative Neuromonitoring Alerts	Hall A2	Level 6
17:20-17:30	Break*		
17:30-17:45	SRS Membership Information Session	Hall C4	Level 2
17:45-17:50	Break*		
17:50-18:50	Early Career Surgeon Session: Self and Career Development: Young Surgeons' Guide to the Spine Galaxy	Hall C3	Level 2
	The Early Career Surgeon Session is supported, in part, by Globus Medical, Medtronic, NuVasive and ZimVie		
18:50	Early Career Surgeon Social*	C3 Foyer	Level 2
	The Early Career Surgeon Social is supported and hosted by Medtronic		

FRIDAY, SEPTEMBER 16, 2022			
07:00-17:00	Registration Open*	Foyer	Level 4
07:00-17:00	Speaker Ready Room Open*	Foyer	Level 5
07:00-08:00	Past President's Breakfast* (by invitation only)	M3	Level 2
08:00-09:50	Abstract Session 5: Hibbs Award-Nominated Papers	Hall A1	Level 5
09:50-10:10	Refreshment Break**	M1	Level 4
10:10-11:45	Abstract Session 6: Neuromuscular, Kyphosis and Presidential Address	Hall A1	Level 5
11:45-12:05	Lunch Pick-Up*	M1	Level 4
12:05-13:35	Member Business Meeting*	Hall A1	Level 5
12:05-13:35	Lunchtime Symposium 4: MIS Deformity Surgery State of the Art: How to Avoid and Manage Complications	Hall A2	Level 6
	Lunchtime Symposium 4 will be live webcast and is being supported, in part, by DePuy Synthes		
13:35-13:55	Break*		
13:55-15:40	Abstract Sessions 7 and 8 (2 Concurrent Sessions)		
	- Abstract 7: Early Onset Scoliosis and Nonoperative	Hall A1	Level 5
	- Abstract 8: Adult Spinal Deformity II	Hall A2	Level 6
15:40-16:00	Refreshment Break**	M1	Level 4
16:00-17:45	Abstract Session 9: Adolescent Idiopathic Scoliosis and Pediatric Deformities	Hall A1	Level 5
18:30-19:30	Presidents Reception* (by invitation only)	Offsite	
19:30-22:00	Farewell Reception* (tickets required)	Offsite	

SATURDAY, SEPTEMBER 17, 2022			
07:00-08:00	SRS Board of Directors Meeting*	M3	Level 2
07:30-11:00	Registration Open*	Foyer	Level 4
07:30-11:00	Speaker Ready Room Open*	Foyer	Level 5
08:00-10:10	Abstract Session 10: Basic Science, Nonoperative, QSVC	Hall A1	Level 5
10:10-10:30	Break**	M1	Level 4
10:30-11:55	Abstract Session 11: Cervical, QSVC, and Miscellaneous	Hall A1	Level 5
11:55	SRS 57th Annual Meeting Concludes		

**Denotes non-CME Session/Activity **Refreshment breaks are supported, in part, by ZimVie*

GUEST LECTURES

WEDNESDAY, SEPTEMBER 14

HOWARD STEEL LECTURE: COLLABORATION AND ITS CONTRIBUTION TO SUCCESS

Tobias Degsell

Tobias Degsell likes data, views the world in patterns, and is gifted with brilliantly explaining complex things in simpler words. Besides being labeled as a Gold Finder by one of the Big Five Tech Companies, Tobias Degsell is often called a Change Maker, Collaboration Evangelist, and a Thought Leader.

Before founding his company Combiner, Tobias worked as a curator at the Nobel Prize Museum in Stockholm. For years, he studied all the Nobel Laureates, trying to understand how they developed their ideas into reality. Nowadays, he helps companies and organizations all over the world to think and act new. He loves to inspire diverse teams as well as advises and help them on how to face reality, problem-solving, and developing innovative solutions.

A staunch believer in bridges, Tobias feels satisfied if he could add at least one "brick" to a bridge that helps span a gap somewhere. He also asserts that we need more people who will dare to think and act in new ways, with actions rooted in Collaboration, Diversity, and Trust.

Tobias Degsell has given hundreds of keynote speeches over the past decade. He has been to Africa, Asia, Europe, and North America, and has worked with companies and organizations, such as Apple, Deutche Telekom, ETH, Google, ETH, Roche, Samsung, the Swedish Central Bank, University of Virginia, the World Economic Forum, to name a few.

Areas of Expertise
Creativity • Collaboration • Learning Organisations • Problem Solving

Web: combiner.se
LinkedIn: www.linkedin.com/in/tobias-degsell

THURSDAY, SEPTEMBER 15

HARRINGTON LECTURE: IMPACT OF HARRINGTON INSTRUMENTATION ON PRESENT SPINE SURGERY

Jürgen Harms, MD

Jürgen Harms studied medicine in Frankfurt a.M. and Saarbrücken, Germany from 1963 to 1968. After promotion from university, he worked as General surgeon and Trauma surgeon in Neuburg/Donau and Trauma clinic Ludwigshafen with training in orthopaedics and trauma surgery until 1980 and was 1978 awarded Prof of Orthopedics and Trauma Surgery. From 1980 he worked for 31 years as Head of Spine Surgery of SRH Klinikum Karlsbad-Langensteinbach, Germany until he established in 2012 the spine surgery division of Ethianum Klinik, a newly launched hospital in Heidelberg associated to the University Hospital Heidelberg, where he carries out challenging spinal surgeries since that time. *'Choose a job you love, and you will never have to work a day in your life.' (Confucius)*

Jürgen Harms is an internationally recognised specialist in the field of spinal surgery. He pioneered advanced surgical techniques in scoliosis surgery, tumour surgery, transoral surgery, the TLIF technique or dorsal fixation of the atlanto-axial complex, which are practised worldwide. In addition, he was the developer of the polyaxial screw-rod systems, which are considered state of the art. His many years of successful exchange between medicine and technology also led to the development of new implant systems, including the Harms titanium basket. For more than 20 years, Harms has endeavoured to highlight the importance of anterior surgery. The possibilities and results are comprehensively presented in the book

"MODERN MANAGEMENT OF SPINAL DEFORMITIES," published together with Bob Dickson. The *Harms Study Group* is considered one of the most successful study group with more than 100 trend-setting publications and lectures on spine surgery. Recently, a new international subgroup of the Harms Study Group was established dedicating exclusively to pathogenesis of scoliosis.

2022 SRS AWARDS

2022 WALTER P. BLOUNT HUMANITARIAN AWARD

Presented for outstanding service to those with spinal deformity and for generosity to the profession and Society. The 2022 Blount award will be presented on Wednesday, September 14.

LAWRENCE G. LENKE, MD

Lawrence G. Lenke, MD is the Surgeon-In-Chief at NewYork-Presbyterian Och Spine Hospital, Professor of Orthopedic Surgery (in Neurological Surgery) with Tenure, and Chief of Spinal Deformity Surgery at Columbia University Vagelos College of Physicians and Surgeons. His practice is devoted exclusively to the treatment of complex pediatric and adult spinal deformity.

After graduating Summa Cum Laude from the University of Notre Dame, he attended medical school at Northwestern University in Chicago. He then completed his surgical internship and orthopaedic surgical residency at Washington University School of Medicine, where he also completed a pediatric and adult spinal surgery fellowship under the direction of Keith Bridwell, MD. Dr. Lenke remained at Washington University as an attending spinal surgeon, rising from the ranks of Assistant Professor to the Jerome J. Gilden Distinguished Professor of Orthopaedic Surgery in less than 10 years. He was in practice there for 23 years and relocated to Columbia University/New York-Presbyterian Hospital System to start the Och Spine Hospital in New York in July 2015.

Dr. Lenke is world-renowned for the surgical treatment of pediatric and adult patients with various forms of spinal pathology with expertise in the most complex deformities. He has trained over 125 Spinal Surgery Fellows, has had over 750 visiting surgeons from the US and around the world view his surgeries, and has chaired over 125 spinal surgery meetings over his 30-year career. His prolific clinical research culminating in numerous publications (over 600), presentations (over 1000), as well as being a visiting professor/honored guest speaker at over 100 institutions worldwide has led to innovative treatments for his patients and many others globally. He and his colleagues of the Harms Study Group developed the Lenke Classification System of Adolescent Idiopathic Scoliosis (AIS), which has remained the global standard for AIS classification for over 20 years now. He also was co-PI of the landmark Scoli-Risk-1 Prospective International study of complex Adult Spinal Deformity co-sponsored by the SRS and AOSpine, was the founding chair of the Fox Pediatric Spinal Deformity Study Group and the AOSpine Deformity Knowledge Forum, and is currently the leading enrollee of the Complex Adult Deformity Study (CADS) of the ISSG. Dr. Lenke has been listed in America's Top Doctors continuously for the past 15 years and Best Doctors in America the past 20 years running.

He served as president of the Scoliosis Research Society (SRS) in 2010-2011, and while president, he chaired a task force that led to the development of Spine Deformity, which debuted in January 2013 as the official journal of the SRS. He also helped to install the SRS Research, Education and Outreach (REO) funding campaign for the society. He has been a recipient of the Russell Hibbs award for the top Clinical Research presentation at the SRS Annual Meeting 4 times and the Thomas Whitecloud award for the top Clinical presentation at the IMAST meeting 3 times. Dr. Lenke was also honored with the North American Spine Society's 2013 Leon Wiltse Award for excellence in leadership and/or clinical research in spine care.

Dr. Lenke has been married to Elizabeth Lenke, BSN, MHA, MSW for over 33 years and have proudly raised 3 children Lauren (age 31), Bradley (28), and Erin (26).

2022 SRS AWARDS

2022 LIFETIME ACHIEVEMENT AWARD

Presented to a member who has exhibited long and distinguished service to SRS and to spinal deformity research and care. The 2022 Lifetime Achievement award will be presented on Thursday, September 15.

MICHAEL MCMASTER, MD, DSc, FRCS

Michael J McMaster MD, DSc, FRCS. was the chief surgeon and founder of the Scottish National Spine Deformity Service based in Edinburgh treating all children with spinal deformities from the whole of Scotland.

His major interest, and the subject of his research and publications was in the early diagnosis, progression and management of congenital deformities of the spine. He is the author of multiple publications and book chapters on spinal deformities in children and adults and has been invited on many occasions to lecture internationally including the Harrington Lecture at the SRS meeting Miami in 2005. In 2014 the SRS Spine Deformity Journal published a bibliometric review of the world literature and found that his paper on Congenital Scoliosis was at 31 in the top 100 most highly cited classic articles on spine deformity surgery.

He was born in Northern Ireland and graduated in medicine from Queens University Belfast. His early orthopedic training was at the Robert Jones and Agnes Hunt Orthopedic Hospital England, the Rheumatoid Foundation Hospital Finland, and laterally as an orthopaedic fellow and associate orthopedic surgeon at the Mayo Clinic USA.

On his return to Scotland in 1976 he succeeded Prof JIP James and developed the spine deformity service at the Princess Margaret Rose Orthopedic Hospital Edinburgh. In 1978 he was an ABC Travelling Fellow to the USA and Canada and was a founding member of the British Scoliosis Society, later becoming its President. In 2001 he was awarded the King James IV Professorship from the Royal College of Surgeons Edinburgh and in 2011 received a Doctorate in Science (by thesis) from the University of Edinburgh, both based on his work in spine deformity surgery.

In 2007 he was the Local Organizing Host for the 42nd Annual Meeting of the SRS held in Edinburgh and in 2012 was the Senior SRS Traveling Fellow mentoring international surgeons selected to visit spine centers in the USA.

He retired from the NHS in 2010 after working for 34 years as Chief of the Orthopaedic Spine Service at both the Royal Infirmary and the Royal Hospital for Sick Children in Edinburgh.

2022 ANNUAL MEETING AWARDS

The 2022 Annual Meeting awards for the best basic/translational science and clinical research papers (Russell A. Hibbs Awards) and the best basic/translational science and clinical research E-posters (John H. Moe and Louis A. Goldstein Awards) at the 57th Annual Meeting will be presented on Saturday, September 17.

56TH ANNUAL MEETING RUSSELL A. HIBBS AWARDS

Presented to the best basic science and clinical research papers at the 55th Annual Meeting.

2021 HIBBS AWARD FOR BEST BASIC SCIENCE/ TRANSLATIONAL RESEARCH PAPER

Genetic Age Determined by Telomere Length is Significantly Associated with Risk of Complications in Adult Deformity Surgery Despite No Significant Difference in Chronological Age: Pilot Study of 43 Patients

Michael Safaee, MD; Jue Lin, PhD; Christopher P. Ames, MD

2021 HIBBS AWARDS FOR BEST CLINICAL RESEARCH PAPER

Adverse Events in Multilevel Surgery in Elderly Patients with Spinal Deformity: Report of the Prospective Evaluation of Elderly Deformity Surgery (PEEDS)

Sigurd H. Berven, MD; Lawrence G. Lenke, MD; Michael Venezia Venezia, DO; John T. Street, MD; Allan R. Martin, MD, PhD, FRCS(C); Justin S. Smith, MD, PhD; Eric O. Klineberg, MD; Michael P. Kelly, MD; Christopher I. Shaffrey, MD; Benny T. Dahl, MD, PhD, DMSci; Marinus de Kleuver, MD, PhD; Maarten Spruit, MD; Ferran Pellisé, MD, PhD; Kenneth M. Cheung, MD, MBBS, FRCS; Ahmet Alanay, MD; David W. Polly, MD; Jonathan N. Sembrano, MD; Yukihiro Matsuyama, MD, PhD; Stephen J. Lewis, MD, FRCSC

56TH ANNUAL MEETING JOHN H. MOE AND LOUIS A. GOLDSTEIN AWARDS

Presented to the best basic science and clinical research E-Posters at the 56th Annual Meeting.

2021 MOE AWARD FOR BEST BASIC SCIENCE/ TRANSLATIONAL RESEARCH POSTER

Screw Malalignment May Explain Cord Rupture in Vertebral Body Tethering: A Finite Element Analysis

Wanis Nafo, PhD; Kenny Y. Kwan, MD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Kenneth MC Cheung, MD, MBBS, FRCS

2021 GOLDSTEIN AWARD FOR BEST CLINICAL RESEARCH POSTER

Is Thorascopic VBT a Pulmonary Function Declining or Improving Surgery?

Burcu Akpunarli, MD; Altug Yucekul, MD; Kadir Abul, MD; Peri Kindan, MD; Gokhan Ergene, MD; Sahin Senay, MD; Tais Zulemyan, MD; Yasemin Yavuz, PhD; Caglar Yilgor, MD; Ahmet Alanay, MD

CONFLICT OF INTEREST DISCLOSURES

The Scoliosis Research Society gratefully acknowledges
Globus Medical, NuVasive and ZimVie
for their support of the Pre-Meeting Course.

CONFLICT OF INTEREST DISCLOSURES

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CONFLICT OF INTEREST DISCLOSURES

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Paloma Bas Hermida, MD	Spain	No relationships
Michael S. Chang, MD	United States	Corelink (b); Stryker Spine (b); Spinewave (b); BK (b)

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CONFLICT OF INTEREST 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); Orthopedics Today (Editorial Board) (e); Hospital for Special Surgery (Board of Directors) (e); Parvizi Surgical Innovations (PSI) (c); HS2, LLC (c); Spine Universe (Editorial Board) (e)
Christopher P. Ames, MD	United States	Stryker Spine (g); Biomet Zimmer Spine (g); DePuy Synthes (g); NuVasive (g); Next Orthosurgical (g); K2M (g); Medicrea (g); DePuy Synthes (b); Medtronic (b); Medicrea (b); K2M (b); Titan Spine (a); DePuy Synthes (a); ISSG (a); Operative Neurosurgery (g); SRS (a); ISSG (g); Global Spinal Analytics (g); University of California, San Francisco (f)
Neel Anand, MD	United States	DePuy Synthes (b,d); Medtronic (a,b,g); Globus Medical (c,e,g); Paradigm Spine (c); Spinal Balance (b,c,e); Spinal Simplicity (b,c,e); Theracell (b,c,e); Viseon (b,c,e); Elsevier (g); Atlas Spine (c); Bonovo (c); AF Cell (c); OnPoint Surgical (c,e)
Lindsay M. Andras, MD	United States	Zimmer Biomet (b,d); Eli Lilly (c); Journal of Pediatric Orthopaedics (e); NuVasive (b,d); Orthobullets (b,d,g); Pediatric Orthopaedic Society of North America (e); Scoliosis Research Society (e)
Teresa Bas, MD	United States	No Relationships
Jennifer M. Bauer, MD	United States	DePuy Synthes (b); Proprio (b); OrthoPediatrics (b)
Sigurd H. Berven, MD	United States	Globus Medical (e); Medtronic (b,e,g); Stryker Spine (b,g); Medicrea (b); Innovasis (b,e); Camber spine (b,g); Novapproach (b,g); Green Sun Medical (e,g)
Markku Biedermann	United States	Biedermann Motech (e,f)
Laurel C. Blakemore, MD	United States	Stryker Spine (g)
René M. Castelein, MD, PhD	Netherlands	Stryker Spine (a)
Dong-Gune Chang, MD, PhD	South Korea	No Relationships
Kenneth M. Cheung, MD, MBBS, FRCS	China	Medtronic (b); NuVasive (a,b); Globus Medical (b); Avalon spinecare (a); AO Spine (a); OrthoSmart (g)
Robert H. Cho, MD	United States	DePuy Synthes (b,e); NuVasive (b); OrthoPediatrics (b); Prosidyan (b); Ergobaby (b,e)
David B. Cohen, MD	United States	No Relationships
Aina J. Danielsson, MD, PhD	Sweden	No Relationships
Gustavo B. L. de Azevedo, MD		No Relationships
Tobias Degsell, MD	United States	No Relationships
Robert K. Eastlack, MD	United States	Alphatec Spine (c); Aesculap (b,g); Globus Medical (g); Stryker Spine (e); NuVasive (a,b,c,g); SI Bone (a,b,c,g); Stryker Spine (e); Spine Innovation (c); Seaspine (a,b,c,g); San Diego Spine Foundation (e); Carevature (b); Medtronic (b); Spinal Elements (b)
Peter W. Ferlic, MD, PhD	Austria	DePuy Synthes (a,b); NuVasive (a,b)
Charla R. Fischer, MD	United States	Globus Medical (b); Stryker Spine (b); Zimmer Biomet (b)
Nicholas D. Fletcher, MD	United States	Medtronic (b,d,e); OrthoPediatrics (b,d); NuVasive (b); Zimmer Biomet (d)

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Kai-Ming Gregory Fu, MD	United States	DePuy Synthes (b); Medtronic (b); Misonix (b)
Steven D. Glassman, MD	United States	Medtronic (b,g); Medtronic (a); Stryker Spine (b); Norton Healthcare (f); American Spine Registry (e); NuVasive (a); Integra (a); Intellirod (a); Pfizer (a); International Spine Study Group (a); Medtronic (a)
Tenner Guillaume, MD	United States	Zimmer Biomet (b); NuVasive (b)
Regis W. Haid Jr., MD	United States	Globus Medical (c,g); Medtronic (g); NuVasive (b,c,g); SpineWave (c); Remedy Health (Formerly Vertical Health, formerly SpineUniverse) (c); University of Miami (Honorarium) (g); University of Iowa (Honorarium) (g); Cervical Spine and Decompression & Stabilization (Honorarium) (g); UC Davis Health, Dept. of Neurological Surgery (Honorarium) (g)
Juergen Harms, MD	United States	No Relationships
Kazuhiro Hasegawa, MD, PhD	Japan	No Relationships
Ilkka J. Helenius, MD, PhD	Finland	Medtronic (a,b); Stryker Spine (a,b); NuVasive (a); Globus Medical (b); Cerapedics (a)
Hwee Weng Dennis Hey, MD	Singapore	NuVasive (b,g); Joimax (b,g); Centinel Spine (b,g); Elliquence (g); Medtronic (g); DePuy Synthes (g)
Brian Hsu, MD	Australia	Stryker Spine (d,g)
Charles E. Johnston, MD	United States	Medtronic (g); Elsevier (g)
Han Jo Kim, MD	United States	Zimmer Biomet (g); Stryker Spine (g); Alphatec Spine (b); Surgical Acuity (g); Vivex Biologics (e); Aspen Medical (e); SI Bone (a); NuVasive (b)
Eric O. Klineberg, MD	United States	DePuy Synthes (b); Stryker Spine (b); Medtronic (b); AOSpine (a,e); SonoStem (e)
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A. Noelle Larson, MD	United States	Globus Medical (b); OrthoPediatrics (b); Zimmer Biomet (b); Medtronic (b)
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Stephen J. Lewis, MD, FRCS(C)	Canada	Medtronic (a,d); Stryker Spine (b,d,e); DePuy Synthes (a); Scoliosis Research Society (d); AO Spine (a,d,e)
Elizabeth L. Lord, MD	United States	Medtronic (b)
W.G. Stuart Mackenzie, MD	United States	No Relationships
David S. Marks, FRCS, FRCSOrth	United Kingdom	No Relationships
Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth	United Kingdom	Stryker Spine (a,b,g); DePuy Synthes (a); NuVasive (a); POSNA (a); FDA (a); Growing Spine Foundation (a); Childrens' Spine Foundation (a); Elite Health Services (c); AO Spine (d)
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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Gregory M. Mundis, MD	United States	Stryker Spine (g); NuVasive (a,b,c,e,g); SeaSpine (a,b,e); VISEON (b,e); Carlsmed (b,c)
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Christopher J. Nielsen, MD	Canada	No Relationships
Pierce D. Nunley, MD	United States	Stryker Spine (b,g); Zimmer Biomet (g); NG Medical (b); Spineology (b,c,g); Camber Spine (e); IMSE (b,d,g); Accelus Spine (b,g); Kuros (b,d); Intrinsic Therapeutics (d); NEO Spine (b,d); Regeltec (b,e); NuVasive (b,d)
Thierry A. Odent, MD, PhD	France	No relationships
Acke Ohlin, MD, PhD	Sweden	No Relationships
David O. Okonkwo, MD	United States	NuVasive (b,g); Zimmer Biomet (b,g)
Joshua M. Pahys, MD	United States	DePuy Synthes (b); NuVasive (b); Zimmer Biomet (b)
Paul Park, MD	United States	Globus Medical (b,g); NuVasive (b,g); DePuy Synthes (a,b); ISSG (a); SI Bone (a); Cerapedics (a)
Nicolas Plais, MD	Spain	Medtronic (b); Spinewave (c)
David W. Polly, MD	United States	SI Bone (b,g); Globus Medical (b,g); Medtronic (a,g); MizuhoOSI (a); Springer (g)
Selina C. Poon, MD	United States	No Relationships
Gregory Redding, MD	United States	UpToDate (b)
Pierre Roussouly, MD	France	SMAIO (b,c,g)
Michael Ruf, MD	Germany	No Relationships
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Frank J. Schwab, MD	United States	Globus Medical (b); International Spine Study Group (e); Zimmer Biomet (b,g); Medtronic (b,g); VFT Solutions, See Spine (c); Zimmer Biomet (b,g)
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Se-Il Suk, MD, PhD	South Korea	No Relationships
Juan S. Uribe, MD	United States	NuVasive (a,b,c,g); Misonix (b); SI Bone (b); Alphatec Spine (a,b,c,g); mainstay medical (b)
Michael Y. Wang, MD	United States	Medtronic (b); Stryker Spine (b); DePuy Synthes (b,g); Spineology (b); ISD (c); Medical Device Partners (c); Kinesiometrics (c)
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Michelle C. Welborn, MD	United States	DePuy Synthes (b,d,e); Stryker Spine (b,d); NuVasive (b,d); Zimmer Biomet (a,d,e)
Klane K. White, MD	United States	Biomarin (a,b,e); Ultragenyx (a); Ascendis (a); Theracon (a)
Caglar Yilgor, MD	Turkey	No Relationships
Qianyu Zhuang, MD	China	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
AUTHORS (IF NOT LISTED ABOVE)		
Alex Aabedi, MD	United States	No Relationships
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Tahmina Achekzai, BS	United States	No Relationships
Sarah Acselrod, BA	United States	No Relationships
Biodun Adeniyi, MD, MS	United States	No Relationships
Nitin Agarwal, MD	United States	Thieme Medical Publishers (g); Springer International Publishing (g)
Nadav Ahituv, PhD	United States	No Relationships
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Chibuzo Akalonu, MD	United States	No Relationships
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Izzet Akosman, BS	United States	No Relationships
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Arin Alanay	Turkey	No Relationships
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Terry D. Amaral, MD	United States	No Relationships
Faraz Amzajerdian, BS	United States	No Relationships
Anita Anand, BS	United States	No Relationships
Jason B. Anari, MD	United States	DePuy Synthes (b)
Thomas B. Andersen, MD, PhD, DMSc	Denmark	No Relationships
Brad Anderson, BS	United States	No Relationships
Kathryn B. Anderson, BS	United States	No Relationships
Peter D. Angevine, MD	United States	No Relationships
Fares Ani, MD	United States	No Relationships
Ryohei Annen, MD	Japan	No Relationships
Lilian Antunes, PhD	United States	No Relationships
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Hideyuki Arima, MD, PhD	Japan	No Relationships
Monica Arney, MD	United States	No Relationships
Jahangir K. Asghar, MD	United States	NuVasive (b,g); Medtronic (b e,g); EOS Imaging (d); fore web (b,g); minus (b,g); Stryker Spine (b); Misonix (b); Seaspine (b); Surgentech (b,e)
Ali Asma, MD	United States	No Relationships
Ayman Assi, PhD	Lebanon	No Relationships
Carl-Eric Aubin, PhD	Canada	Medtronic (a,b); GreenSun Medical (a)
Mehmet Aydogan, MD	Turkey	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Elma Ayoub, BS	Lebanon	No Relationships
Olufemi Babalola, MS, MHS	United States	No Relationships
Andrew-Gerard Baddoo, BS	United States	No Relationships
Christopher Baird, MD	United States	No Relationships
Baris Balaban	Turkey	No Relationships
Sriram Balasubramanian, PhD	United States	No Relationships
Christine Baldus, RN	United States	No Relationships
Keith Baldwin, MD, MD, MPH, MSPT	United States	Pfizer Inc. (c)
Tomohiro Banno, MD, PhD	Japan	No Relationships
Ankita Bansal, MBBS, MS	Canada	No Relationships
Hongda Bao, MD	China	No Relationships
Adriana Barba	United States	No Relationships
Soraya Barchi, BSc	Canada	No Relationships
Tanvir J. Bari, MD	Denmark	No Relationships
Ryan Baron, BS	United States	No Relationships
Carrie E. Bartley, MA	United States	No Relationships
Ozgur Basal, MD	Turkey	No Relationships
Tracey P. Bastrom, MA	United States	No Relationships
Natasha Bath, RN	Canada	No Relationships
Ryan Berger, MD	United States	No Relationships
George A. Beyer, MS	United States	No Relationships
Babak H. Beygi, PhD	China	No Relationships
Ni Bi, MD	China	No Relationships
Craig M. Birch, MD	United States	No Relationships
Benoit Bissonnette	Canada	No Relationships
Micah Blais, MD	United States	No Relationships
Andrew Blandino, PhD	United States	No Relationships
Benjamin Blondel, MD, PhD	France	Medicrea / Medtronic (b); Stryker Spine (b); Implanet (b); Clariance (b); 3M (b)
Oheneba Boachie-Adjei, MD	Ghana	Stryker Spine (a,b,e,g); WEIGAO (b,d)
Venkat Boddapati, MD	United States	No Relationships
Louis Boissiere, MD	France	Neo (b); Euros (b); Medicrea/Medtronic (b)
Claire Bonnyman, BS	United States	No Relationships
Anouar Bourghli, MD	Saudi Arabia	No Relationships
Daniel Bouton, MD	United States	Medtronic (b)
James R. Bowen, MD	United States	No Relationships
Felix L. Brassard, MD	Canada	No Relationships
John T. Braun, MD	United States	Zimmer Biomet (b,g)
Sarah Brennenstuhl, PhD	Canada	No Relationships
Keith H. Bridwell, MD	United States	No Relationships
Jonathan Brodeur, BS	United States	No Relationships
Jaysson T. Brooks, MD	United States	DePuy Synthes (b); OrthoPediatrics (b)

If noted, the relationships disclosed as are 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.)

CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Morgan Brown, MS	United States	Norton Healthcare (f); Pfizer (a); Texas Scottish Rite Hospital (a); Alan L. & Jacqueline B. Stuart Spine Research (a); Cerapedics, Inc. (a); Scoliosis Research Society (SRS) (a); Medtronic (a)
Damian Brusko, MD	United States	No Relationships
Xochitl Bryson, BA	United States	No Relationships
Avery L. Buchholz, MD	United States	Medtronic (b); Siemens Healthcare (b); Alphatec Spine (b)
Thomas Buell, MD	United States	No Relationships
David B. Bumpass, MD	United States	Medtronic (b,d)
Denver A. Burton, MD	United States	No Relationships
Mohamad Bydon, MD	United States	No Relationships
Eli M. Cahan, BBA	United States	No Relationships
YinQi Cai, MS	China	No Relationships
Richard E. Campbell, MD	United States	No Relationships
Fiona Campbell, MD	Canada	No Relationships
Maria Capdevila Bayo, MS	Spain	No Relationships
Anthony Capraro, MBS	United States	No Relationships
Ashley Carpenter, MS	United States	No Relationships
Leah Y. Carreon, MD	United States	Medtronic (a); Pfizer, Cerapedics, Empirical Spine (a); Stryker Spine (a)
Anthony A. Catanzano, MD	United States	No Relationships
Derek T. Cawley, MD	Ireland	No Relationships
Meghan Cerpa, MPH	United States	No Relationships
Stefano Cervellati, MD	Italy	No Relationships
Celine Chaaya, BS	Lebanon	No Relationships
Charles M. Chan, MD	United States	No Relationships
Jerry Kwok To Chan	China	No Relationships
Victor Kin Wai Chan	China	No Relationships
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Andrew K. Chan, MD	United States	No Relationships
Hani Chanbour, MD	United States	No Relationships
Yu-Hui F. Chang, PhD	United States	No Relationships
Stuart Changoor, MD	United States	No Relationships
Anastasios Charalampidis, MD	Sweden	No Relationships
Yann Philippe Charles, MD, PhD	France	Stryker Spine (a,b); Clariance (a,b); Ceraver (b); SpineVision (b); Medtronic (a); Philips (a)
Bosco Kin Pok Chau	China	No Relationships
Olivier Chémaly, MD	Canada	No Relationships
Chih-Wei Chen, MD	Taiwan	No Relationships
I-Hsin Chen, MD	Taiwan	No Relationships
Allen L. Chen, PhD, PMP	United States	No Relationships
Jack C. Cheng, MD	China	No Relationships
Christopher Cheng, MD	United States	No Relationships
Prudence Wing Hang Cheung, BDSc (Hons)	China	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Jason Pui Yin Cheung, MD, MBBS, MS, FRCS	China	No Relationships
Sai S. Chilakapati, MS	United States	No Relationships
Tian Fu Chin, MBBS	Malaysia	No Relationships
Chee Kidd Chiu, MBBS, MSOrth	Malaysia	No Relationships
Samuel K. Cho, MD	United States	Globus Medical (a,g); Stryker Spine (b); Medtronic (a)
Pyung Goo Cho, PhD	South Korea	No Relationships
Woojin Cho, MD, PhD	United States	No Relationships
Derek Wai Yin Chung	China	No Relationships
Weng Hong Chung, MD, MSOrth	Malaysia	No Relationships
Abigail Clark, MEng	United States	No Relationships
Daniel Coban, MD	United States	No Relationships
Ryan Coghlan, MS	United States	Pfizer (b,g); QED therapeutics (b,g); Biomarin (b,g)
Theresa Collins-Jones, MD	United States	No Relationships
Caroline Constant, DMV	Switzerland	No Relationships
Claudio Cordani, PT	Italy	No Relationships
Maxence Coulombe, BEng	Canada	No Relationships
Josephine R. Coury, MD	United States	No Relationships
Dennis G. Crandall, MD	United States	Medtronic (g); Spinewave (b,g); Handel (c)
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Melissa T. Cuevas, MS	United States	No Relationships
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Christy L. Daniels, MS	United States	Norton Healthcare (f); Pfizer (a); Texas Scottish Rite Hospital (a); Alan L. & Jacqueline B. Stuart Spine Research (a); Cerapedics, Inc. (a); Scoliosis Research Society (SRS) (a); Medtronic (a)
Alan H. Daniels, MD	United States	Orthofix (a,b); EOS Imaging (b); Stryker Spine (b); Spineart, Southern Spine, Springer, Medicrea, Medtronic (b)
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Lorenzo Deveza, MD, PhD	United States	Lento Medical Inc. (b)
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Vincent Devlin, MD	United States	No Relationships
Ekamjeet Dhillon, MD	United States	No Relationships
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Michael Dinizo, MD		No Relationships
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Hope Douglas, VMD	United States	No Relationships
Casper Dragsted, MD, PhD	Denmark	No Relationships
Huakang Du, BS	China	No Relationships
Ian Duncan, PhD	United States	No Relationships
Conor J. Dunn, MD	United States	No Relationships

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NAME	COUNTRY	DISCLOSURE(S)
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Benjamin D. Elder, MD, PhD	United States	DePuy Synthes (b); Injectsense (c,e); SI Bone (a); Stryker Spine (a)
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Dawn M. Elliott, PhD	United States	No Relationships
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Arash Emami, MD	United States	NuVasive (a)
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Meric Enercan, MD	Turkey	No Relationships
Yigit Erdag, MD	Turkey	No Relationships
Ali Eren, MD	Canada	No Relationships
Gokhan Ergene, MD	Turkey	No Relationships
Fernando Escamez, MD	Spain	No Relationships
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Marc Fakhoury, MS	Lebanon	No Relationships
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Adam N. Fano, BS	United States	No Relationships
Sofia Federico	United States	No Relationships
Erwei Feng, MD	China	No Relationships
Nicomedes Fernández-Baíllo, MD	Spain	No Relationships
Emmanuelle Ferrero, MD, PhD	France	Implanet (b)
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Mitchell Fourman, MD, MPhil	United States	No Relationships
David J. Fralinger, MD	United States	No Relationships
Paul Frechon, MD	France	No Relationships
Brett A. Freedman, MD	United States	Medtronic (a,g); Clear Choice Therapeutics, Inc (c,g); Ankasa (a)
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Sumeet Garg, MD	United States	No Relationships
Giosuè Gargiulo, MD	Italy	No Relationships
Mathilde Gaume, MD	France	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
David Gebben, PhD	United States	No Relationships
Martin Gehrchen, MD, PhD	Denmark	Medtronic (a,d); Stryker Spine (a,d); Globus Medical (d); Cerapedics (a)
Stephen G. George, MD	United States	No Relationships
John P. Ghazi, MD	United States	No Relationships
William H. Gillon, BS	United States	No Relationships
Massimo Girardo, MD	Italy	No Relationships
Mika Gissler, PhD	Finland	No Relationships
Felipe Giuste, BS	United States	No Relationships
Halil Gok, MD	Turkey	No Relationships
David J. Goldberg, MD	United States	No Relationships
James Gordon, MS	United States	No Relationships
Ankur Goswami, MD	United Kingdom	No Relationships
Jacob Greenberg, BS	United States	No Relationships
Ib J. Green-Petersen, MD	Sweden	No Relationships
Harsh Grewal, MD, FACS, FAAP	United States	Zimmer Biomet (b); Auctus Surgical (c)
Eliot B. Grigg, MD	United States	No Relationships
Nick Grishin, PhD	United States	No Relationships
Denisa Grofova, BS	United States	No Relationships
Brian E. Grottkau, MD	United States	3D Biotherapeutics Inc (c)
Alfredo J. Guiroy, MD	United States	No Relationships
Ogulcan Guldeniz, MS, BS	China	No Relationships
Aditi Gupta, PhD	United States	No Relationships
Anuj Gupta, MD	India	No Relationships
Christina Gurnett, MD, PhD	United States	No Relationships
Nadav Gutman, MD	United Kingdom	No Relationships
Aymeric Guy, MS	Canada	No Relationships
Bharath H. D, MBBS, MS	India	No Relationships
Yoon Ha, MD, PhD	South Korea	No Relationships
Alex Ha, MD	United States	No Relationships
Lawrence L. Haber, MD	United States	OrthoPediatrics (b,c,g); Zimmer Biomet (d)
Sleiman Haddad, MD, PhD, FRCS	Spain	No Relationships
Alexander Hafey	United States	No Relationships
Kimberly E. Hall, MD	United States	No Relationships
Kristen Halvorsen, MD	United States	No Relationships
Dae-Woong Ham, MD	South Korea	No Relationships
Hooman Hamedani, BS	United States	No Relationships
D. Kojo Hamilton, MD, FAANS	United States	Prosydian (a); NuVasive (a)
Azmi Hamzaoglu, MD	Turkey	Medtronic (a,b)
Makoto Handa, MD	Japan	No Relationships
You Hao, PhD	United States	No Relationships
Doris M. Hardacker, MD	United States	No Relationships
Kyle Hardacker, MD	United States	No Relationships
Christina K. Hardesty, MD	United States	OrthoPediatrics (b,g); Medtronic (b)

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Jennifer Harpe-Bates, DNAP	United States	Medtronic (b)
Andrew B. Harris, MD	United States	No Relationships
Robert A. Hart, MD	United States	DePuy Synthes (b); Globus Medical (b); Medtronic (b); Seaspine (b); Orthofix (b)
Sayyida Hasan, BS	United States	No Relationships
Tomohiko Hasegawa, MD, PhD	Japan	No Relationships
Fthimnir Hassan, MPH	United States	No Relationships
Susanna Heiskanen, MD	Finland	No Relationships
Linda Helenius, MD, PhD	Finland	Medtronic (a); Stryker Spine (a)
Woon Theng Heng, MBBS	Malaysia	No Relationships
Mark Herbert, BS	United States	No Relationships
John A Herring, MD	United States	Medtronic (g)
Lloyd A. Hey, MD	United States	No Relationships
Jessica H. Heyer, MD	United States	No Relationships
Rachel Hilliard	United States	No Relationships
Jeffrey M. Hills, MD	United States	No Relationships
Coleman Hilton, MS	United States	No Relationships
Bren Hines, RN	United States	No Relationships
Dan Hoernschemeyer, MD	United States	Zimmer Biomet (a,b); OrthoPediatrics (b,c); Biomarin (d)
Erin M. Honcharuk, MD	United States	No Relationships
Daniel Hong, MD	United States	No Relationships
MA Hongru, MD	China	No Relationships
Klaus Hopster, DVM, PhD, DECVAA	United States	No Relationships
Naobumi Hosogane, MD, PhD	Japan	No Relationships
Richard Hostin, MD	United States	No Relationships
Jason J. Howard, MD	United States	No Relationships
M. Timothy Hresko, MD	United States	No Relationships
Ming-Hsiao Hu, MD	Taiwan	No Relationships
Zongshan Hu, PhD	China	No Relationships
Lik Hang Alec Hung, MD	China	No Relationships
Jennifer K. Hurry, MASc	Canada	No Relationships
Ki S. Hwang, MD	United States	Centinel (a); Stryker Spine (b)
Tina L. Iannacone, BSN	United States	No Relationships
Koichiro Ide, MD	Japan	No Relationships
Shiro Ikegawa, MD, PhD	Japan	No Relationships
Brice Ilharreborde, MD, PhD	France	Implanet (b); Medtronic (b); Zimmer Biomet (b)
Bailey Imbo, BA	United States	No Relationships
Meghan N. Imrie, MD	United States	No Relationships
Carlo Iorio, MD	Canada	No Relationships
Lisa Isaac, MD, FRCP(C)	Canada	No Relationships
Masaaki Ito, MD, PhD	Japan	No Relationships
Henry J. Iwinski, MD	United States	No Relationships
Rajiv Iyer, MD	United States	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Elena Jaber, BS	Lebanon	No Relationships
Amit Jain, MD	United States	Stryker Spine (b); DePuy Synthes (b); Globus Medical (b)
Nadine M. Javier, BS	United States	No Relationships
Arvind Jayaswal, MD	India	No Relationships
Russell W. Jennings, MD	United States	No Relationships
Yang Jiao, MBBS	China	No Relationships
Bharadwaj Jilakara, BA	United States	No Relationships
Jose Jimenez, MD	United States	No Relationships
Taylor R. Johnson, MD	United States	No Relationships
Mitchell A. Johnson, BS	United States	No Relationships
Julie Joncas, RN	Canada	No Relationships
Soren Jonzzon, MD	United States	No Relationships
Rachel Joujon-Roche, BS	United States	No Relationships
Stephen Kadlecek, PhD	United States	No Relationships
Sheila Kahwaty, PA-C	United States	No Relationships
Adam S. Kanter, MD	United States	NuVasive (e,g); Zimmer Biomet (b,g)
Selhan Karadereler, MD	Turkey	No Relationships
Ilkay Karaman, MD	Turkey	No Relationships
Duru Karasoy, PhD	Turkey	No Relationships
Satoshi Kato, PhD	Japan	No Relationships
Japsimran Kaur, BS	United States	No Relationships
Noriaki Kawakami, MD, DMSc	Japan	Medtronic (b); KISCO (b); Japan Spinal Deformity Institution (e); ZImmer (b)
Sachiko Kawasaki, MD	Japan	No Relationships
Georges Kawkabani, MD, MS	Lebanon	No Relationships
Ozcan Kaya, MD	Turkey	No Relationships
Floreana N. Kebaish, MD	United States	No Relationships
Ho Man Kee, MS	China	No Relationships
Brian A. Kelly, MD	United States	Medtronic (b)
Jawad Khalifeh, MD	United States	No Relationships
Babak Khandehroo, MD	United States	No Relationships
Anas M. Khanshour, PhD	United States	No Relationships
Nejib Khouri, MD	France	No Relationships
Yared Kidane, PhD	United States	No Relationships
David C. Kieser, MD, PhD	New Zealand	No Relationships
Andrew J. Kim	United States	No Relationships
Nigel Kim, MS	United States	No Relationships
Kyung Hyun Kim, PhD	South Korea	No Relationships
Sang Hyun Kim, PhD	South Korea	No Relationships
Ho-Joong Kim, MD	South Korea	No Relationships
Peri Kindan, MD	Turkey	No Relationships
Abdukahar Y. Kiram, PhD	China	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Christopher J. Kleck, MD	United States	Medtronic (a,b,e); Medacta (b); SI Bone (a); Globus Medical (a); Synergy (a); Orthofix (a); Biocomposites (b); Allosource (b); SeaSpine (a)
Frank S. Kleinstueck, MD	Switzerland	DePuy Synthes (a,d)
Lydia R. Klinkerman, BS	United States	No Relationships
Tetsuya Kobayashi, MD, PhD	Japan	No Relationships
Motoya Kobayashi, MD	Japan	No Relationships
Jonathan Koch, MD	United Kingdom	No Relationships
Yoshinao Koike, MD	Japan	No Relationships
Heiko Koller, MD	Germany	No Relationships
Ryan Kong, BS	United States	No Relationships
Toshiaki Kotani, MD, PhD	Japan	No Relationships
Robert Koucheki, HBSc	Canada	No Relationships
Martin Koyle, MD, FRCS(C)	Canada	No Relationships
Joseph Ivan Krajbich, MD	United States	No Relationships
Oscar Krol, BS	United States	No Relationships
Brianna Kuhse, BS	United States	No Relationships
Preetika Kulkarni	United States	No Relationships
Eren Kuris, MD	United States	Seaspine (b); Spineart (b)
Kenta Kurosu, MD	Japan	No Relationships
Mun Keong Kwan, MBBS, MSOrth	Malaysia	No Relationships
Ohsang Kwon, MD	South Korea	No Relationships
Matthew E. LaBarge, BS	United States	No Relationships
Hubert Labelle, MD	Canada	Spinologics Inc (c,g); Rodin4D (g); Boston Brace (a)
Renaud Lafage, MS	United States	No Relationships
Po-Liang Lai, MD	Taiwan	No Relationships
Rachel Lai, BA	United States	No Relationships
Nikita Lakomkin, MD	United States	No Relationships
Tsz-Ping Lam, MBBS	China	No Relationships
Vincent Lamas, MD	France	No Relationships
Robert S. Lang, MD	United States	No Relationships
Joanna L. Langner, MS	United States	No Relationships
Fethi Laouissat, MD	France	SMAIO (b); Spineart (b)
Daniel Larrieu, PhD	France	No Relationships
Rufina Wing Lum Lau, PT	China	No Relationships
David F. Lawlor, MD	United States	No Relationships
Bruno Lazaro, MD	United States	No Relationships
Jordan Lebovic, BA	United States	No Relationships
Yuan-Fuu Lee, MD	Taiwan	No Relationships
Wayne YW Lee, PhD	China	No Relationships
Sang Hun Lee, MD	United States	Medtronic (b); DePuy Synthes (b); Elliquence (d)
Nathan J. Lee, MD	United States	No Relationships
Ronald A. Lehman, MD	United States	Medtronic (b,g); Stryker Spine (b,g); Department of Defense (a)

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Maarit K. Leinonen, MD, PhD	Finland	No Relationships
Stanley Ho Fung Leung	China	No Relationships
Eric Leung, BS	United States	No Relationships
Jean-Christophe A. Leveque, MD	United States	NuVasive (d)
David Levin, MD, FRCS(C)	Canada	No Relationships
Xiao-Yan Li, PhD	United States	No Relationships
Yang Li, PhD	China	No Relationships
Jie Li, MD	China	No Relationships
Song Li, MD, PhD	China	No Relationships
Quan Li, MD	China	No Relationships
Tao Li, MD	China	No Relationships
Steele I. Liles, BS	United States	No Relationships
Jiachen Lin, MD, PhD	China	No Relationships
Breton G. Line, BS	United States	International Spine Study Group (b)
Zhen Liu, PhD	China	No Relationships
Lian Liu, MD	China	No Relationships
Wanyou Liu, MS	China	No Relationships
Changwei Liu, MD	China	No Relationships
Xue-cheng Liu, MD, PhD	United States	No Relationships
Amanda Liu, BS	China	No Relationships
Kerstin Lofdahl Hallerman, MD, PhD	Sweden	No Relationships
Joseph M. Lombardi, MD	United States	No Relationships
Michael Longo, BA	United States	No Relationships
Baron S. Lonner, MD	United States	DePuy Synthes (a,b,d,e,g); Zimmer Biomet (b,g); OrthoPediatrics (a,b,c,e); Spine Search (c); Setting Scoliosis Straight Foundation (a,e)
Carina Lott, MS	United States	No Relationships
Craig R. Louer, MD	United States	NSite Medical (e)
Francis C. Lovecchio, MD	United States	No Relationships
Luis Loza, BS	United States	No Relationships
Brett Lullo, MD	United States	No Relationships
Andrew J. Luzzi, MD	United States	No Relationships
Keith Lyons, MD	United States	No Relationships
Masayoshi Machida, MD	Canada	No Relationships
William G. Mackenzie, MD	United States	Biomarin (a,e)
Jean-Marc Mac-Thiong, MD, PhD	Canada	DePuy Synthes (a); Medline Industries (a); Medtronic (a); Spinologics and subsidaries (c,e); Abbvie (a); Asahi Kasei Pharma (a)
Luigi Magnano, MD	Sweden	No Relationships
Marcus Malmqvist, MD	Sweden	No Relationships
Aniruddh Mandalapu	United States	No Relationships
Sai-hu Mao, PhD	China	No Relationships
Hilal Maradit Kremers, MD	United States	No Relationships
Gerard F. Marciano, MD	United States	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Adam Margalit, MD	United States	No Relationships
Michelle Claire Marks, PT	United States	Setting Scoliosis Straight (f)
Javier Martínez, PhD, MS	Spain	No Relationships
Jeffrey E. Martus, MD	United States	No Relationships
Abir Massaad, PhD	Lebanon	No Relationships
Smitha E. Mathew, MBBS	United States	No Relationships
Nabil Matmati, PhD	United States	No Relationships
Morio Matsumoto, MD, PhD	Japan	NuVasive (a,b); Medtronic (a); Kyocera (a)
Hiroko Matsumoto, PhD	United States	Pediatric Spine Foundation (Pediatric Spine Study Group) (b)
Yukihiro Matsuyama, MD, PhD	Japan	No Relationships
Mikko Mattila, MD, PhD	Finland	No Relationships
Oscar H. Mayer, MD	United States	No Relationships
Anna McClung, BSN	United States	No Relationships
Christopher L. McDonald, MD	United States	No Relationships
Joseph M. McDonough, MS	United States	No Relationships
Maureen McGarry, BS, BBE	United States	No Relationships
Christopher B. McLeod, MD	United States	No Relationships
Kyle D. Meadows	United States	No Relationships
Andrew Megas, DO	United States	No Relationships
Elio Mekhael, BS	Lebanon	No Relationships
Marco Meli, MD	Italy	No Relationships
Gregory A. Mencio, MD	United States	No Relationships
Emmanuel N. Menga, MD	United States	Evolution Spine (b,g); Globus Medical (b)
Addisu Mesfin, MD	United States	Globus Medical (a); DePuy Synthes (d); Axiomed (c); Medtronic (d); Stryker Spine (d)
Giorgos Michalopoulos, MD	United States	No Relationships
Yuki Mihara, MD, PhD	Japan	No Relationships
Anthony L. Mikula, MD	United States	No Relationships
Lotfi Miladi, MD	France	EUROS Company (g)
Todd A. Milbrandt, MD, MS	United States	Medtronic (b); OrthoPediatrics (b); Zimmer Biomet (b); Viking Scientific (c); Nview (b)
Nancy H. Miller, MD, PhD	United States	No Relationships
Firoz Miyanji, MD	Canada	DePuy Synthes (b); Zimmer Biomet (b,g); Stryker Spine (b); AO Fracture, Tumour, and Deformity Expert Group (e)
Kouzaburou Mizutani, MD	Japan	No Relationships
Kevin C. Mo, BS, MHA	United States	No Relationships
Courtney Moltzen, BS	United States	No Relationships
Anna Monley, BS	United States	No Relationships
Blake Montgomery, MD	United States	No Relationships
Axel C. Moore, PhD	United States	No Relationships
Harold G. Moore, BS	United States	No Relationships
Lucía Moreno-Manzanaro, BS	Spain	No Relationships
Paul Moroz, MD	United States	No Relationships
Cole Morrissette, MS	United States	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Hamisi M. Mraja, MD	Turkey	No Relationships
Frederick Mun, BS	United States	No Relationships
Hideki Murakami, MD, PhD	Japan	No Relationships
Joshua S. Murphy, MD	United States	DePuy Synthes (b,e); OrthoPediatrics (a,b); Astura Spine (g)
Farah Musharbash, MD	United States	No Relationships
Ayhan Mutlu, MD	Turkey	No Relationships
Wanis Nafo, PhD	South Korea	No Relationships
Satoshi Nagatani, MD	Japan	No Relationships
Narihito Nagoshi, MD, PhD	Japan	No Relationships
Keiichi Nakai, MD	Japan	No Relationships
Masaya Nakamura, MD, PhD	Japan	No Relationships
Keita Nakayama, MD	Japan	No Relationships
Rajkishen Narayanan, MD	United States	No Relationships
Zeina Nasser, PhD, MSc	Lebanon	No Relationships
Nabil Nassim, BS	Lebanon	No Relationships
Kevin M. Neal, MD	United States	OrthoPediatrics (b,g)
Alberto Negrini	Italy	ISICO (Italian Scientific Spine Institute) (c)
Venu M. Nemani, MD, PhD	United States	Medtronic (b,d); NuVasive (d); Stryker Spine (d)
Adam Nessim, BS	United States	No Relationships
Brian J. Neuman, MD	United States	Baxter (d)
Harrah R. Newman	United States	No Relationships
Sung Hyun Noh, MD	South Korea	No Relationships
Ayato Nohara, MD	Japan	No Relationships
Satoshi Nori, MD, PhD	Japan	No Relationships
Wendy M. Novicoff, PhD	United States	No Relationships
Susana Núñez Pereira, MD	Spain	No Relationships
Eli O'Brien, BS	United States	No Relationships
Susan Odum, PhD	United States	Medtronic (b)
Shin Oe, MD	Japan	Medtronic (g); Japan Medical Dynamic Marketing (g); Jyuzen Memorial Hospital (g)
Matthew E. Oetgen, MD	United States	No Relationships
Inez Oh, PhD	United States	No Relationships
Tetsuya Ohara, MD	Japan	No Relationships
Soren Ohrt-Nissen, MD, PhD	Denmark	No Relationships
Hiroki Okayasu, MD	Japan	No Relationships
Mattan R. Orbach	United States	No Relationships
Omer Orhun	Turkey	No Relationships
Carlos D. Ortiz-Babilonia, BS	United States	No Relationships
Joseph A. Osorio, MD, PhD	United States	Medtronic (b,e); Alphatec Spine (b); DePuy Synthes (b,e); Carslmed (e)
Nao Otomo, MD	Japan	No Relationships
Matthew Owen, BS	United States	No Relationships
Derrick Owusu Nyantakyi, MPH	Ghana	No Relationships
Stephane Owusu-Sarpong, MD	United States	No Relationships

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CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Alp Ozpinar	United States	No Relationships
Robert Palmer, MD	United States	No Relationships
Matteo Palmisani, MD	Italy	No Relationships
Rosa Palmisani, MD	Italy	No Relationships
Naveen Pandita, MS	United Kingdom	No Relationships
Yesha Parekh, BS	United States	No Relationships
Eric C. Parent, PhD	Canada	No Relationships
Paul J. Park, MD	United States	No Relationships
Peter G. Passias, MD	United States	Zimmer Biomet (b); Allosource (g); CSRS (a); Globus Medical (g); Medtronic (b); SpineWave (b); Terumo (b)
Kevin Patel, M.R.	United States	No Relationships
Mohammed Shakil Patel, FRCS	United Kingdom	No Relationships
Neil Patel, BS	United States	No Relationships
Carl B. Paulino, MD	United States	No Relationships
Philip Payne, PhD	United States	Abbott (e); Philips Healthcare (e)
Raquel Peat, PhD, MS, MPH	United States	No Relationships
Tuna Pehlivanoglu, MD	Turkey	No Relationships
Jimin Pei, PhD	United States	No Relationships
Matias Pereira Duarte, MD	Canada	No Relationships
Francisco Javier S. Perez-Grueso, MD	Spain	No Relationships
Tanja Perokorpi, MS	Finland	No Relationships
Govindaraja Perumal Vijayaraghavan, MBBS, MS	India	No Relationships
Sebastien Pesenti, MD, PhD	France	No Relationships
Maty Petcharaporn, BS	United States	No Relationships
Tiffany N. Phan	United States	No Relationships
Gregory Photopoulos, BHSc	Canada	No Relationships
Helene Pillet, PhD	France	No Relationships
Zachariah W. Pinter, MD	United States	No Relationships
Stephen Plachta, MD	United States	No Relationships
Connie Poe-Kochert, RN	United States	No Relationships
Kwadwo Poku Yankey, MD	Ghana	No Relationships
Michael Pompliano, MD	United States	No Relationships
Kiley F. Poppino, BS	United States	No Relationships
D. Dean Potter, MD	United States	Medtronic (b)
Greg Poulter, MD	United States	Medtronic (a,b,e,g)
Harilla Profka, BS	United States	No Relationships
Solène Prost, MD	France	No Relationships
Themistocles S. Protopsaltis, MD	United States	Globus Medical (b); NuVasive (b); Stryker Spine (b); Medtronic (b); Altus (g); SpineAlign (g); Torus Medical (g); 3Spine (a,g); Medtronic (a,g)
Varun Puvanesarajah, MD	United States	No Relationships
Bangping Qian, MD	China	No Relationships
Yiwen Qian, BS	United States	No Relationships

If noted, the relationships disclosed as are 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.)

CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Xiaodong Qin, PhD	China	No Relationships
Catherine Qiu, MS	United States	No Relationships
Alejandro Quinonez, BS	United States	No Relationships
Nasir A. Quraishi, PhD, FRCS	United Kingdom	No Relationships
Micheal Raad, MD	United States	No Relationships
Rami Rachkidi, MD, MSc	Lebanon	No Relationships
Lærke C. Ragborg, MD	Denmark	No Relationships
Arimatias Raitio, MD, PhD	Finland	No Relationships
Tina Raman, MD	United States	No Relationships
Taghi Ramazanian, MD	United States	No Relationships
Manuel Ramirez Valencia, MD	Spain	No Relationships
Brandon A. Ramo, MD	United States	No Relationships
Patricia Rampy, MS, CNIM	United States	No Relationships
Arya Rao	United States	No Relationships
Barry L. Raynor, BS	United States	No Relationships
Giulia A. Rebagliati, MD	Italy	No Relationships
Guillaume Rebeyrat, MS	France	No Relationships
Alma Rechev Ben Natan, BA	United States	No Relationships
Anthony I. Riccio, MD	United States	Arthrex (a); OrthoPediatrics (a,g); Elsevier (g)
Manuel Rigo, MD	Spain	Ortholutions (Germany) and Align Clinic (CA, USA) (b); Rigo Quera Salvá S.L.P Rehabilitation Private Clinic (f)
Lee Riley, MD	United States	LifeNet Health (e)
Lawrence A. Rinsky, MD	United States	No Relationships
Jonathan J. Rios, PhD	United States	No Relationships
Fernando Rios, MD	United States	No Relationships
Guillaume Riouallon, MD	France	Medtronic (b); Euros (b,d,e)
Rahim Rizi, PhD	United States	No Relationships
Stephen Rodriguez, MD	United States	No Relationships
Kenneth J. Rogers, PhD	United States	No Relationships
Kristen Roles, RN	United States	No Relationships
Steven G. Roth, MD	United States	No Relationships
Souvik Roy, BS	United States	No Relationships
Ali Rteil, BS	Lebanon	No Relationships
Theodore Rudic	United States	No Relationships
Vincent Ruggieri, BS	United States	No Relationships
Aleix Ruiz de Villa, PhD	Spain	No Relationships
Kai Ruppert, PhD	United States	No Relationships
Danielle Ruskin, PhD, CPsych	Canada	No Relationships
Eddy Saad, MS	Lebanon	No Relationships
Maria Saadé, BS	Lebanon	No Relationships
Arthur Sackeyfio, MD	Ghana	No Relationships
Karen Sacks, RN	United States	No Relationships
Stephen Saela, MD	United States	No Relationships
Elham Sagheb Hossein Pour, MS	United States	No Relationships

If noted, the relationships disclosed as are 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.)

CONFLICT OF INTEREST DISCLOSURES

NAME	COUNTRY	DISCLOSURE(S)
Toshiki Saito, MD, PhD	Japan	No Relationships
Bradley Saitta, MD	United States	No Relationships
Harold I. Salmons, MD	United States	No Relationships
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Jose Miguel Sánchez-Márquez, MD, PhD	Spain	No Relationships
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CONFLICT OF INTEREST DISCLOSURES

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Pediatric Spine Study Group	United States	NuVasive (a); DePuy Synthes (a); OrthoPediatrics (a); Zimmer Biomet (a); Medtronic (a); Globus Medical (a); Pediatric Spine Foundation (a); Stryker Spine (a)
Harms Study Group	United States	DePuy Synthes (a); EOS Imaging (a); NuVasive (a); Stryker Spine (a); Medtronic (a); POSNA (a); Globus Medical (a); FDA (a); Zimmer Biomet (a); Medicrea (a); Washington University (a); CHU Sainte-Justine (a); Scoliosis Research Society (a)
European Spine Study Group	Spain	DePuy Synthes (a); Medtronic (a)
Harms Study Group	United States	DePuy Synthes (a); Stryker Spine (a); Zimmer Biomet (a); NuVasive (a); Medtronic (a); FDA (a); Globus Medical (a); Washington University (a); Johnson & Johnson Medical Products (a); CHU Sainte-Justine Hospital (a); Medicrea (a); EOS Imaging (a); Globus Medical (a)
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MEETING AGENDA

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The Scoliosis Research Society gratefully acknowledges
OrthoPediatrics
for their Educational Grant support of the Annual Meeting.

ANNUAL MEETING AGENDA

TUESDAY, SEPTEMBER 13, 2022

Program (faculty and times) are subject to change

13:00 - 17:00 HIBBS SOCIETY MEETING HALL A2

Chairs: Javier Pizones, MD, PhD, René M. Castelein, MD, PhD, Dong-Gune Chang, MD, PhD & Qianyu Zhuang, MD

13:00 - 14:15

EARLY ONSET SCOLIOSIS

13:00 - 13:05 Introduction
René M. Castelein, MD, PhD

13:05 - 13:20 Congenital Scoliosis at Multiple Levels
Charles E. Johnston, MD

13:20 - 13:35 Displastic Hyperkyphosis
James O. Sanders, MD

13:35 - 13:50 Thoracic Cage Deformity
Patrick J. Cahill, MD

13:50 - 14:05 Cervical Hemivertebra
Joshua M. Pahys, MD

14:05 - 14:15 Case Discussion

14:15 - 15:25

ADOLESCENT IDIOPATHIC SCOLIOSIS

14:15 - 14:30 Leveling Shoulders in a Lenke Type 2 Curve
Suken A. Shah, MD

14:30 - 14:45 Avoiding Distal Adding-On in a Rigid Lenke Type 5 Curve
Peter O. Newton, MD

14:45 - 15:00 Idiopathic Double Curve Sanders 3
Amer F. Samdani, MD

15:00 - 15:15 Severe Neglected AIS
Daniel J. Sucato, MD, MS

15:15 - 15:25 Case Discussion

15:25 - 15:45 REFRESHMENT BREAK HALL A2 FOYER

15:45 - 17:00 HALL A2

ADULT SPINAL DEFORMITY

15:45 - 16:00 Lower Arc PSO
Lawrence G. Lenke, MD

16:00 - 16:15 Adult Scoliosis With a Stiff Fractional Curve
Michael P. Kelly, MD

16:15 - 16:30 Broken Rods Following a Lumbar PSO
Christopher P. Ames, MD

16:30 - 16:45 PKF in the Cervicothoraic Junction
Christopher I. Shaffrey, MD

16:45 - 16:55 Case Discussion

16:55 - 17:00 Conclusion
René M. Castelein, MD, PhD

18:30 - 21:30 LEADERSHIP DINNER (BY INVITATION ONLY)

ANNUAL MEETING AGENDA

WEDNESDAY, SEPTEMBER 14, 2022

Program (faculty and times) are subject to change

07:30 - 12:00 PRE-MEETING COURSE (PMC): EVOLUTION OF RESEARCH FOR THE SCOLIOSIS RESEARCH SOCIETY: DEFINING THE R IN OUR SRS — HALL A1

07:30 - 08:39 — HALL A1

PART 1: EARLY EFFORTS FROM KEY CENTERS AND INDIVIDUALS

Moderators: Mark A. Erickson, MD & Virginie Lafage, PhD

07:30 - 07:35 Course Welcome
Shay Bess, MD & Justin S. Smith, MD, PhD

07:35 - 07:45 Minneapolis and the Moe Legacy: Formation of the Scoliosis Research Society - Why It Was Necessary and Why It Will Always Remain Important
Joseph H. Perra, MD

07:45 - 07:55 The Impact of Paul Harrington and the Discipline of Marc Asher
Douglas C. Burton, MD

07:55 - 08:05 Segmental Fixation and the Importance of Sagittal Spinopelvic Alignment: The Rise of CD Instrumentation
Nicolas Plais, MD

08:05 - 08:12 Discussion

08:12 - 08:22 Thoracic Pedicle Screw Instrumentation for Correction of Spinal Deformities
Yoon Ha, MD, PhD

08:22 - 08:32 Legacy of Alf Nachemson and the Psychological Impact of Spine Deformity
Aina J. Danielsson, MD, PhD

08:32 - 08:39 Discussion

08:39 - 09:38 — HALL A1

PART 2: UNDERSTANDING DIFFERENT SPINE DEFORMITY TYPES

Moderators: Charla R. Fischer, MD & Brian Hsu, MD

08:39 - 08:48 Classification of Adolescent Idiopathic Scoliosis: Why We Needed Another Classification System and What Are Next Steps
Lawrence G. Lenke, MD

08:48 - 08:57 Why Early Onset Scoliosis Requires a Separate Focus for Diagnosis, Research, and Clinical Care
Behrooz A. Akbarnia, MD

08:57 - 09:04 Discussion

09:04 - 09:13 Adult Spinal Deformity: Why It Was Ignored, Why It is Important, and What We Need for the Future
Pierre Roussouly, MD

09:13 - 09:22 Classification of Adult Spine Deformity: Differentiating ASD from AIS
Frank J. Schwab, MD

09:22 - 09:31 Adult Cervical Deformity: Finally Getting the Attention Our Patients Need
Justin S. Smith, MD, PhD

09:31 - 09:38 Discussion

09:38 - 10:03 REFRESHMENT BREAK — M1

10:03 - 10:57 — HALL A1

PART 3: EXPANDING BEYOND INDIVIDUAL CENTERS TO MULTICENTER COLLABORATIONS

Moderators: D. Kojo Hamilton MD, FAANS & Javier Pizones, MD, PhD

10:03 - 10:11 Harms Study Group: Perfecting the Analysis and Treatment of Adolescent Idiopathic Scoliosis
Peter O. Newton, MD

10:11 - 10:19 Pediatric Spine Study Group: Promoting Collaborative Pediatric Research Using Registry Data
A. Noelle Larson, MD

Program (faculty and times) are subject to change

10:19 - 10:26 Discussion

10:26 - 10:34 International Spine Study Group: The Impact of Multicenter Research - Unlocking the Potential to Maximize Clinical Research and Patient Care
Shay Bess, MD

10:34 - 10:42 European Spine Study Group: The Dynamics of European Research and the Value of Multicultural Comparative Research
Ferran Pellisé, MD, PhD

10:42 - 10:50 American Spine Registry: Leveraging EMR and Societal Data to Improve Quality and Outcomes
Steven D. Glassman, MD

10:50 - 10:57 Discussion

10:57 - 12:00 HALL A1

PART 4: EVOLUTION OF THE SCOLIOSIS RESEARCH SOCIETY

Moderators: Shay Bess, MD & Justin S. Smith, MD, PhD

10:57 - 11:07 Integration of Neurosurgery Into the SRS: Why We Truly Are One Society Providing Care for Spinal Deformity
Christopher I. Shaffrey, MD

11:07 - 11:17 Diversity, Equity, and Inclusion as a Cornerstone for the Future of the SRS
Laurel C. Blakemore, MD

11:17 - 11:24 Discussion

11:24 - 11:34 Emergence of Predictive Analytics in Medicine and Why Data Science is Critical for Our Society and Our Patients
Christopher P. Ames, MD

11:34 - 11:44 M&M 2.0: The Future of SRS Data Collection
Shay Bess, MD

11:44 - 11:54 Development of the Scoliosis Research Society Questionnaire and Next Steps for SRS Directed Research
Marinus de Kleuver, MD, PhD

11:54 - 12:00 Discussion and Closing Comments
Shay Bess, MD & Justin S. Smith, MD, PhD

12:00 - 12:20 LUNCH PICK-UP M1

12:20 - 13:20 LUNCHTIME SYMPOSIA (LTS) (THREE CONCURRENT SESSIONS) HALLS A1, A2, A4

12:20 - 13:20 HALL A2

LTS 1: TWEENERS: TO FUSE OR NOT TO FUSE? TREATMENT OF EARLY ONSET SCOLIOSIS IN PATIENTS WHO ARE NOT YET SKELETALLY MATURE

Moderators: Robert H. Cho, MD & Joshua M. Pahys, MD

12:20 - 12:21 Introduction
Robert H. Cho, MD

12:21 - 12:22 Juvenile Idiopathic Scoliosis Case Presentation
Joshua M. Pahys, MD

12:22 - 12:27 I Would Use MCGR
Selina C. Poon, MD

12:27 - 12:32 I Would Fuse Now
Colin Nnadi, MBBS, FRCSI, FRCS (Orth)

12:32 - 12:39 Discussion

12:39 - 12:40 Neuromuscular Scoliosis Case Presentation
Robert H. Cho, MD

Program (faculty and times) are subject to change

12:40 - 12:45 I Would Use a Growth-Friendly Construct
Nicholas D. Fletcher, MD

12:45 - 12:50 I Would Fuse Now
Tenner Gillaume, MD

12:50 - 12:57 Discussion

12:57 - 12:58 Syndromic Tweener Case Presentation
Joshua M. Pahys, MD

12:58 - 13:03 I Would Use a Growth-Friendly Construct
Michelle C. Welborn, MD

13:03 - 13:08 I Would Fuse Now
Paul D. Sponseller, MD, MBA

13:08 - 13:15 Discussion

13:15 - 13:20 Current State of Research on Tweeners
Muharrem Yazici, MD

12:20 - 13:20 **HALL A1**

LTS 2: FROM ALIGNMENT TO BALANCE, THERE IS MORE THAN ONE STEP

Moderators: Kariman Abelin Genevois MD & Jean-Charles Le Huec, MD, PhD

12:20 - 12:24 Posture, Body Balance and Spine Alignment: What Do We Talk About?
Jean-Charles Le Huec, MD, PhD

12:24 - 12:28 Sagittal Alignment Variations in Different Postures
Hwee Weng Dennis Hey, MD

12:28 - 12:32 The Spine in Movement: Dynamic Assessment of the Spine in Deformity Patients
Thierry Odent, MD, PhD

12:32 - 12:36 How to Predict Structural Deformity: From Abnormal to Fixed Malalignment
Michael P. Kelly, MD

12:36 - 12:41 Case 1
Michael P. Kelly, MD

12:41 - 12:45 When Cervical Spine and Lumbar Spine Pathology Overlap
Kazuhiro Hasegawa, MD, PhD

12:45 - 12:50 Case 2
Kazuhiro Hasegawa, MD, PhD

12:50 - 12:54 When Degenerative Lumbar Pathology and Hip Joint Pathology Overlap
Kariman Abelin Genevois, MD

12:54 - 12:59 Case 3
Javier Pizones, MD, PhD

12:59 - 13:03 Can We Predict Postoperative Changes? Chain of Reaction: When Does it Work? When Do Preoperative Simulation and Postoperative Achievement Meet?
Han Jo Kim, MD

13:03 - 13:08 Case 4
Jean-Charles Le Huec, MD, PhD

13:08 - 13:13 Case 5
Kariman Abelin Genevois, MD

13:13 - 13:20 Session Summary
Kariman Abelin Genevois, MD & Jean-Charles Le Huec, MD, PhD

Program (faculty and times) are subject to change

12:20 - 13:20 **HALL A4**

LTS 3: CERVICAL SPINE: DEFORMITY AND INSTABILITY CASE CONTROVERSIES

Moderator: Jennifer M. Bauer, MD

12:20 - 12:53 PART 1 - ON WHOM AND WHEN TO OPERATE

12:20 - 12:21 Introduction
Jennifer M. Bauer, MD

12:21 - 12:25 Congenital Abnormalities
Ilkka J. Helenius, MD, PhD

12:25 - 12:29 Developmental Kyphosis
Suken A. Shah, MD

12:29 - 12:33 Adult Kyphosis
Byron F. Stephens, MD

12:33 - 12:37 Questions/Catch Up

12:37 - 12:41 Trisomy 21 Instability
Jennifer M. Bauer, MD

12:41 - 12:45 Myelopathy in the Setting of Adult Cervical Deformity
Rajiv K. Sethi, MD

12:45 - 12:49 Skeletal Dysplasias
W.G. Stuart Mackenzie, MD

12:49 - 12:53 Questions/Catch Up

12:53 - 13:20 PART 2 - PANEL CASE DISCUSSION
Panelists: Ilkka J. Helenius, MD; W.G. Stuart Mackenzie, MD; Byron F. Stephens, MD; Suken A. Shah, MD

13:20 - 13:40 BREAK

13:40 - 15:10 ABSTRACT SESSION 1: ADOLESCENT IDIOPATHIC SOLUTIONS **HALL A1**

Moderators: Amy L. McIntosh, MD & David W. Polly, MD

13:40 - 13:45 Welcome

13:45 - 13:49 Paper #1: Results of a Prospective IDE on VBT: Clinical and Radiographic Outcomes of Anterior Vertebral Body Tethering Versus Posterior Spinal Fusion
Carina Lott, MS; Catherine Qiu, MS; James Gordon, MS; Anthony Capraro, MBS; Divya Talwar, PhD; Benjamin Sinder, PhD; John (Jack) M. Flynn, MD; Jason B. Anari, MD; Patrick J. Cahill, MD

13:49 - 13:53 Paper #2: VBT in Skeletally Immature Patients: Results of a Prospective US FDA IDE Study
A. Noelle Larson, MD; Smitha E. Mathew, MBBS; D. Dean Potter, MD; Todd A. Milbrandt, MD, MS

13:53 - 13:57 Paper #3: Improved Outcomes after Anterior Vertebral Tethering for AIS using Ideal versus Acceptable Indications: A Twelve Year Experience
John T. Braun, MD; David F. Lawlor, MD; Sofia Federico, Pre-medical student; Preetika Kulkarni, Pre-medical student; Jonathan Brodeur, BS; Brian E. Grottkau, MD

13:57 - 14:06 Discussion

14:06 - 14:10 Paper #4: Redefining the Diagnosis of Tether Failure in Vertebral Body Tethering: A Biomechanical Analysis
Ogulcan Guldeniz, MS, BS; Christopher C. Yip, MBBS; Wanis Nafo, PhD; Kenneth M. Cheung, MD, MBBS, FRCS

14:10 - 14:14 Paper #5: What Happens After a Vertebral Body Tether Break: Incidence, Location, and Progression With 5-Year Follow-Up
Michael Yang, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Alejandro Quinonez, BS; Maureen McGarry, BBE; Brandon J. Toll, BA; Harsh Grewal, FACS, FAAP; Joshua M. Pahys, MD

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14:14 - 14:18 **Paper #6: Tether Breakage in Vertebral Body Tethering is Better Explained by Inter-Screw Distance than Inter-Screw Angle**
Hiu-Tung S. Wan; Ogulcan Guldeniz, MS, BS; Kenny Y. Kwan, MD; Matthew Hei Yu Yeung; Christopher C. Yip, MBBS; Wanis Nafo, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Stefan Parent, MD, PhD; Michelle C. Welborn, MD; Amer F. Samdani, MD; Michael G. Vitale, MPH; Ron El-Hawary, MD; Kenneth M. Cheung, MD, MBBS, FRCS

14:18 - 14:27 **Discussion**

14:27 - 14:31 **Paper #7: Risk of Repeat Surgery 10 Years After Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis**
Alfredo J. Guiroy, MD; Steven W. Hwang, MD; Suken A. Shah, MD; A. Noelle Larson, MD; Harry L. Shufflebarger, MD; Jahangir K. Asghar, MD

14:31 - 14:35 **Paper #8: In Adolescent Idiopathic Scoliosis, Do All Instrumentation-Related Complications Require Revision Surgery?**
Stephen Plachta, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Michael Yang, MD; Suken A. Shah, MD; Firoz Miyanji, MD; Peter O. Newton, MD; Harms Study Group; Joshua M. Pahys, MD

14:35 - 14:39 **Paper #9: Non-Fusion Versus Fusion Surgery in Pediatric Idiopathic Scoliosis: What Trade-Offs in Outcomes are Acceptable for the Patient and Family**
A. Noelle Larson, MD; Michelle Claire Marks, PT; Juan M. Sepulveda, PhD; Peter O. Newton, MD; Vincent Devlin, MD; Raquel Peat, MPH; Michelle Tarver, MD, PhD; Olufemi Babalola, MHS; Allen L. Chen, PMP; David Gebben, PhD; Patrick J. Cahill, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Keith R. Bachmann, MD; Baron S. Lonner, MD

14:39 - 14:48 **Discussion**

14:48 - 14:52 **Paper #10: Long Term Quality of Life Outcomes for Thoracic AIS Patients With or Without Fusion: A Minimum of 15-Year Follow-Up Study**
Amanda Liu, BS; Kenny Y. Kwan, MD

14:52 - 14:56 **Paper #11: Clinical, Radiological, and HRQOL Outcomes After Selective Thoracic Fusion With Minimum 20-Year Follow-Up: Assessment of the Degenerative Changes of Unfused Lumbar Spine With MRI Study**
Azmi Hamzaoglu, MD; Meric Enercan, MD; Hamisi M. Mraja, MD; Halil Gok, MD; Ozcan Kaya, MD; Ugur Tasci, MD; Tunay Sanli, MA; Onur Levent Ulusoy, MD; Ayhan Mutlu, MD; Selhan Karadereler, MD

14:56 - 15:00 **Paper #12: SRS Self-Image in Adolescent Idiopathic Scoliosis at 10 Year Follow-Up: As Good as it Gets?**
Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Joshua M. Pahys, MD; Nicholas D. Fletcher, MD; Stephen G. George, MD; Suken A. Shah, MD; Tracey P. Bastrom, MA; Carrie E. Bartley, MA; Lawrence G. Lenke, MD; Peter O. Newton, MD; Harms Study Group

15:00 - 15:10 **Discussion**

15:10 - 15:30 REFRESHMENT BREAK M1

15:30 - 17:15 ABSTRACT SESSION 2: ADULT SPINAL DEFORMITY I HALL A1

Moderators: Jwalant Mehta, MD, FRCS (Orth) & Byron F. Stephens, MD

15:30 - 15:34 **Paper #13: Outcomes of Operative Treatment for Adult Spinal Deformity (ASD): A Prospective, Multicenter Assessment With Minimum 3-Year Follow-Up**
Elias Elias, MPH, MSc; Shay Bess, MD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Zeina Nasser, MSc; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

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15:34 - 15:38 **Paper #14: Clinical Outcomes of Corrective Fusion Surgery From the Thoracic Spine to the Pelvis for Adult Spinal Deformity at 1, 2, and 5 Years Postoperatively**
Hideyuki Arima MD, PhD; Yu Yamato MD, PhD; Go Yoshida, MD, PhD; Tomohiro Banno, MD, PhD; Shin Oe, MD; Yuki Mihara, MD, PhD; Koichiro Ide, MD; Yuh Watanabe, MD; Keiichi Nakai, MD; Kenta Kurosu, MD; Yukihiro Matsuyama, MD, PhD

15:38 - 15:42 **Paper #15: Difference in Impact of Spinal Fusion on Activity of Daily Living Between US and Japanese Adult Spinal Deformity Patients**
Naobumi Hosogane, MD, PhD; Mitsuru Yagi, MD, PhD; Christopher P. Ames, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; International Spine Study Group

15:42 - 15:51 **Discussion**

15:51 - 15:55 **Paper #16: Does Perioperative Teriparatide in Osteoporotic Patients Help Increase Bone Density, and Decrease Mechanical Complications – Minimum 2-Year Radiological Study Measuring Hounsfield Units**
Neel Anand, MD; Anita Anand, BS; Jose Jimenez, MD; Arya Rao, Medical Student; Babak Khandehroo, MD; Sheila Kahwaty, PA-C

15:55 - 15:59 **Paper #17: Normalizing Lumbopelvic and Thoracolumbar Alignment Reduces Mechanical Complications in Adult Spinal Deformity**
Jeffrey M. Hills, MD; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Shay Bess, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Gregory M. Mundis, MD; Eric O. Klineberg, MD; Munish C. Gupta, MD; Han Jo Kim, MD; Michael P. Kelly, MD; International Spine Study Group

15:59 - 16:03 **Paper #18: The Importance of Thoracolumbar Junctional Angle in Development of Acute Proximal Junctional Kyphosis in Adult Spinal Deformity Surgery**
Ho-Joong Kim, MD; Dae-Woong Ham, MD; Ohsang Kwon, MD

16:03 - 16:07 **Paper #19: Proximal Junctional Failure (PJF) in Primary Thoracolumbar Fusion/Fixation to the Sacrum/Pelvis for Adult Symptomatic Lumbar Scoliosis (ASLS): Long-Term Follow-Up of a Prospective Multicenter Cohort of 160 Patients**
Bruno Lazaro, MD; Juan Sardi, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Brian Dial, MD; Jeffrey M. Hills, MD; Christine Baldus, RN; Elizabeth L. Yanik, PhD; Chun-Po Yen, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

16:07 - 16:19 **Discussion**

16:19 - 16:23 **Paper #20: Surgical Correction of Coronal Malalignment (CM) Improves Clinical Outcomes in a Large Cohort of Adult Spinal Deformity (ASD) Patients**
Paul Frechon, MD; Louis Boissiere, MD; Anouar Bourghli, MD; Ferran Pellisé, MD, PhD; Javier Pizones, MD, PhD; Ahmet Alanay, MD; Frank S. Kleinstueck, MD; Daniel Larrieu, PhD; David C. Kieser, MD, PhD; Derek T. Cawley, MD; Ibrahim Obeid, MD; European Spine Study Group

16:23 - 16:27 **Paper #21: Outcomes After Coronal Alignment Correction in Patients With Trunk Shift Towards the Curve Convexity**
Michael Dinizo, MD; Karnmanee Srisanguan, BS; Tina Raman, MD

16:27 - 16:33 **Discussion**

16:33 - 16:37 **Paper #22: Defining Spinopelvic Alignment in Adult Population Over 60 Years Old: Prospective Analysis of 214 Volunteers**
Sung Hyun Noh, MD; Yoon Ha, MD, PhD; Sang Hyun Kim, PhD; Pyung Goo Ho, PhD; Kyung Hyun Kim, PhD

16:37 - 16:41 **Paper #23: Variation of Global Sagittal Alignment Parameters According to Gender, Pelvic Incidence, and Age**
Yann Philippe Charles, MD, PhD; Sebastien Pesenti, MD, PhD; Brice Ilharreborde, MD, PhD; Solène Prost, MD; Fethi Laouissat, MD; Ibrahim Obeid, MD; Emmanuelle Ferrero, MD, PhD; Guillaume Riouallon, MD; Erik- André Sauleau, MD, PhD; Benjamin Blondel, MD, PhD

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16:41 - 16:45 **Paper #24: Can AI Identify Patterns of Complex Adult Spinal Deformity With Distinct Perioperative Outcomes?**
Renaud Lafage, MS; Mitchell Fourman, MPhil; Shay Bess, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Christopher P. Ames, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCSC; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

16:45 - 16:54 **Discussion**

16:54 - 16:58 **Paper #25: Sagittal Malalignment Affects Capacities of Adaptations to Walk Faster**
Krystel Abi Karam, MS; Rami Rachkidi, MD, MSc; Karl Semaan, MS; Eddy Saad, MS; Marc Fakhoury, MS; Maria Saadé, BS; Elma Ayoub, BS; Celine Chaaya, BS; Ali Rteil, BS; Elena Jaber, BS; Elio Mekhael, BS; Nabil Nassim, BS; Abir Massaad, PhD; Virginie Lafage, PhD; Wafa Skalli, PhD; Ayman Assi, PhD

16:58 - 17:02 **Paper #26: ASD With High Pelvic Retroversion Develop Changes in Their Acetabular Orientation During Walking**
Guillaume Rebeyrat, MS; Wafa Skalli, PhD; Rami Rachkidi, MD, MSc; Karl Semaan, MS; Eddy Saad, MS; Georges Kawkabani, MD, MS; Abir Massaad, PhD; Virginie Lafage, PhD; Helene Pillet, PhD; Ayman Assi, PhD

17:02 - 17:06 **Paper #27: Sagittal Malalignment Increases Risks of Trips and Falls During Stair Step Ascent and Descent**
Marc Fakhoury, MS; Krystel Abi Karam, MS; Karl Semaan, MS; Eddy Saad, MS; Maria Saadé, BS; Elma Ayoub, BS; Celine Chaaya, BS; Ali Rteil, BS; Elena Jaber, BS; Elio Mekhael, BS; Nabil Nassim, BS; Abir Massaad, PhD; Virginie Lafage, PhD; Wafa Skalli, PhD; Rami Rachkidi, MD, MSc; Ayman Assi, PhD

17:06 - 17:15 **Discussion**

17:15 - 17:35 BREAK

17:35 - 18:35 CASE DISCUSSIONS (THREE CONCURRENT SESSIONS) HALLS A1, A2, A4

17:35 - 18:35 HALL A1

CASE DISCUSSION 1: PEDS 1 - DISLOCATIONS, CORONAL AND SAGITTAL DECOMPENSATION

Moderators: Keith R. Bachman, MD & Megan Johnson, MD

17:35 - 17:50 **Paper #1A: The Strategy of Treatment Rotational Dislocation of the Spine in Severe Rigid Kyphoscoliotic Deformity**
Zhiyue Shi, MD; Jingming Xie, MD; Yingsong Wang, MD; Ying Zhang, MD; Zhi Zhao, MD; Tao Li, MD; Ni Bi, MD; Quan Li, MD

17:50 - 18:05 **Paper #1B: Congenital Spinal Dislocation: A Case Series and Review of the Literature**
Evan Yarnall, BS; Andrew J. Kim ; Amer F. Samdani, MD; Joshua M. Pahys, MD; Eric O. Klineberg, MD; Paul Moroz, MD; Peter J. Stasikelis, MD; Steven W. Hwang, MD

18:05 - 18:20 **Paper #1C: Coronal Decompensation in Patients With Cervicothoracic Hemivertebra Undergoing Posterior-Only Hemivertebra Resection**
Yong Qiu, PhD; Yang Li, PhD; Zezhang Zhu, MD, PhD; Zhen Liu, PhD; Xu Sun, MD; Benlong Shi, PhD; Sai-hu Mao, PhD

18:20 - 18:35 **Paper #1D: PJK Secondary to Overcorrection of Scheurmann's Kyphosis: Restore Kyphosis or Extend to the Neck?**
Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Terry D. Amaral, MD

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17:35 - 18:35 HALL A4

CASE DISCUSSION 2: PEDS 2 - CARDIAC, NEUROFIBROMATOSIS, AND GROWTH PRESERVATION

Moderators: Teresa Bas, MD, PhD & Juan Carlos Rodriguez-Olaverri, MD

17:35 - 17:50 **Paper #2A: Thoracogenic Scoliosis in Adolescent Survivors of Single Ventricle Infants**
Carina Lott, MS; Mitchell A. Johnson, BS; Abigail Clark, MEng; David J. Goldberg, MD; John (Jack) M. Flynn, MD; Patrick J. Cahill, MD; Jason B. Anari, MD

17:50 - 18:05 **Paper #2B: Apical Correction and Global Balance Surgical Strategy Can Improve Cardiopulmonary Function in Patients With Severe and Rigid Scoliosis at a 2-Year Follow-Up**
Jianxiong Shen, MD; Yang Jiao, MBBS; Erwei Feng, MD; Jiachen Lin, MD, PhD; Zhen Wang, MD; Junduo Zhao, MBBS

18:05 - 18:20 **Paper #2C: Clinical and Radiographic Outcomes Following Complex Spine Reconstruction in Neurofibromatosis With Severe Spinal Deformity**
Kwadwo Poku Yankey, MD; Derrick Owusu Nyantakyi, MPH; Arthur Sackeyfio, MD; Irene A. Wulff, MD; Oheneba Boachie-Adjei, MD; Paul D. Sponseller, MD, MBA; Sumeet Garg, MD; Brenda A. Sides, MA; Amer F. Samdani, MD; David B. Bumpass, MD; Burt Yaszay, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD; Munish C. Gupta, MD

18:20 - 18:35 **Paper #2D: Concurrent Management of Congenital Scoliosis and Accompanying Compensatory Curves With Self Sliding Pedicle Screw Fixation in the Growing Spine**
Hamisi M. Mraja, MD; Tunay Sanli, MA; Ugur Tasci, MD; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

17:35 - 18:35 HALL A2

CASE DISCUSSION 3: ADULT

Moderators: Khaled M. Kebaish, MD & Khoi D. Than, MD

17:35 - 17:50 **Paper #3A: A Novel Two-Stage Surgical Approach Allows for Preservation of Motions Segments at the Lumbosacral Junction in Patients Undergoing Long Posterior Thoracolumbar Fusion**
Micheal Raad, MD; Kevin C. Mo, MHA; Kevin Y. Wang, BS; Floreana N. Kebaish, MD; Khaled M. Kebaish, MD

17:50 - 18:05 **Paper #3B: Does Fusion Length Matter? Total Hip Arthroplasty Dislocation After Extension of Lumbosacral Fusion Without Change in Lumbar Lordosis**
Christopher L. McDonald, MD; Daniel Alsoof, MBBS; Bassel G. Diebo, MD; Eren Kuris, MD; Alan H. Daniels, MD

18:05 - 18:20 **Paper #3C: The 'Candy Cane' Technique for Construct Augmentation and Correction of Severe Angular Chin-On-Chest Kyphoscoliosis**
Nitin Agarwal, MD; Kevin Patel, M.R.; Souvik Roy, BS; Alp Ozpinar ; Nima Alan, MD; D. Kojo Hamilton, MD, FAANS

18:20 - 18:35 **Paper #3D: The Use of Cannulated Reamers to Facilitate Thoracic Discectomy Via a Minimally Invasive Retropleural Thoracotomy Approach - Surgical Technique and Early Outcomes**
Venu M. Nemani, MD, PhD; Jesse Shen, MSc; Rajiv K. Sethi, MD; Jean-Christophe A. Leveque, MD

18:35 - 18:50 BREAK

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18:50 - 20:00 OPENING CEREMONIES — HALL A1

18:50 - 18:55 **Welcome to Stockholm**
Acke Ohlin, MD, PhD & Paul Gerdhem, MD, PhD

18:55 - 19:00 **Presidential Message**
Christopher I. Shaffrey, MD

19:00 - 19:05 **Acknowledgement of Research Grant Recipients, Including Directed Research Award**
Mitsuru Yagi, MD, PhD

19:05 - 19:07 **Biedermann Award**
Markku Biedermann

19:07 - 19:12 **Acknowledgement of Awards & Scholarship Winners**
Nicholas D. Fletcher, MD

19:12 - 19:22 **Presentation of Blount Humanitarian Award**
Nicholas D. Fletcher, MD

19:22 - 19:32 **Corporate Partners Acknowledgement**
Muharrem Yazici, MD

19:32 - 19:37 **Introduction of Howard Steel Lecturer**
Christopher I. Shaffrey, MD

19:37 - 19:57 **Howard Steel Lecture**
Tobias Degsell

19:57 - 20:00 **Closing Remarks**
Christopher I. Shaffrey, MD

20:00 - 22:00 WELCOME RECEPTION — M1

Join colleagues and friends for a hosted reception hors d'oeuvres and cocktails immediately following the Opening Ceremonies.

Available at no charge to in-person meeting delegates, $100 for registered guests.

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08:00 - 09:50 ABSTRACT SESSION 3: QUALITY/SAFETY/VALUE/COMPLICATIONS I HALL A1

Moderators: Bassel G. Diebo, MD & Jeffrey L Gum, MD

08:00 - 08:05 **Welcome**

08:05 - 08:09 **Paper #28: Perioperative Complications in Adult Spine Deformity Surgery: Classification and Prevention Strategies**
Go Yoshida, MD, PhD; Louis Boissiere, MD; Sigurd H. Berven, MD; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCSC; Yukihiro Matsuyama, MD, PhD

08:09 - 08:13 **Paper #29: The ISSG-AO Complication Intervention Score, But Not Major/Minor Designation, is Correlated With Length of Stay**
Joseph Wick, MD; Andrew Blandino, PhD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Han Jo Kim, MD; Peter G. Passias, MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Eric O. Klineberg, MD; International Spine Study Group

08:13 - 08:17 **Paper #30: Evaluation of Abbreviated Adult Spinal Deformity Surgical Adverse Event Prediction Tools in Adult Symptomatic Lumbar Scoliosis**
James Wondra, BS; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christopher P. Ames, MD; Ferran Pellisé, MD, PhD; Alba Vila-Casademunt, MS; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Jacob Greenberg, BS; Lawrence G. Lenke, MD; Keith H. Bridwell, MD

08:17 - 08:26 **Discussion**

08:26 - 08:30 **Paper #31: A Rough Road to Recovery: The Impact of Complications After Adult Spinal Deformity Surgery on Specific Health Related Quality of Life Domains**
Breton G. Line, BS; Shay Bess, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Jeffrey L. Gum, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Alan H. Daniels, MD; Munish C. Gupta, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Eric O. Klineberg, MD; International Spine Study Group

08:30 - 08:34 **Paper #32: In Adult Spinal Deformity Surgery, Are All Mechanical Complications Created Equally?**
Hani Chanbour, MD; Steven G. Roth, MD; Matthew E. LaBarge, BS; Jeffrey M. Hills, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH

08:34 - 08:38 **Paper #33: Time-Dependent Interpretation of Mechanical Complications Using Cox Regression and Survival Analysis**
Caglar Yilgor, MD; Altug Yucekul, MD; Ilkay Karaman, MD; Omer Orhun ; Tais Zulemyan, MSc; Duru Karasoy, PhD; Yasemin Yavuz, PhD; Sleiman Haddad, MD, PhD, FRCS; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; European Spine Study Group

08:38 - 08:47 **Discussion**

08:47 - 08:51 **Paper #34: Proximal Junctional Kyphosis is a Compensation for Postoperative Negative C2-FH in ASD Patients: A Cross-sectional Study**
Xin Zhang, MD; Hongda Bao, MD; Shibin Shu, PhD; Zhen Liu, PhD; Xu Sun, MD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD

08:51 - 08:55 **Paper #35: The Influence of Ligament Biomechanics on Proximal Junctional Angle and Failure in Patients With Adult Spinal Deformity**
Micah Blais, MD; Bahar Shahidi, PhD; Eli O'Brien, BS; Brad Anderson, BS; Brianna Kuhse, BS; Courtney Moltzen, BS; Tina L. Iannacone, BSN; Robert K. Eastlack, MD; Gregory M. Mundis, MD

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08:55 - 08:59 **Paper #36: Does the Use of Postoperative Brace Play a Protective Role Following Adult Deformity Surgery?**
Javier Pizones, MD, PhD; Francisco Javier S. Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Alba Vila-Casademunt, MS; Louis Boissiere, MD; Fernando Escamez, MD; Gloria Talavera, MD; Jose Miguel Sánchez- Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; Frank S. Kleinstueck, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Ibrahim Obeid, MD; European Spine Study Group

08:59 - 09:08 **Discussion**

09:08 - 09:12 **Paper #37: Lower Hounsfield Units and Severe Multifidus Sarcopenia are Independent Predictors of Increased Risk for Proximal Junctional Kyphosis and Failure Following Thoracolumbar Fusion**
Zachariah W. Pinter, MD; Anthony L. Mikula, MD; Sarah Townsley, MD; Harold I. Salmons, MD; Nikita Lakomkin, MD; Giorgos Michalopoulos, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; Mohamad Bydon, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD

09:12 - 09:16 **Paper #38: Houndsfield Units Thresholds are Associated with PJK, Major Intraoperative Blood Loss, and Implant Complications After ASD Surgery**
Jeffrey L. Gum, MD; Kevin C. Mo, MHA; Douglas C. Burton, MD; Brian J. Neuman, MD; Han Jo Kim, MD; Richard Hostin, MD; Peter G. Passias, MD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; D. Kojo Hamilton, MD, FAANS; Frank J. Schwab, MD; Alan H. Daniels, MD; Alex Soroceanu, MPH; Robert A. Hart, MD; Breton G. Line, BS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Khaled M. Kebaish, MD; International Spine Study Group

09:16 - 09:20 **Paper #39: Are Supplemental-Rod Constructs (SRCs) Associated With Increased Rates of PJK/PJF?**
Jeffrey L. Gum, MD; Jonathan Elysee, MS; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Breton G. Line, BS; Samrat Yeramaneni, PhD; Kevin C. Mo, MHA; Virginie Lafage, PhD; Justin K. Scheer, MD; Alex Soroceanu, MPH; Thomas Buell, MD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; International Spine Study Group

09:20 - 09:29 **Discussion**

09:29 - 09:33 **Paper #40: Is High-Dose Tranexamic Safe in Spine Surgery? A Systematic Review and Meta-Analysis**
Francis C. Lovecchio, MD; Izzet Akosman, BS; Mitchell Fourman, MPhil; J. Manuel Sarmiento, MD; Keith Lyons, MD; Han Jo Kim, MD

09:33 - 09:37 **Paper #41: New Onset Central Diabetes Insipidus (CDI) in Pediatric Posterior Scoliosis Fusions**
Kyle Hardacker, MD; Doris M. Hardacker, MD

09:37 - 09:41 **Paper #42: Complex ASD Patients Receiving High-Dose TXA Have Significantly Lower Blood Loss Compared to Low-*Dose* TXA Without Increased Thromboembolic Complications**
Kevin C. Mo, MHA; Andrew B. Harris, MD; Renaud Lafage, MS; Brian J. Neuman, MD; Richard Hostin, MD; Samrat Yeramaneni, PhD; Alex Soroceanu, MPH; Han Jo Kim, MD; Eric O. Klineberg, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; D. Kojo Hamilton, MD, FAANS; Frank J. Schwab, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Michael P. Kelly, MD; Breton G. Line, BS; Christopher P. Ames, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Lawrence G. Lenke, MD; Khaled M. Kebaish, MD; International Spine Study Group

09:41 - 09:50 **Discussion**

09:50 - 10:10 REFRESHMENT BREAK M1

Program (faculty and times) are subject to change

10:10 - 12:15 ABSTRACT SESSION 4: QUALITY/SAFETY/VALUE/COMPLICATIONS II AND HARRINGTON LECTURE — HALL A1

Moderators: David E. Lebel, MD, PhD & Colin Nnadi, MBBS, FRCSI, FRCS (Orth)

10:10 - 10:14 **Paper #43: A Modified Enhanced Recovery After Surgery (ERAS) Protocol in Perioperative Care of Adolescents Idiopathic Scoliosis (AIS)**
David E. Lebel, MD, PhD; Masayoshi Machida, MD; Robert Koucheki, HBSc; Fiona Campbell, MD; Natasha Bath, RN; Lisa Isaac, FRCP(C); Martin Koyle, MD, FRCS(C); Danielle Ruskin, CPsych; David Levin, MD, FRCS(C); Sarah Brennenstuhl, PhD; Jennifer Stinson, PhD, RN

10:14 - 10:18 **Paper #44: Liposomal Bupivacaine in the Continuous Improvement of Multimodal Pain Management Following Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis**
Karen Sacks, RN; Ali Asma, MD; Robert S. Lang, MD; Petya Yorgova; Kenneth J. Rogers, PhD; Suken A. Shah, MD

10:18 - 10:22 **Paper #45: AIS Post-Operative Rapid Recovery Program: Liposomal Bupivacaine (LB) and IV Dexamethasone (D)**
Amy L. McIntosh, MD; Christopher B. McLeod, MD; Brandon A. Ramo, MD

10:22 - 10:26 **Paper #46: The Collateral Effect of Enhanced Recovery After Surgery Protocols on Spine Patients With Neuromuscular Scoliosis**
Niklas Tøndevold, MD; Thomas B. Andersen, DMSc; Tanvir J. Bari, MD; Martin Gehrchen, MD, PhD

10:26 - 10:35 **Discussion**

10:35 - 10:39 **Paper #47: Accuracy of Non-Invasive Hemoglobin (nHgb) Monitoring in an AIS Population**
Amy L. McIntosh, MD; Christopher B. McLeod, MD

10:39 - 10:43 **Paper #48: Coming Up Short: Estimated Versus Calculated Blood Loss in Adolescent Idiopathic and Neuromuscular Scoliosis Surgery**
Christina K. Hardesty, MD; Christopher Cheng, MD; Connie Poe-Kochert, RN; George H. Thompson, MD; Jochen P. Son-Hing, MD

10:43 - 10:52 **Discussion**

10:52 - 10:56 **Paper #49: Pain Medication Use Two Years After Adolescent Idiopathic Scoliosis Fusion Surgery**
Tracey P. Bastrom, MA; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Peter O. Newton, MD; Harms Study Group

10:56 - 11:00 **Paper #50: Factors Associated With Opioid Use Disorder Following Spinal Fusion for Adolescent Idiopathic Scoliosis**
Taylor R. Johnson, MD; Eli M. Cahan, BBA; Nicole A. Segovia, MPH; Kristen Halvorsen, MD; Japsimran Kaur, BS; Charles M. Chan, MD; Nadine M. Javier, BS; Xochitl Bryson, BA; John S. Vorhies, MD

11:00 - 11:04 **Paper #51: Back Pain and Quality of Life 10 Years After Segmental Pedicle Screw Instrumentation for Adolescent Idiopathic Scoliosis (AIS): Comparison to Age and Gender Matched Untreated AIS Patients and Healthy Controls**
Matti Ahonen, MD, PhD; Johanna Syvänen, MD, PhD; Linda Helenius, MD, PhD; Mikko Mattila, MD, PhD; Tanja Perokorpi, MS; Elias Diarbakerli, PhD; Paul Gerdhem, MD, PhD; Ilkka J. Helenius, MD, PhD

11:04 - 11:13 **Discussion**

11:13 - 11:17 **Paper #52: From PHQ-2 to SRS-22: Impact of Depression Screening Tool on SRS Scores in AIS Patients**
Anthony A. Catanzano, MD; Peter O. Newton, MD; Vrajesh Shah, BS; Burt Yaszay, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA

11:17 - 11:21 **Paper #53: Machine-Learning for Surgeon Performance Benchmarking in Adolescent Idiopathic Scoliosis (AIS) Surgery**
Aditi Gupta, PhD; Inez Oh, PhD; Ferran Pellisé, MD, PhD; Michelle Claire Marks, PT; Nicholas D. Fletcher, MD; Joshua M. Pahys, MD; Maty Petcharaporn, BS; Amer F. Samdani, MD; Peter O. Newton, MD; Christopher P. Ames, MD; Philip Payne, PhD; Nigel Kim, MS; Michael P. Kelly, MD

Program (faculty and times) are subject to change

11:21 - 11:25 **Paper #54: Predictive Models Identify Patient and Surgical Variables That Synergistically Produce an Optimal Outcome Following Adult Spine Deformity (ASD) Surgery**
Shay Bess, MD; Breton G. Line, BS; Christopher P. Ames, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Jeffrey L. Gum, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; Michael P. Kelly, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Douglas C. Burton, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

11:25 - 11:34 **Discussion**

11:34 - 11:39 **Harrington Lecture Introduction**
Christopher I. Shaffrey, MD

11:39 - 11:59 **Harrington Lecture**
Jürgen Harms, MD

11:59 - 12:15 **Presentation of the Lifetime Achievement Award (Introduction and Acceptance)**
Marinus de Kleuver, MD, PhD

12:15 - 12:50 LUNCH PICK-UP & BREAK M1

12:50 - 14:20 INDUSTRY WORKSHOPS C1, C2, C3, C4, ROOM 38

Delegates are encouraged to attend the industry workshops. Each workshop is programmed by a single-supporting company and features presentations on topics and technologies selected by the company. Lunch will be available during the workshops. CME credits are not available for workshops.

Industry workshops at the Annual Meeting will be hosted by: DePuy Synthes, Globus Medical, Medtronic, NuVasive and Stryker. Please see page 221 for program information.

14:20 - 14:40 REFRESHMENT BREAK M1

14:40 - 17:20 HALF-DAY COURSES (HDC) (TWO CONCURRENT SESSIONS) HALL A1, HALL A2

14:40 - 17:20 HALL A1

HDC 1: PEDIATRIC SYNDROMIC SCOLIOSIS: HOW TO SAFELY MANAGE AMC TO SED & EVERYTHING IN BETWEEN

Moderators: Joshua M. Pahys, MD & Jwalant S. Mehta MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

PART 1: HYPERMOBILE

14:40 - 14:41 **Introduction**
Joshua M. Pahys, MD

14:41 - 14:48 **Marfan and Ehlers Danlos Syndrome**
Paul D. Sponseller, MD, MBA

14:48 - 14:55 **Larsen and Down Syndrome**
Lindsay M. Andras, MD

14:55 - 15:02 **Cervical Spine Disorders**
Michael Ruf, MD

15:02 - 15:11 **Case Discussion**

PART 2: MUSCLE WEAKNESS/MYOPATHY

15:11 - 15:18 **Prader-Wili Syndrome**
David S. Marks, MBBS, FRCS, FRCS (Orth)

15:18 - 15:25 **Arthrogryposis Multiplex Congenita (AMC)**
Selina C. Poon, MD

15:25 - 15:32 **Rett Syndrome**
Eric O. Klineberg, MD

15:32- 15:41 **Case Discussion**

Program (faculty and times) are subject to change

PART 3: POOR BONE QUALITY/VERTEBRAL ANOMALIES

15:41 - 15:48 Achondroplasia
Klane K. White, MD

15:48 - 15:55 Spondyloepiphyseal Dysplasia (SED)
Kota Watanabe, MD, PhD

15:55 - 16:02 Osteogenesis Imperfecta (OI)
Michelle C. Welborn, MD

16:02 - 16:09 Neurofibromatosis (NF)
David W. Polly, MD

16:09 - 16:18 Case Discussion

PART 4: COMPLICATIONS & CHALLENGES

16:18 - 16:25 Mechanical Failures
Ilkka J. Helenius, MD, PhD

16:25 - 16:32 Respiratory Challenges
Gregory Redding, MD

16:32 - 16:40 Case Discussion

16:40 - 16:44 Paper #55: Angelman and Prader-Willi Syndrome: Sister Imprinting Disorders and High Complication Rates Following Spinal Deformity Surgery
Drew Winsauer, BS; David C. Thornberg, BS; Stephen Rodriguez, MD; Kiley F. Poppino, BS; Brandon A. Ramo, MD

16:44 - 16:48 Paper #56: Surgical Treatment of Scoliosis in Patients Diagnosed With Down Syndrome: A 15-Year Experience
Megan Johnson, MD; Brandon A. Ramo, MD; Claire Bonnyman, BS; Lydia R. Klinkerman, BS

16:48 - 16:52 Paper #57: Treatment of Kyphosis in Ankylosing Spondylitis by Osteotomy Through the Gap of a Pathological Fracture: A Retrospective Study
Hongqi Zhang, MD

16:52 - 17:01 Discussion

17:01 - 17:05 Paper #58 How to Rectify the Convex Coronal Imbalance in Patients With Unstable Dystrophic Scoliosis Secondary to Type I Neurofibromatosis: Experience From a Case Series
Sai-hu Mao, PhD; Song Li, MD, PhD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; Zhen Liu, PhD; Xu Sun, MD; Bo Yang, MD; Benlong Shi, PhD

17:05 - 17:09 Paper #59: Continuous-Incremental-Heavy Halo-Gravity Traction Combined With Posterior-Only Approach for Cervical Kyphosis Correction in Patients With Neurofibromatosis-1
Hongqi Zhang, MD

17:09 - 17:20 Discussion

14:40 - 17:20 HALL A2

HDC 2: CURRENT UPDATES IN UNDERSTANDING AND MANAGEMENT OF INTRAOPERATIVE NEUROMONITORING ALERTS

Moderator: Steven W. Hwang, MD

14:40 - 14:55 Introduction to Neuromonitoring, Basic Neuroanatomy, and IONM Modalities
Stephen J. Lewis, MD, FRCSC

14:55 - 15:04 Anticipation of Preoperative Likelihood and Preoperative Change in Management
Lawrence G. Lenke, MD

15:04 - 15:11 Communication With Family Preoperative Anticipation and After Event
Daniel J. Sucato, MD, MS

15:11 - 15:18 Intraoperative Diagnosis and Management
Amer F. Samdani, MD

15:18 - 15:25 When to Do a Wake Up Test? When is More Imaging Required?
Steven W. Hwang, MD

ANNUAL MEETING AGENDA

THURSDAY, SEPTEMBER 15, 2022

Program (faculty and times) are subject to change

15:25 - 15:40 **Panel Discussion**
Stephen J. Lewis, MD, FRCSC

15:40 - 15:47 **Unilateral MEP Changes: What Do They Mean and How to Manage**
Christopher Nielsen, MD

15:47 - 15:54 **Managing Bilateral MEP Changes With Preserved SSEP**
David E. Lebel, MD, PhD

15:54 - 16:01 **What is the Best Modality to Monitor Lumbar Roots: Is EMG and SSEP Sufficient**
Sigurd H. Berven, MD

16:01 - 16:08 **Delayed Neurologic Injury and Return to OR**
Munish Gupta, MD

16:08 - 16:15 **Key Messages from AOSpine Clinical Expert Forum on Neuromonitoring**
Kenneth M. Cheung, MD, MBBS, FRCS

16:15 - 16:35 **Panel Case Discussion**
David E. Lebel, MD, PhD

16:35 - 16:40 **Summary**
Stephen J. Lewis, MD, FRCSC

16:40 - 16:44 **Paper #60: Establishing Expert Consensus: Determinants of High-Risk & Preventative Strategies for Neurological Events in Complex Spinal Deformity Surgery**
Rajiv Iyer, MD; Michael G. Vitale, MPH; Adam N. Fano, BS; Hiroko Matsumoto, PhD; Daniel J. Sucato, MD, MS; Amer F. Samdani, MD; Justin S. Smith, MD, PhD; Munish C. Gupta, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Daniel M. Sciubba, MD; Samuel K. Cho, MD; David W. Polly, MD; Oheneba Boachie-Adjei, MD; Peter D. Angevine, MD; Stephen J. Lewis, MD, FRCSC; Lawrence G. Lenke, MD

16:44 - 16:48 **Paper #61: Multicenter Analysis of Intraoperative Neuromonitoring Alerts in Spinal Surgery for Idiopathic and Non-Idiopathic Scoliosis**
Eugenio Dema, MD; Matteo Palmisani, MD; Naomi Festa, Clinical Neurophysiologist; Massimo Girardo, MD; Rosa Palmisani, MD; Giosuè Gargiulo, MD; Stefano Cervellati, MD; Laura Zavatti, MD; Marco Meli, MD

16:48 - 16:52 **Paper #62: The Adjunct Use of Descending Neurogenic-Evoked Potentials When TCeMEPs Degrade Into Warning Criteria: Minimizing False-Positive Events**
Scott J. Luhmann, MD; Barry L. Raynor, BS; Brian A. Kelly, MD

16:52 - 17:01 **Discussion**

17:01 - 17:05 **Paper #63: Utility of Intraoperative Neurophysiological Monitoring in Detecting Motor and Sensory Nerve Injuries in Pediatric High-Grade Spondylolisthesis**
Carlo Iorio, MD; Samuel Strantzas, MSc, DABNM; Michael Vandenberk, MSc, CNIM; Stephen J. Lewis, MD, FRCSC; Reinhard D. Zeller, MD, FRCS(C); Robert Koucheki, HBSc; Brett Rocos, MD; David E. Lebel, MD, PhD

17:05 - 17:09 **Paper #64: A Novel MRI-Based Sagittal Classification of Spinal Cord in Patients With Kyphosis: Association With the Intraoperative Neuromonitoring Data Loss**
Hui Xu, MD; Zongshan Hu, PhD; Ziyang Tang, MD; Yanjie Xu, MD; Jie Li, MD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; Zhen Liu, PhD

17:09 - 17:20 **Discussion**

17:20 - 17:30 BREAK

17:30 - 17:45 MEMBERSHIP INFO SESSION — **HALL C4**

Interested in becoming an SRS member but not sure how? Join in this short informational session to learn about the application process and more!

17:45 - 17:50 BREAK

Program (faculty and times) are subject to change

17:50 - 18:50 EARLY CAREER SURGEON SESSION C3

Moderators: Moderators: Kariman Abelin Genevois, MD, Caglar Yilgor, MD, Jaysson T. Brooks, MD & Kenny Y. Kwan, MD

YOUNG SURGEONS' GUIDE TO THE SPINE GALAXY

17:50 - 17:52 **ECS Task Force: Past**
Kariman Abelin Genevois, MD

17:52 - 17:54 **ECS Task Force: Present**
Caglar Yilgor, MD

17:54 - 17:56 **ECS Task Force: Future**
Kenny Y. Kwan, MD

PART 1: IMPROVING SURGICAL TECHNIQUE

17:56 - 18:00 **Learning to Learn: Observe, Comprehend, and Teach**
Anand Segar, BHB, MBChB, DPhil (Oxon), FRACS

18:00 - 18:04 **Discussion**

18:04 - 18:08 **Balancing Innovative Techniques and Patients' Health Interest**
Kenneth M. Cheung, MD, MBBS, FRCS

PART 2: CLINICAL RESEARCH IN SPINE WORLD

18:08 - 18:12 **What and When to Read & What and When to Write**
Peter W. Ferlic, MD, PhD

18:12- 18:16 **Discussion**

18:16 - 18:20 **Value of Single-Center, Multicenter, and Study Group Research**
Ahmet Alanay, MD

PART 3: PRACTICE BUILDING IN SPINAL DEFORMITY

18:20 - 18:24 **Building Trust With Physicians That Practice Near You**
Gustavo Borges Laurindo de Azevedo, MD

18:24- 18:28 **Discussion**

18:28 - 18:32 **Creative Business Opportunities to Generate Practice Revenue**
Todd J. Albert, MD

PART 4: IMPORTANCE OF "MISCELLANEOUS"

18:32 - 18:36 **Lessons Learned from Tumors and Cervical Spine**
Elizabeth L. Lord, MD

18:36- 18:40 **Discussion**

18:40 - 18:44 **Another Route to Knowledge: Context of Miscellanies in Spine**
Michael P. Kelly, MD

18:44 - 18:50 **SRS Mentorship Program Update**
Robert H. Cho, MD & Brian G. Smith, MD

18:50 EARLY CAREER SURGEON SOCIAL C3 FOYER

Supported and hosted by Medtronic

ANNUAL MEETING AGENDA

FRIDAY, SEPTEMBER 16, 2022

Program (faculty and times) are subject to change

08:00 - 09:50 ABSTRACT SESSION 5: HIBBS AWARD-NOMINATED PAPERS FOR BEST BASIC SCIENCE/TRANSLATIONAL RESEARCH AND CLINICAL RESEARCH — HALL A1

Moderators: Serena S. Hu, MD & Christopher I. Shaffrey, MD

08:00 – 08:05 **Welcome**

08:05 - 08:11 **Paper #65: Curve Progression and Health Related Quality of Life (HRQoL) in Idiopathic Scoliosis: 40-Year Follow-Up from Diagnosis†**
Lærke C. Ragborg, MD; Casper Dragsted, MD, PhD; Soren Ohrt-Nissen, MD, PhD; Thomas B. Andersen, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, MD, PhD, DMSci

08:11 - 08:17 **Paper #66: Major Complications Following Anterior Vertebral Body Tethering Surgery†**
Firoz Miyanji, MD; Baron Lonner, MD; Ali Eren, MD; Patrick J. Cahill, MD; Ahmet Alanay, MD; Lawrence L. Haber, MD; Suken A. Shah, MD; Laurel C. Blakemore, MD; Stefan Parent, MD, PhD; Kevin M. Neal, MD; Harms Study Group; Peter O. Newton, MD

08:17 - 08:23 **Paper #67: Maternal Risk Factors for Congenital Vertebral Anomalies - Population-Based Case-control Study***
Susanna Heiskanen, MD; Arimatias Raitio, MD, PhD; Johanna Syvänen, MD, PhD; Maarit K. Leinonen, MD, PhD; Mika Gissler, PhD; Ilkka J. Helenius, MD, PhD

08:23 - 08:37 **Discussion**

08:37 - 08:43 **Paper #68: Variants in Collagen Homeostasis Genes are Associated With Adolescent Idiopathic Scoliosis***
Carol A. Wise, PhD; Anas M. Khanshour, PhD; Hao Yu, PhD; Aki Ushiki, PhD; Xiao-Yan Li, PhD; Nao Otomo, MD; Yoshinao Koik, MD; Elisabet Einarsdottir, PhD; Yan-Hui Fan, PhD; Lilian Antunes, PhD; Yared Kidane, PhD; Rory Sheng ; Yichi Zhang, BS; Richa Singhania, PhD; Jimin Pei, PhD; Nick Grishin, PhD; Bret Evers, MD, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; You-Qiang Song, PhD; John A Herring, MD; Christina Gurnett, MD, PhD; Paul Gerdhem, MD, PhD; Shiro Ikegawa, MD, PhD; Jonathan J. Rios, PhD; Stephen Weiss, PhD; Nadav Ahituv, PhD

08:43 - 08:49 **Paper #69: The Impact of Growth, Cessation of Growth, and Bracing on Curve Progression in Idiopathic Scoliosis***
Michelle C. Welborn, MD; Ryan Coghlan, MS; Amer F. Samdani, MD; Joseph D. Stone, MD; Robert H. Cho, MD; Selina C. Poon, MD; Vishwas R. Talwalkar, MD; James O. Sanders, MD; Susan Sienko, PhD

08:49 - 08:55 **Paper #70: In Vivo Analysis of Respiratory Dysfunction Using Hyperpolarized Xenon-129 MRI in TIS Rabbit Model***
Rachel Hilliard ; Kai Ruppert, PhD; Faraz Amzajerdian, BS; Yi Xin, PhD; Hooman Hamedani, BS; Luis Loza, BS; Tahmina Achekzai, BS; Ryan Baron, BS; Ian Duncan, PhD; Harilla Profka, BS; Yiwen Qian, BS; Stephen Kadlecek, PhD; Alessandra Fusco, DVM; Adriana Barba ; Klaus Hopster, DMV, DrMedVet; Hope Douglas, VMD; Jason B. Anari, MD; Benjamin Sinder, PhD; Brian D. Snyder, MD, PhD; Thomas P. Schaer, VMD; Rahim Rizi, PhD; Patrick J. Cahill, MD

08:55 - 09:09 **Discussion**

09:09 - 09:15 **Paper #71: Long-Term Clinical, Radiographic, and Cost Analysis of the Corrective Spine Surgery for Adult Symptomatic Lumbar Deformity at Mean 7.5-Year-Follow-Up†**
Mitsuru Yagi, MD, PhD; Toshiyuki Shimizu, MD; Satoshi Suzuki, MD, PhD; Yohei Takahashi, MD, PhD; Satoshi Nori, MD, PhD; Narihito Nagoshi, MD, PhD; Osahiko Tsuji, MD, PhD; Yoshiyuki Yato, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

09:15 - 09:21 **Paper #72: Bone Morphogenetic Protein (BMP) Use in Adult Spinal Deformity Surgery Is Associated With Reduced Implant Failures and Lower Cost/QALY at Mean 4 Years Postoperative†**
Shay Bess, MD; Breton G. Line, BS; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Eric O. Klineberg, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

Program (faculty and times) are subject to change

09:21 - 09:27 **Paper #73: Opioid Sparing Anesthesia for Adult Spinal Deformity Surgery Reduces Postoperative Pain, Length of Stay, ICU Stay, Opioid Consumption, and Opioid-Related Complications: A Propensity Matched Analysis†**
Jeffrey L. Gum, MD; Leah Y. Carreon, MD; Benjamin M. Sampedro; Jennifer Harpe-Bates, DNAP; Bren Hines, RN; Morgan Brown, MS; Christy L. Daniels, MS; Neil Werthmann, BS; Steven D. Glassman, MD

09:27 - 09:33 **Paper #74: Complication Rates Following Adult Spinal Deformity (ASD) Surgery: The Category of Complication Dictates Timing†**
Renaud Lafage, MS; Jonathan Elysee, MS; Eric O. Klineberg, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Han Jo Kim, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Peter G. Passias, MD; Munish C. Gupta, MD; Richard Hostin, MD; D. Kojo Hamilton, MD, FAANS; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

09:33 - 09:49 **Discussion**

09:49 - 09:50 **Audience Vote**

09:50 - 10:10 REFRESHMENT BREAK — M1

10:10 - 11:45 ABSTRACT SESSION 6: NEUROMUSCLUAR, KYPHOSIS — HALL A1

Moderators: Eugenio Dema, MD & Scott J. Luhmann, MD

10:10 - 10:14 **Paper #75: Can a Threshold Curve Magnitude be Identified as a Surgical Indication in Cerebral Palsy Scoliosis?**
Jenny L. Zheng, BS; Patrick J. Cahill, MD; Jessica H. Heyer, MD; Paul D. Sponseller, MD, MBA; Burt Yaszay, MD; Harms Study Group; Keith Baldwin, MD, MPH, MSPT

10:14 - 10:18 **Paper #76: Prevalence and Risk Factors of Pelvic Rod/Screw Radiographic Lucency After Surgery in Spastic Cerebral Palsy Scoliosis Patients: A Longitudinal Study**
Armagan C. Ulusaloglu, MD; Ali Asma, MD; James R. Bowen, MD; Petya Yorgova; Jason J. Howard, MD; M. Wade Shrader, MD; Suken A. Shah, MD

10:18 - 10:22 **Paper #77: Proximal Junctional Kyphosis After Spinal Deformity Correction in Cerebral Palsy: Incidence and Predictive Analytics**
Nicholas Gajewski, MD; Ali Asma, MD; Paul D. Sponseller, MD, MBA; Amit Jain, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Burt Yaszay, MD; Suken A. Shah, MD; Harms Study Group

10:22 - 10:31 **Discussion**

10:31 - 10:35 **Paper #78: Postoperative Urinary Retention Occurs in 1 in 5 Patients After Posterior Spinal Fusion for Neuromuscular Scoliosis**
Rachel Lai, BA; Kenneth D. Illingworth, MD; David L. Skaggs, MD, MMM; Lindsay M. Andras, MD

10:35 - 10:39 **Paper #79: Pelvic Obliquity Correction in Scoliosis Surgery in Cerebral Palsy - A Radiographic Analysis of 208 Patients**
Ib J. Green-Petersen; Luigi Magnano, MD; Anastasios Charalampidis, MD; Paul Gerdhem, MD, PhD

10:39 - 10:43 **Paper #80: Ten-Year Follow-Up of Spinopelvic Parameters in Children With Achondroplasia**
Luiz Silva, MD; Ali Asma, MD; Kenneth J. Rogers, PhD; Armagan C. Ulusaloglu, MD; James R. Bowen, MD; William G. Mackenzie, MD; W.G. Stuart Mackenzie, MD

10:43 - 10:52 **Discussion**

10:52 - 10:56 **Paper #81: The One-Way Self-Expanding Rod: Results and Complications in a Prospective Series of 21 Neuromuscular Scoliosis With More Than 3-Year Follow-Up**
Lotfi Miladi, MD; Mathilde Gaume, MD; Nejib Khouri, MD

10:56 - 11:00 **Paper #82: Gradual Correction of Scheuermann's Kyphosis by Using Growth Modulation: Preliminary Results of Flexible Posterior Vertebral Tethering**
Mehmet Aydogan, MD; Tuna Pehlivanoglu, MD; Yigit Erdag, MD; Umut D. Akturk, MD; Abdulhalim Akar, MD; Ozgur Basal, MD

11:00 - 11:04 **Paper #83: Surgical Outcomes for Spinal Deformity in Osteogenesis Imperfecta**
Susan Sienko, PhD; Carol A. Tucker, PhD; Michelle C. Welborn, MD

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

ANNUAL MEETING AGENDA

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11:04 - 11:13 Discussion

11:13 - 11:15 2023 IMAST Preview
Stefan Parent, MD, PhD

11:15 – 11:17 2023 Annual Meeting Preview
Rajiv K. Sethi, MD

11:17 – 11:20 2023 Global Education Courses Preview
Saumyajit Basu, MBBS, MS, DNB, FRCS

11:20 – 11:25 Introduction of the President
Serena S. Hu, MD

11:25 – 11:45 Presidential Address
Christopher I. Shaffrey, MD

11:45 - 12:05 LUNCH PICK-UP M1

12:05 - 13:35 SRS MEMBER BUSINESS MEETING HALL A1

All SRS members are invited to the Member Business Meeting. Agendas will include reports from the various SRS committees, updates on SRS activities and programs, and voting (online).

12:05 - 13:35 LTS 4: MIS DEFORMITY SURGERY STATE OF THE ART: HOW TO AVOID AND MANAGE COMPLICATIONS HALL A1

Moderators: Regis W. Haid Jr., MD, Praveen V. Mummaneni, MD, David W. Polly, MD & Ann R. Stroink, MD

12:05 - 12:11 Preplanning in MIS Deformity: Age Appropriate Spinopelvic Targets
Virginie Lafage, PhD

12:11 - 12:17 Thinking Through the Indications and Approaches for MIS Deformity Surgery: The MIISA and MISDEF 2 Algorithms
Praveen V. Mummaneni, MD

DEBATE 1

12:17 - 12:20 MISDEF Class 2 Case With Stenosis at L1-5
Kai-Ming Gregory Fu, MD

12:20 - 12:26 Prepsoas Approach is Preferred for Indirect Decompression to Minimize Complications
Dean Chou, MD

12:26 - 12:32 Transpsoas Approach is Preferred for Indirect Decompresssion to Minimize Complications
Pierce D. Nunley, MD

12:32 - 12:38 MIS/Endoscopic/Hybrid Approach With TLIF is Tried and True for Direct Decompression to Minimize Complications
Lee Tan, MD

12:38 - 12:44 Single Position Lateral Surgery: It's the Best Way to Save Time
Robert K. Eastlack, MD

12:44 - 12:50 MIS With ALIF/ACR Has the Lowest Complications and Best Results
Gregory M. Mundis, MD

12:50 - 12:56 Dual Position Lateral and Prone Surgery: Tried and True Results to Avoid Complications
Paul Park, MD

12:56 - 13:02 Discussion

DEBATE 2

13:02 - 13:05 MIS Versus Open: Sagittal Imbalance MISDEF Class 3 Case Presented
Sigurd H. Berven, MD

13:05 - 13:11 Prone Lateral Surgery: It's the Best Way to Save Time and Maximize Lordosis
Juan S. Uribe, MD

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

Program (faculty and times) are subject to change

13:11 - 13:17 Open PSO is the Gold Standard: Why Mess With Success?
Justin S. Smith, MD, PhD

13:17 - 13:23 Tips and Tricks to Avoid PJK and Pseudarthrosis With MIS at the TL Junction
Neel Anand, MD

13:23 - 13:29 Tips and Tricks to Avoid DJK and Pseudarthrosis With MIS at the LS Junction
David O. Okonkwo, MD

13:29 - 13:35 Discussion

13:35 - 13:55 BREAK

13:55 - 15:40 ABSTRACT SESSION 7 & 8 (TWO CONCURRENT SESSIONS) HALL A1, HALL A2

13:35 - 15:40 HALL A1

ABSTRACT SESSION 7: EARLY ONSET SCOLIOSIS AND NONOPERATIVE (RUNS CONCURRENTLY TO SESSION 8)

Moderators: Teresa Bas, MD, PhD & Judson W. Karlen, MD

13:55 - 13:59 Paper #84: Unplanned Return to the Operating Room (UPROR) Occurs in Half of MCGR Patients at 2.4 Years After Initial Implantation
Amy L. McIntosh, MD; Anna McClung, BSN; John T. Smith, MD; Paul D. Sponseller, MD, MBA; Matthew E. Oetgen, MD; Pediatric Spine Study Group

13:59 - 14:03 Paper #85: Complications Associated With Use of MCGRs and TGRs in the Management Of EOS: A Multicenter Database Study Of 800 Patients
Smitha E. Mathew, MBBS; David L. Skaggs, MD, MMM; Craig M. Birch, MD; Matthew E. Oetgen, MD; Pediatric Spine Study Group

14:03 - 14:07 Paper #86: Incidence and Characteristics of Instrumentation Failure in Growth-Sparing Surgery for Pediatric Spine Deformities: A Retrospective Review of 1139 Surgeries
Noriaki Yokogawa, MD; Satoru Demura, MD, PhD; Toru Yamaguchi, MD; Satoshi Suzuki, MD, PhD; Teppei Suzuki, MD, PhD; Kei Watanabe, MD, PhD; Keita Nakayama, MD; Yuki Taniguchi, MD, PhD; Hideki Murakami, MD, PhD; Takuya Yamamoto, MD; Ryo Sugawara, MD, PhD; Tetsuya Ohara, MD; Noriaki Kawakami, DMSc

14:07 - 14:16 Discussion

14:16 - 14:20 Paper #87: How Deep is Too Deep: The Role of Tissue Depth in Magnetically Controlled Growing Rod (MCGR) Force
Benjamin Sinder, PhD; Vincent Ruggieri, BS; Jason Smith, PA-C; John (Jack) M. Flynn, MD; Patrick J. Cahill, MD; Brett Lullo, MD; Jason B. Anari, MD

14:20 - 14:24 Paper #88: Proximal Level Selection in Magnetically Controlled Growing Rods: T2 or T3 May Be Protective Against UPROR
Fernando Rios, MD; Bahar Shahidi, PhD; Joshua M. Pahys, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Lindsay M. Andras, MD; Matthew E. Oetgen, MD; Peter O. Newton, MD; Burt Yaszay, MD; Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD

14:24 - 14:28 Paper #89: The Lower Instrumented Vertebra Dilemma in Growing Rod Surgery
Gloria Talavera, MD; Rajkishen Narayanan, MD; Javier Martínez, PhD, MS; Lucía Moreno-Manzanaro, BS; Fernando Escamez, MD; Jose Miguel Sánchez-Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; Paul D. Sponseller, MD, MBA; George H. Thompson, MD; Francisco Javier S. Perez-Grueso, MD; John B. Emans, MD; Steven W. Hwang, MD; Javier Pizones, MD, PhD; Pediatric Spine Study Group

14:28 - 14:37 Discussion

14:37 - 14:41 Paper #90: The Price of Another Centimeter: Reimplantation With a Second Set of Magnetic Growing Rods Yields Diminishing Returns
David J. Fralinger, MD; Ali Asma, MD; Luiz Silva, MD; William G. Mackenzie, MD; Peter G. Gabos, MD; William G. Mackenzie, MD; Suken A. Shah, MD

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Program (faculty and times) are subject to change

14:41 - 14:45 **Paper #91: Predicting Pulmonary Function from Thoracic Deformity Parameters in Pre-Operative EOS Patients**
Mattan R. Orbach; A. Noelle Larson, MD; Oscar H. Mayer, MD; Ron El-Hawary, MD; Patrick J. Cahill, MD; Sriram Balasubramanian, PhD

14:45 - 14:49 **Paper #92: Quantification of Diaphragm Motion via Free-breathing Dynamic Magnetic Resonance Imaging**
You Hao, PhD; Jayaram K. Udupa, PhD; Yubing Tong, PhD; Joseph M. McDonough, MS; Caiyun Wu, MS; Carina Lott, MS; Abigail Clark, MEng; Oscar H. Mayer, MD; Jason B. Anari, MD; Drew A. Torigian, MA; Patrick J. Cahill, MD

14:49 - 14:58 **Discussion**

14:58 - 15:02 **Paper #93: Index Definitive Fusion Produces Outcomes Equivalent to Growth-Sparing Methods in Patients > Age 6 Years**
Charles E. Johnston, MD; David C. Thornberg, BS; Robert Palmer, MD

15:02 - 15:06 **Paper #94: Mortality Rate in Patients Treated for Early Onset Idiopathic Scoliosis Before Maturity**
Aina J. Danielsson, MD, PhD; Kerstin Lofdahl Hallerman, MD, PhD

15:06 - 15:10 **Paper #95: Curve Characteristics and Surgical Outcomes in Scoliosis Associated With Childhood Sternotomy or Thoracotomy: A Multicenter Study Over 19 Years**
Joanna L. Langner, MS; Teeto Ezeonu, BS; Abdul-Lateef Shafau, BS; Japsimran Kaur, BS; Kiley F. Poppino, BS; Claire Shivers, BS; Sai S. Chilakapati, MS; Kimberly E. Hall, MD; Meghan N. Imrie, MD; Lawrence A. Rinsky, MD; Anthony I. Riccio, MD; John S. Vorhies, MD

15:10 - 15:19 **Discussion**

15:19 - 15:23 **Paper #96: Prediction of Future Curve Severity in Idiopathic Scoliosis Between Age 6 and Skeletal Maturity Without Treatment: A Validated Natural History Model**
Eric C. Parent, PhD; Sabrina Donzelli, MD; Maryna Yaskina, PhD; Alberto Negrini; Giulia A. Rebagliati, MD; Claudio Cordani, PT; Stefano Negrini, MD

15:23 - 15:27 **Paper #97: Natural History of Idiopathic Scoliosis: Validated Models of Curve Progression for Three Group Ages (Pre, At and Post Growth Spurt)**
Stefano Negrini, MD; Maryna Yaskina, PhD; Sabrina Donzelli, MD; Giulia A. Rebagliati, MD; Alberto Negrini; Claudio Cordani, PT; Eric C. Parent, PhD

15:27 - 15:31 **Paper #98: Early Brace Treatment for Idiopathic Scoliosis May Change the Paradigm to Improve Curves Permanently**
Karina A. Zapata, DPT, PhD; Matthew Owen, BS; Donald Virostek, BS, LPO/CPO; Daniel J. Sucato, MD, MS

15:31- 15:40 **Discussion**

13:35 - 15:40 **HALL A2**

ABSTRACT SESSION 8: ADULT SPINAL DEFORMITY (RUNS CONCURRENTLY TO SESSION 7)

Moderators: David B. Cohen, MD & Rajiv K. Sethi, MD

13:55 - 13:59 **Paper #99: Quantifying the Contribution of Lower Limb Compensation to Upright Posture: What Happens if ASD Patients Do Not Compensate?**
Renaud Lafage, MS; Jonathan Elysee, MS; Shay Bess, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCSC; Christopher P. Ames, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

13:59 - 14:03 **Paper #100: A Complement Type to SRS-Schwab Adult Spinal Deformity Classification: The Failure of Pelvic Compensation**
Ho-Joong Kim, MD; Ohsang Kwon, MD; Dae-Woong Ham, MD; Sanghoon Lee, MD

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14:03 - 14:07 **Paper #101: Height Gain Following Correction of Adult Spinal Deformity: Magnitude, Anatomic Distribution, and Association With Patient Satisfaction**
Bassel G. Diebo, MD; Zachary Tataryn, MD; Daniel Alsoof, MBBS; Renaud Lafage, MS; Robert A. Hart, MD; Peter G. Passias, MD; Christopher P. Ames, MD; Justin K. Scheer, MD; Stephen J. Lewis, MD, FRCSC; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Vedat Deviren, MD; Breton G. Line, BS; Alex Soroceanu, MPH; D. Kojo Hamilton, MD, FAANS; Eric O. Klineberg, MD; Gregory M. Mundis, MD; Han Jo Kim, MD; Jeffrey L. Gum, MD; Justin S. Smith, MD, PhD; Juan S. Uribe, MD; Michael P. Kelly, MD; Khaled M. Kebaish, MD; Munish C. Gupta, MD; Pierce D. Nunley, MD; Robert K. Eastlack, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Lawrence G. Lenke, MD; Frank J. Schwab, MD; Shay Bess, MD; Virginie Lafage, PhD; Alan H. Daniels, MD; International Spine Study Group

14:07 - 14:16 **Discussion**

14:16 - 14:20 **Paper #102: Pre-Contoured Rods in Achieving Planned Regional and Global Alignment: A Lot of Planning but Does it Matter in Adult Spinal Deformity? A Multicentered Study**
Michael Fields, MD, BS; Nathan J. Lee, MD; Eric Leung, BS; Paul J. Park, MD; Venkat Boddapati, MD; Joseph A. Osorio, MD, PhD; Avery L. Buchholz, MD; Greg Poulter, MD; Christopher J. Kleck, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD

14:20 - 14:24 **Paper #103: Assessing the International Spine Study Group and European Spine Study Group Sagittal Alignment Goals in an Asymptomatic Adult Cohort**
Bradley Saitta, MD; Michael Schallmo, MD; Susan Odum, PhD; Ryan Berger, MD; Adam M. Wegner, MD, PhD; P. Bradley Segebarth, MD

14:24 - 14:28 **Paper #104: Importance of Modifiable Non-Radiographic Parameters for Adult Spinal Deformity**
Kouzaburou Mizutani, MD; Tetsuya Kobayashi, MD, PhD; Issei Senoo, MD, PhD; Mutsuya Shimizu, MD, PhD; Hiroki Okayasu, MD

14:28 - 14:37 **Discussion**

14:37 - 14:41 **Paper #105: Factors Effecting Opioid Use of European Adult Spinal Deformity Patients: Minimum 5-Year Follow-Up Study**
Kadir Abul, MD; Arin Alanay; Caglar Yilgor, MD; Altug Yucekul, MD; Yasemin Yavuz, PhD; Tais Zulemyan, MSc; Louis Boissiere, MD; Anouar Bourghli, MD; Ibrahim Obeid, MD; Javier Pizones, MD, PhD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; European Spine Study Group

14:41 - 14:45 **Paper #106: Spinal Cord Stimulators Adversely Affect Outcomes in Deformity Surgery**
Michael S. Chang, MD; Biodun Adeniyi, MD, MS; Dennis G. Crandall, MD; Yu-Hui F. Chang, PhD

14:45 - 14:49 **Paper #107: Evaluating the Impact of Multiple Sclerosis on 2-Year Postoperative Outcomes Following Long Fusion for Adult Spinal Deformity: A Propensity Score-Matched Analysis**
Ryan Kong, BS; George A. Beyer, MS; Hallie A. Tiburzi, BS; Frank A. Segreto, BS; Neil V. Shah, MD, MS; Adam J. Wolfert, BS; Daniel Alsoof, MBBS; Renaud Lafage, MS; Peter G. Passias, MD; Frank J. Schwab, MD; Alan H. Daniels, MD; Virginie Lafage, PhD; Bassel G. Diebo, MD; Carl B. Paulino, MD

14:49 - 14:58 **Discussion**

14:58 - 15:02 **Paper #108: Determining a Cutoff Value for Hand Grip Strength to Predict Favorable Outcomes of Adult Spinal Deformity Surgery**
Ho-Joong Kim, MD; Ohsang Kwon, MD; Dae-Woong Ham, MD

15:02 - 15:06 **Paper #109: Circumferential Minimally-Invasive Adult Spinal Deformity Surgery Provides Incremental Benefit for Increasingly Frail Patients**
Peter G. Passias, MD; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Oscar Krol, BS; Bailey Imbo, BA; Nima Alan, MD; Pierce D. Nunley, MD; Michael Y. Wang, MD; Paul Park, MD; Adam S. Kanter, MD; David O. Okonkwo, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Dean Chou, MD; Nitin Agarwal, MD; Andrew K. Chan, MD; Richard G. Fessler, MD; Juan S. Uribe, MD; Neel Anand, MD; Khoi D. Than, MD; Damian Brusko, MD; Saman Shabani, MD; Sumedh Shah, MD; Kai-Ming Gregory Fu, MD; Breton G. Line, BS; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Frank J. Schwab, MD; Shay Bess, MD; Praveen V. Mummaneni, MD; International Spine Study Group

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15:06 - 15:10 **Paper #110: Relationship Between Adult Spinal Deformity Surgery and Employment, Sick Leaves, Return to Work, and Early Retirement: Minimum 5-Year Follow-Up Study**
Caglar Yilgor, MD; Altug Yucekul, MD; Tais Zulemyan, MSc; Yasemin Yavuz, PhD; Javier Pizones, MD, PhD; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; European Spine Study Group

15:10 - 15:19 **Discussion**

15:19 - 15:23 **Paper #111: The Equilibration of Sagittal Alignment Over Time In the Adult Spinal Deformity Patient – Is the Immediate Postoperative Radiograph Misleading in Ultimate Sagittal Alignment?**
Paul J. Park, MD; Fthimnir Hassan, MPH; Cole Morrissette, MS; Nathan J. Lee, MD; Yong Shen, BS; Mark Herbert, BS; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

15:23 - 15:27 **Paper #112: Long-Term Loss of Alignment Following ASD in the Absence of Mechanical Complications: Aging Spine?**
Sleiman Haddad, MD, PhD, FRCS; Maria Capdevila Bayo, MS; Susana Núñez Pereira, MD; Aleix Ruiz de Villa, PhD; Alba Vila-Casademunt, MS; Manuel Ramirez Valencia, MD; Javier Pizones, MD, PhD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Ferran Pellisé, MD, PhD; European Spine Study Group

15:27 - 15:31 **Paper #113: Loss of Sagittal Correction >3 Years After Adult Spinal Deformity Surgery**
Francis C. Lovecchio, MD; Renaud Lafage, MS; Han Jo Kim, MD; D. Kojo Hamilton, MD, FAANS; Jeffrey L. Gum, MD; Alex Soroceanu, MPH; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; Munish C. Gupta, MD; Douglas C. Burton, MD; Shay Bess, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

15:31 - 15:40 **Discussion**

15:40 - 16:00 REFRESHMENT BREAK — M1

16:00 - 17:45 ABSTRACT SESSION 9: ADOLESCENT IDIOPATHIC SCOLIOSIS AND PEDIATRIC DEFORMITIES — HALL A1

Moderators: Patrick J. Cahill, MD & Kenny Y. Kwan, MD

16:00 - 16:04 **Paper #114: Curve Overcorrection Predicts Coronal Imbalance in Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis**
Soren Ohrt-Nissen, MD, PhD; Prudence Wing Hang Cheung, BDSc (Hons); Sachiko Kawasaki, MD; Hideki Shigematsu, MD, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS

16:04 - 16:08 **Paper #115: Simultaneous Overcorrection of Lowest Instrumented Vertebral Tilt and Main Thoracic Curve is Related to Progression of Unfused Residual Lumbar Curve After Posterior Fusion in Adolescent Idiopathic Scoliosis**
I-Hsin Chen, MD; Chih-Wei Chen, MD; Ming-Hsiao Hu, MD; Po-Yao Wang, MD; Yu-Cheng Yeh, MD; Yuan- Fuu Lee, MD; Po-Liang Lai, MD; Shu-Hua Yang, MD

16:08 - 16:12 **Paper #116: Incidence and Predictors of Growth Modulation and Overcorrection After Anterior Vertebral Body Tethering**
Joshua M. Pahys, MD; Steven W. Hwang, MD; Maureen McGarry, BBE; Alejandro Quinonez, BS; Harsh Grewal, FACS, FAAP; Amer F. Samdani, MD

16:12 - 16:21 **Discussion**

16:21 - 16:25 **Paper #117: Progressive Intervertebral Disc and Vertebral Body Adaptations Induced by Posterolateral Tethering in a Porcine Scoliosis Model**
Axel C. Moore, PhD; Adriana Barba; Harrah R. Newman; Kyle D. Meadows; Benjamin Sinder, PhD; Alessandra Fusco, DVM; Rachel Hilliard; Sriram Balasubramanian, PhD; Edward Vresilovic, MD; Jason B. Anari, MD; Patrick J. Cahill, MD; Thomas P. Schaer, VMD; Dawn M. Elliott, PhD; Brian D. Snyder, MD, PhD

16:25 - 16:29 **Paper #118: Major Cobb Angle Did Not Decrease in 92% of Patients After Vertebral Body Tethering Surgery Following First Erect Radiograph**
Tiffany N. Phan; Tishya Wren, PhD; Firoz Miyanji, MD; Stefan Parent, MD, PhD; Michelle C. Welborn, MD; David L. Skaggs, MD, MMM; Kenneth D. Illingworth, MD; Pediatric Spine Study Group; Lindsay M. Andras, MD

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16:29 - 16:33 **Paper #119: Differential Vertebral Growth is Maintained 4 Years After Vertebral Body Tethering Surgery for Idiopathic Scoliosis**
Gregory Photopoulos, BHSc; Jennifer K. Hurry, MASc; Ankita Bansal, MBBS, MS; Firoz Miyanji, MD; Stefan Parent, MD, PhD; Joshua S. Murphy, MD; Ron El-Hawary, MD; Pediatric Spine Study Group

16:33 - 16:42 **Discussion**

16:42 - 16:46 **Paper #120: 3-D Vertebral Shape Changes Confirm Growth Modulation After Anterior Vertebral Body Tethering for Idiopathic Scoliosis**
Joshua N. Speirs, MD; Stefan Parent, MD, PhD; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Maty Petcharaporn, BS; Tracey P. Bastrom, MA; Peter O. Newton, MD

16:46 - 16:50 **Paper #121: 3D Analysis of the Preoperative Deformity in AIS Can be Used to Guide Surgical Decision Making for Selective Thoracic Fusion**
Vidyadhar V. Upasani, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Stephen G. George, MD; Stefan Parent, MD, PhD; Peter O. Newton, MD

16:50 - 16:54 **Paper #122: Baseline Vitamin D Insufficiency During Pubertal Growth is Associated With Low Peak Bone Mass in Adolescent Idiopathic Scoliosis: A 6-Year Prospective Cohort Study**
Kenneth GP Yang, BMed; Wayne YW Lee, PhD; Lik Hang Alec Hung, MD; Jack C. Cheng, MD; Tsz-Ping Lam, MBBS

16:54 - 17:03 **Discussion**

17:03 - 17:07 **Paper #123: Predictors of Radiographic Success When Utilizing a Lower Instrumented Vertebra of L3 in Idiopathic Scoliosis**
Chia-Hung Sze, MTM; Scott J. Luhmann, MD

17:07 - 17:11 **Paper #124: Can We Stop Distally at LSTV-1 for Adolescent Idiopathic Scoliosis With Lenke 1A/2A Curves? A Minimum 2-Year Follow-Up Study**
Xiaodong Qin, PhD; Yong Qiu, PhD; Zhen Liu, PhD; Bangping Qian, MD; Zezhang Zhu, MD, PhD

17:11 - 17:15 **Paper #125: Preoperative and Surgical Factors That Maximize Change in Lumbosacral Takeoff Angle (LSTOA)**
Keith R. Bachmann, MD; Theodore Rudic; Richard E. Campbell, MD; Alexander Hafey; Monica Arney, MD; Wendy M. Novicoff, PhD; Peter O. Newton, MD

17:15 - 17:24 **Discussion**

17:24 - 17:28 **Paper #126: A Thoracoscopic Anterior Approach to the Spine for Adolescent Idiopathic Scoliosis Does Not Have a Detrimental Effect on Pulmonary Function at 2 Years Compared to Posterior-Only Surgery**
Harold G. Moore, BS; Anna McClung, BSN; David C. Thornberg, BS; Brenda C. Santillan, BS; Daniel J. Sucato, MD, MS

17:28 - 17:32 **Paper #127: Two to Five Years' Pulmonary Functions After Thoracic, Thoracolumbar, and Double-Curve VBT Surgery**
Caglar Yilgor, MD; Burcu Akpunarli, MD; Altug Yucekul, MD; Kadir Abul, MD; Peri Kindan, MD; Gokhan Ergene, MD; Sahin Senay, MD; Tais Zulemyan, MSc; Yasemin Yavuz, PhD; Ahmet Alanay, MD

17:32 - 17:36 **Paper #128: Expansion Sternoplasty to Treat a Novel Form of Thoracic Insufficiency**
Blake Montgomery, MD; Emily Eickhoff, BS; Christopher Baird, MD; Benjamin Zendejas, MD; Russell W. Jennings, MD; Brian D. Snyder, MD, PhD

17:36 - 17:45 **Discussion**

18:30 - 19:30 PRESIDENT'S RECEPTION (BY INVITATION ONLY) OFFSITE

19:30 - 22:00 FAREWELL RECEPTION (TICKET REQUIRED) OFFSITE

Open to all registered delegates and registered guests. Tickets are $50 for registered delegates and $175 for registered guests and must be purchased in advance. A limited number of tickets may be available onsite, please stop at the registration desk for information and ticket availability.

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08:00 - 10:10 ABSTRACT SESSION 10: BASIC SCIENCE, NONOPERATIVE, QSUC — HALL A1

Moderators: Michael P. Kelly, MD & Stefano Negrini, MD

08:00 - 08:04 **Paper #129: Delineation of Dual Molecular Diagnosis in Patients With Vertebral Deformities**
Nan Wu, MD; Lian Liu, MD; Huakang Du, BS; Paul Gerdhem, MD, PhD; Zhihong Wu, MD; Terry Jianguo Zhang, MD

08:04 - 08:08 **Paper #130: Cytoskeletal Keratins Are Overexpressed in a Zebrafish Model of Idiopathic Scoliosis**
Elizabeth A. Terhune, MS; Melissa T. Cuevas, MS; Cambria I. Wethey, BA; Denisa Grofova, BS; Anna Monley, BS; Lori Silveira, PhD; Nancy H. Miller, MD, PhD

08:08 - 08:12 **Paper #131: Coding Variants Coupled With Rapid Modeling in Zebrafish Implicate Dynein Genes, DNAAF1 and ZMYND10, as Adolescent Idiopathic Scoliosis Candidate Genes**
Yunjia Wang, MD; Hongqi Zhang, MD

08:12 - 08:21 **Discussion**

08:21 - 08:25 **Paper #132: Characteristics of Scoliosis Mice Induced by Chondrocyte-Specific Inactivation**
Makoto Handa, MD; Satoru Demura, MD, PhD; Noriaki Yokogawa, MD; Satoshi Kato, PhD; Kazuya Shinmura, PhD; Ryohei Annen, MD; Motoya Kobayashi, MD; Yohei Yamada, MD; Satoshi Nagatani, MD; Hiroyuki Tsuchiya, PhD

08:25 - 08:29 **Paper #133: Myokines in Serum Can Predict the Outcome of Brace Treatment in Girls With Adolescent Idiopathic Scoliosis**
Wu Zhichong, PhD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; Feng Zhenhua, PhD

08:29 - 08:33 **Paper #134: Biomechanical Effectiveness of Various Brace Designs to Treat Adolescent Idiopathic Scoliosis: An International Multicenter Study**
Aymeric Guy, MS; Maxence Coulombe, BEng; Hubert Labelle, MD; Manuel Rigo, MD; M S Wong, PhD; Babak H. Beygi, PhD; James Wynne, CPO, FAAOP; M. Timothy Hresko, MD; Eric Ebermeyer, MD; Philippe Vedreine ; Xue-cheng Liu, MD, PhD; John G. Thometz, MD; Benoit Bissonnette ; Charlotte Sapaly, MS; Soraya Barchi, BSc; Carl-Eric Aubin, PhD

08:33 - 08:42 **Discussion**

08:42 - 08:46 **Paper #135: Bracing Improves Curves and Aesthetics in Risser 3-4 Adolescents With 30 to 45° Curves. Retrospective Results From a Cohort of 1104 Consecutive Patients**
Stefano Negrini, MD; Fabio Zaina, MD; Sabrina Donzelli, MD

08:46 - 08:50 **Paper #136: Predicting Surgery: Accuracy of the BrAIST Endpoint Definitions at 2-Year Follow-Up**
Lori A. Dolan, PhD; Stuart L. Weinstein, MD

08:50 - 08:54 **Paper #137: Gut Microbiota in Adolescents With Severe Adolescent Idiopathic Scoliosis**
Jie Li, MD; Yanjie Xu, MD; Zongshan Hu, PhD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; Zhen Liu, PhD

08:54 - 09:03 **Discussion**

09:03 - 09:07 **Paper #138: Incidence and Causes of Instrument-Related Complications Following Primary Definitive Fusion for Pediatric Spine Deformity**
Satoru Demura, MD, PhD; Tetsuya Ohara, MD; Kota Watanabe, MD, PhD; Satoshi Suzuki, MD, PhD; Haruhisa Yanagida, MD, PhD; Toru Yamaguchi, MD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Toshiaki Kotani, MD, PhD; Keita Nakayama, MD; Kei Watanabe, MD, PhD; Takuya Yamamoto, MD; Yuki Taniguchi, MD, PhD; Katsushi Takeshita, MD; Ryo Sugawara, MD, PhD; Tatsuya Sato, MD, PhD; Kenta Fujiwara, MD; Tsutomu Akazawa, MD, PhD; Hideki Murakami, MD, PhD; Noriaki Kawakami, DMSc

09:07 - 09:11 **Paper #139: Mechanical Complications in the Surgical Correction of Scheuermann's Kyphosis and the Restoration of Normative Spinal Sagittal Alignment**
Nadav Gutman, MD; Jonathan Koch, MD; Nasir A. Quraishi, PhD, FRCS; Mohammed Shakil Patel, FRCS

09:11 - 09:15 **Paper #140: Long-Term Outcomes and Complications of Isolated Anterior Thoracolumbar Fusion for Neuromuscular Scoliosis Associated With Myelomeningocele**
Daniel Bouton, MD; Michelle C. Welborn, MD; Joseph Ivan Krajbich, MD

09:15 - 09:24 **Discussion**

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

Program (faculty and times) are subject to change

09:24 - 09:28 **Paper #141: A Matched Comparison of 2-Year Clinical and Radiographic Outcomes in Syrinx-Associated Versus Adolescent Idiopathic Scoliosis: A 30-Year Experience at a Single Institution**
Harold G. Moore, BS; Anna McClung, BSN; David C. Thornberg, BS; Brenda C. Santillan, BS; Daniel J. Sucato, MD, MS

09:28 - 09:32 **Paper #142: Complications Following Scoliosis Surgery for Patients With Myelomeningocele Who Have "AIS Like" Curves are Similar to Patients With Idiopathic Scoliosis**
Erin M. Honcharuk, MD; Drew Winsauer, BS; David C. Thornberg, BS; Megan Johnson, MD; Karl E. Rathjen, MD

09:32 - 09:36 **Paper #143: COVID-19 Significantly Impacted Initial Consultation for Idiopathic Scoliosis**
Matias Pereira Duarte, MD; Julie Joncas, RN; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD; Olivier Chémaly, MD; Felix L. Brassard, MD; Soraya Barchi, BSc; Stefan Parent, MD, PhD

09:36 - 09:45 **Discussion**

09:45 - 09:55 **Presentation of the Hibbs Awards**
Shay Bess, MD

09:55 - 10:10 **Transfer of the Presidency Introduction & Speech**
Christopher I. Shaffrey, MD & Serena S. Hu, MD

10:10 - 10:30 REFRESHEMENT BREAK M1

10:30 - 11:55 ABSTRACT SESSION 11: CERVICAL, QSVC, AND MISCELLANEOUS HALL A1

Moderators: Mostafa El Dafrawy, MBBCh & Joseph H. Perra, MD

10:30 - 10:34 **Paper #144: Outcomes of Operative Treatment for Adult Cervical Deformity: A Prospective, Multicenter Assessment With Minimum 2-Year Follow-Up**
Elias Elias, MPH, MSc; Shay Bess, MD; Breton G. Line, BS; Renaud Lafage, MS; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Zeina Nasser, MSc; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton, MD, FAANS; Michael P. Kelly, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

10:34 - 10:38 **Paper #145: Postoperative SVA >4cm Has no Impact on Neck Pain Scores After C2-T2 Fusion for Myelopathy: Results from a Multicenter Cohort Study**
Zachariah W. Pinter, MD; Bradford L. Currier, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Mohamad Bydon, MD; Benjamin D. Elder, MD, PhD; Scott Wagner, MD; Arjun Sebastian, MD

10:38 - 10:42 **Paper #146: At What Point Does Degenerative Become Deformity: When Good Outcomes Necessitate Sagittal Correction in Adult Cervical Deformity Surgery**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Peter Tretiakov, BS; Bailey Imbo, BA; Oscar Krol, BS; Rachel Joujon-Roche, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Ekamjeet Dhillon, MD; Jeffrey J. Varghese, MD; Bassel G. Diebo, MD; Shaleen Vira, MD; Heiko Koller, MD; Andrew J. Schoenfeld, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Virginie Lafage, PhD

10:42 - 10:51 **Discussion**

10:51 - 10:55 **Paper #147: Multifidus Sarcopenia is Associated With Worse Patient Reported Outcomes Following Posterior Cervical Decompression and Fusion**
Zachariah W. Pinter, MD; Harold I. Salmons, MD; Sarah Townsley, MD; Brett A. Freedman, MD; Bradford L. Currier, MD; Benjamin D. Elder, MD, PhD; Ahmad Nassr, MD; Mohamad Bydon, MD; Scott Wagner, MD; Arjun Sebastian, MD

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

ANNUAL MEETING AGENDA

SATURDAY, SEPTEMBER 17, 2022

Program (faculty and times) are subject to change

10:55 - 10:59 **Paper #148: All-Cause Mortality Following Cervical and Thoracolumbar Adult Deformity Surgery: Incidence and Causes**
Kevin C. Mo, MHA; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Peter Tretiakov, BS; Shay Bess, MD; Kevin Y. Wang, BS; Samrat Yeramaneni, PhD; Brian J. Neuman, MD; Richard Hostin, MD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; D. Kojo Hamilton, MD, FAANS; Frank J. Schwab, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Alex Soroceanu, MPH; Han Jo Kim, MD; Robert A. Hart, MD; Breton G. Line, BS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Lawrence G. Lenke, MD; Khaled M. Kebaish, MD; International Spine Study Group

10:59 - 11:03 **Paper #149: Radiographic and Clinical Findings Associated With Klippel-Feil Syndrome**
Andrew Megas, DO; Aniruddh Mandalapu; Gabrielle Santangelo, MD; Addisu Mesfin, MD, Emmanuel N. Menga, MD

11:03 - 11:12 **Discussion**

11:12 - 11:16 **Paper #150: Machine Learning Identifies Clusters of the Adolescent Spine Based on Sagittal Balance**
Lorenzo Deveza, MD, PhD; Birhiray Dion, BS; Martin Gehrchen, MD, PhD; Benny T. Dahl, MD, PhD, DMSci

11:16 - 11:20 **Paper #151: Comparison of Spinopelvic Configuration and Roussouly Alignment Types Between Pediatric and Adult Populations**
Yann Philippe Charles, MD, PhD; Vincent Lamas, MD; Sebastien Pesenti, MD, PhD; Brice Ilharreborde, MD, PhD; Guillaume Riouallon, MD; Federico Solla, MD; Ibrahim Obeid, MD; Emmanuelle Ferrero, MD, PhD; Erik- André Sauleau, MD, PhD; Benjamin Blondel, MD, PhD

11:20 - 11:24 **Paper #152: Biomechanical Comparison of Lumbar, Sacral and Iliac Screw Strain With the Kickstand Rod Versus Conventional Pelvic Fixation in Adult Spinal Deformity Surgery**
Alex Ha, MD; Josephine R. Coury, MD; Andrew J. Luzzi, MD; Daniel Hong, MD; Fthimnir Hassan, MPH; Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Dilip K. Sengupta, MD

11:24 - 11:33 **Discussion**

11:33 - 11:37 **Paper #153: The H2-FAILS Score Accurately Predicts 30-Day Mortality After Surgery for Metastatic Disease of the Spine**
Farah Musharbash, MD; Jawad Khalifeh, MD; Micheal Raad, MD; Varun Puvanesarajah, MD; Sang Hun Lee, MD; Brian J. Neuman, MD; Khaled M. Kebaish, MD

11:37 - 11:41 **Paper #154: Does Functional Outcome Improve After Surgery for Metastatic Spine Tumors in Patients With SINS 7-12 and SINS >12?**
Saman Shabani, MD; Enrique Vargas, BS; Alma Rechev Ben Natan, B.A; Alex Aabedi, MD; Nitin Agarwal, MD; Praveen V. Mummaneni, MD; Dean Chou, MD

11:41 - 11:45 **Paper #155: Development of A Spinal Deformity Surgical Checklist: An SRS Safety and Value Committee Survey Investigation**
Rafael De la Garza Ramos, MD; Justin K. Scheer, MD; Nabil Matmati, PhD; Lloyd A. Hey, MD; Douglas C. Burton, MD; Marinus de Kleuver, MD, PhD; Christopher P. Ames, MD; Vijay Yanamadala, MBA

11:45 - 11:55 **Discussion**

11:55 SRS 57TH ANNUAL MEETING CONCLUDES

Key: † = Hibbs Award Nominee – Best Clinical Paper * = Hibbs Award Nominee – Best Basic Science/Translational Paper

CASE DISCUSSION ABSTRACTS

The Scoliosis Research Society gratefully acknowledges
ZimVie
for their support of the Annual Meeting Beverage Breaks.

CASE DISCUSSION ABSTRACTS

1A. THE STRATEGY OF TREATMENT ROTATIONAL DISLOCATION OF THE SPINE IN SEVERE RIGID KYPHOSCOLIOTIC DEFORMITY

Zhiyue Shi, MD; Jingming Xie, MD; Yingsong Wang, MD; Ying Zhang, MD; Zhi Zhao, MD; Tao Li, MD; Ni Bi, MD; Quan Li, MD

Hypothesis
Preoperative traction combined grade 4 or above osteotomy and spinal shortening is effective and safe treatment rotational dislocation of kyphoscoliosis.

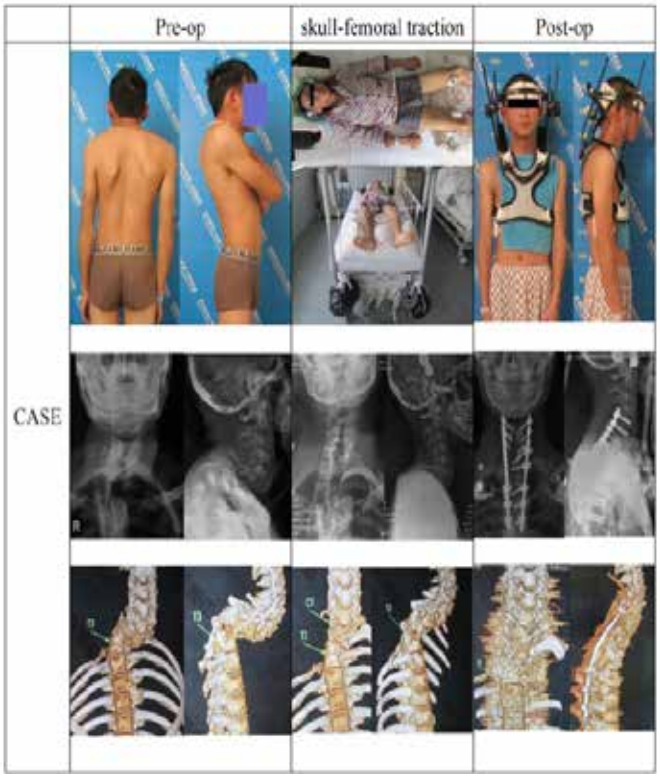
Design
Retrospective analysis.

Introduction
Rotational dislocation in kyphoscoliotic deformities leads to a short, sharp angled kyphosis at the junction of two-lordoscoliotic curves. It is a huge challenging and neurological risk for surgical treatment for rotational dislocation in kyphoscoliotic deformities.

Methods
Inclusion criteria:All patients were diagnosed as rotation dislocation in spinal deformity who presented the two scoliotic curves pattern of the apex of the kyphosis on the frontal radiograph, and the double-vertebrae sign of rotational dislocation of the spine on CT scans. Sagittal kyphosis angle > 90°. 7 cases of severe spinal deformity with vertebral rotation dislocation were retrospectively analyzed from 2015 to 2017. There were 3 male and 4 female, average age 18.71Yrs ,the etiologic diagnosis included 4 cases of congenital kyphosis, 2 cages of TB, and 1 case of neurofibromatosis. 2 cases were incomplete neurologic deficits with ASIA scales C. Rotation dislocation of spine level was from T2 to L1. All patients were treated by skull-femoral traction for 2 weeks before surgery and underwent posterior grade 4 or above osteotomy, circumferential spinal cord decompression, spinal shortening and correction of kyphoscoliosis.

Results
The final skull-femoral traction force in the 7 cases was 61 % of body weight. The average operative time and blood loss were 530.00±65.83 minutes, 1400±412.31ml. Grade 4 osteotomy was performed in 2 cases, grade 5 osteotomy in 2 cases and grade 6 osteotomy in 3 cases. The mean coronal Cobb improved from 48.29°to 33.57°after traction and to 16.86°at post-op. The mean sagittal kyphosis Cobb improved from 110.43°to 84.86°after traction and to 46.71°at post-op. The 2 cases with incomplete neurologic deficits were improved from ASIA C to ASIA D at 2 years following up.

Conclusion
Preoperative traction should be used to improve rotation dislocation and reduce the complexity and risk of surgical procedure.Posterior grade 4 or above osteotomy, circumferential spinal cord decompression , spinal shortening is a safe and powerful procedure for treatment rotational dislocation of the spine in severe rigid kyphoscoliosis.



1B. CONGENITAL SPINAL DISLOCATION: A CASE SERIES AND REVIEW OF THE LITERATURE

Evan Yarnall, BS; Andrew J. Kim; Amer F. Samdani, MD; Joshua M. Pahys, MD; Eric O. Klineberg, MD; Paul Moroz, MD; Peter J. Stasikelis, MD; Steven W. Hwang, MD

Hypothesis
Untreated congenital spinal dislocation has a high risk of progressive neurological compromise.

Design
Multicenter retrospective series

Introduction
Congenital spinal dislocation is a rare, complex entity that can be associated with a high risk of complications, such as neurological deficits. Despite this, there is a paucity of literature regarding surgical management of this condition.

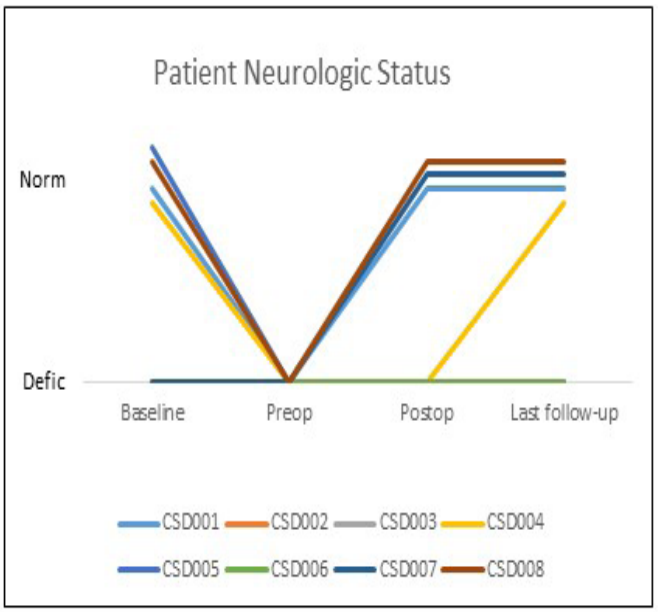
Methods
Data were collected for patients with a diagnosis of congenital dislocation at diagnosis, pre-op, post-op and last follow-up. Patients were then grouped to compare changes in neurological status using Student's t-tests.

Results
8 patients with a mean age at diagnosis of 15 months had an average of 49 months of follow-up. 4 patients also had tethered cords released surgically. The mean interval between diagnosis and surgery was 16 months. 4 patients who had normal neurological exams deteriorated prior to surgery, and the remaining 4 had deficits at presentation. 7 dislocations were located in the thoracolumbar spine and 1 was located in the cervicothoracic spine. The average focal kyphosis corrected from 44° to 16°(p<0.05). All 8 patients had vertebral column resections. 2 patients had intraoperative complications of durotomies without need for

CASE DISCUSSION ABSTRACTS

further intervention. 3/8 (40%) required additional surgery for pseudarthrosis or instrumentation-related complications a mean 23 months after index surgery. 4 patients had improvement in their neurological status post-op, but 4 did not. Patients who neurologically recovered after surgery tended to have greater focal kyphosis (50° vs 32°, $p<0.05$) and were older (61 vs. 15 months, $p<0.05$). Patients with a deterioration of neurological status prior to their surgery had longer wait times between their diagnosis and surgery (28 vs. 4 months, $p<0.05$). 144 patients were identified in the literature review. The average pre-op and post-op kyphosis were 54° and 48°, respectively. 19/46 (41%) patients had a normal neurologic exam pre-op and 9/34 (26%) improved after surgical intervention. 5/30 (17%) had complications including complete paraplegia, partial transection of the spinal cord, and dense lower extremity monoparesis.

Conclusion
In patients with congenital spinal dislocations, early intervention is crucial to minimize risk of neurological decline. Although 40% of patients will require additional surgery, patients do well overall with many improving neurologically after surgery.



1C. CORONAL DECOMPENSATION IN PATIENTS WITH CERVICOTHORACIC HEMIVERTEBRA UNDERGOING POSTERIOR-ONLY HEMIVERTEBRA RESECTION

Yong Qiu, PhD; Yang Li, PhD; Zezhang Zhu, MD, PhD; Zhen Liu, PhD; Xu Sun, MD; Benlong Shi, PhD; Sai-hu Mao, PhD

Hypothesis
The postoperative coronal decompensation (CD) often presented in patients with congenital cervicothoracic hemivertebra (CTH) undergoing posterior hemivertebra resection, of which the prevalence and the possible mechanisms of this specific phenomenon should be well analyzed.

Design
A retrospective and consecutive study

Introduction
Though the spinal alignment could be well corrected via posterior hemivertebra resection in CTH patients, the high prevalence of CD was remarkable and there was short of literature documenting the incidence or its possible mechanisms. This study aimed to investigate the prevalence of postoperative CD in patients with CTH scoliosis undergoing posterior-only hemivertebra resection and to propose possible mechanisms of this specific phenomenon.

Methods
A consecutive series of 51 patients with CTH undergoing posterior-only hemivertebra resection with a minimum of 2-year follow-up were reviewed. At pre-operation, post-operation, and each follow-up, the local scoliosis, clavicle angle, head shift, neck tilt, Cobb angle of compensatory curve were measured. The CD was defined as compensatory curve beyond 20° and progression more than 10° compared with immediate post-operation during follow-up. The incidence and possible mechanisms of CD were recoded and analyzed.

Results
A total of 12 patients (23.5%) presented postoperative CD. The values of compensatory curve were 11.3±7.1° before surgery and 4.6±4.1° after surgery ($p=0.001$), which was 28.0±2.6° when diagnosed as CD and developed to 21.3±2.5° at the last follow-up. The CD was classified into compensatory and idiopathic types according to the curve characteristics. The compensatory type of CD usually presented within 6 months after operation and was responsible for further reconstruction of shoulder balance. The idiopathic type of CD occurred at adolescent which may be attributed to the rapid body growth.

Conclusion
The CD would be often presented in patients with CTH undergoing posterior hemivertebra resection, of whom the prevalence was 23.5%. The CD could be divided into compensatory and idiopathic types, of which the reconstruction of shoulder balance and rapid body growth were 2 key mechanisms, respectively.

1D. PJK SECONDARY TO OVERCORRECTION OF SCHEURMANN'S KYPHOSIS: RESTORE KYPHOSIS OR EXTEND TO THE NECK?

Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Terry D. Amaral, MD

Hypothesis
Overcorrection of Scheurmann's kyphosis leads to prominent clinical and radiographic PJK, requiring revision surgery producing a management dilemma.

Design
Case Report.

Introduction
17 year old male who had idiopathic scoliosis with a 55° T1-T11 curve, 45° T11-L5 curve and hyperkyphosis of 90°. Patient was originally managed non-surgically before undergoing T1-L4 posterior spinal fusion. Navigation was utilized for screw insertion. Patient did well postoperatively and was discharged showing good correction.

Methods
1-2 months follow up, mother noticed a neck abnormality with the patient having difficulty keeping his head upright. Mother was assured it would be corrected with physical therapy. Physical therapy was started but mother continued to see a goose neck appearance. CT scan was carried out and showed that implants were in place.

Results
At most recent 1 year follow up, Cobb angle was measured at 14° and patient has PJK of 52° measured from T1-C6. Patient had a mild anterior C6 over C7 subluxation of 2mm and a C7-T1 disc space narrowing. Patients can hold his head upright, but has a severe goose neck appearance with shortened and widened neck. On x-ray, cervical lordosis is 75° Additionally, patients has mild leg length discrepancy, and pelvic asymmetry that parallels L4 tilt. He continues to complain of upper back and neck pain, which has not responded to non-operative treatment. Surgical dilemma is extension of fusion to C2 vs. restoration of kyphosis using multiple Smith-Peterson osteotomies.

Conclusion
Proximal junction kyphosis after Scheurmann's kyphosis can be a management challenge. Further extension to the cervical spine has significant drawbacks. The best strategy is to avoid overcorrection.

2A. THORACOGENIC SCOLIOSIS IN ADOLESCENT SURVIVORS OF SINGLE VENTRICLE INFANTS

Carina Lott, MS; Mitchell A. Johnson, BS; Abigail Clark, MEng; David J. Goldberg, MD; John (Jack) M. Flynn, MD; Patrick J. Cahill, MD; *Jason B. Anari, MD*

Hypothesis
With an increasing survivorship and incidence of spinal deformity, patients with single ventricle physiology may require surgical intervention to manage their scoliosis.

Design
Retrospective review

Introduction
The incidence of spinal deformity in children who undergo chest surgery at an early age is increased compared to the general population. Children born with single ventricle anatomy are a unique population as they typically require three open chest surgeries prior to 5 years of age. We aim to understand the incidence and severity of scoliosis in children with single ventricle heart disease and to describe the expected course of treatment for those who require operative care.

Methods
We performed a retrospective review of children who underwent single ventricle reconstruction surgery between 2003-2011 at a single institution. Patients were included if they were ≥ 12 years of age at most recent chest or spine radiograph and if they had at least two years of clinical follow-up. Patient demographics, clinical and radiographic variables were recorded and comparisons were made between those who required surgical intervention and those who did not.

Results
Of the 470 patients who underwent single ventricle reconstruction procedure between 2003-2011, 129 met inclusion criteria and served as the study cohort. Of these, thirty-six (30%) showed spinal deformity, with a mean cobb angle of 37.8°±21.1, and 9 required surgical treatment to manage their scoliosis. No difference was found between age at single ventricle surgery between patients who required surgery and those who did not (p=0.09). Eight patients had a posterior spinal fusion and 1 patient had a rib-based construct. Average age at spine surgery was 13.7±2.1 years (Table 1). Infections accounted for all 3 post-op complications, one of which required a reoperation for a surgical debridement.

Conclusion
Scoliosis is a relatively common occurrence following single ventricle reconstruction surgery. With interoperative monitoring, cardiac anesthesia expertise, and close post-operative collaboration with the cardiology service, patients with a single ventricle can safely undergo corrective spine deformity surgery.

Table 1. Patients with single ventricle reconstruction surgery who developed scoliosis. 9 patients required spinal surgery to manage their scoliosis.

	Patients Requiring Spinal Surgery (n= 9)	Patients not Requiring Spinal Surgery (n= 27)	p-value
Gender *Male* *Female*	 4 5	 12 15	 1
Follow-up (years)	15.6 ± 2.75	16.7 ± 2.2	0.28
Age at single ventricle reconstruction surgery (years)	4.1 ± 1.7	2.9 ± 1.1	0.09
Age at Spinal Surgery	13.7 ± 2.1	--	--
Type of Spine Surgery *PSF* *Rib-based distraction*	 7 1	 --	 --
Age at most recent radiograph	15.4 ± 2.1	15.9 ± 2.1	0.51
Average Pre-op Cobb Angle (°)	63.3 ± 15.1	--	--
Average Cobb Angle at most recent radiograph (°)	26.5 ± 17.8	30.1 ± 15.2	0.61

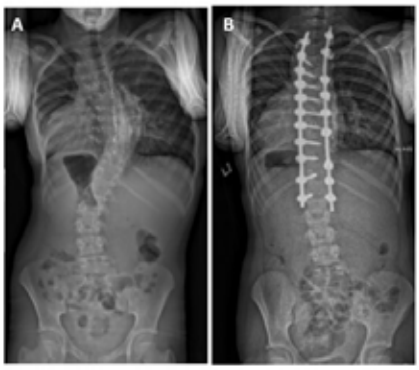


Figure 1. Pre-operative radiograph (A) and post-operative radiograph (B) of patient with single ventricle physiology who underwent posterior spinal fusion.

2B. APICAL CORRECTION AND GLOBAL BALANCE SURGICAL STRATEGY CAN IMPROVE CARDIOPULMONARY FUNCTION IN PATIENTS WITH SEVERE AND RIGID SCOLIOSIS AT A 2-YEAR FOLLOW-UP

Jianxiong Shen, MD; *Yang Jiao, MBBS*; Erwei Feng, MD; Jiachen Lin, MD, PhD; Zhen Wang, MD; Junduo Zhao, MBBS

Hypothesis
Apical correction and global balance surgical strategy is not only safe and effective for the treatment of severe and rigid scoliosis, but it also can improve patients' long term cardiopulmonary function.

CASE DISCUSSION ABSTRACTS

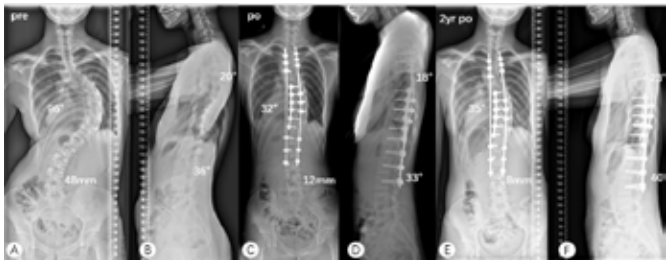
Design
Retrospective study.

Introduction
Patients with severe and rigid scoliosis (Cobb angle >90°, flexibility <30%) often have moderate or severe restrictive pulmonary dysfunction. The surgical treatment of these patients is still challenging. Apical correction and global balance surgical strategy can provide reasonable correction and low incidence of complications, however, the effects of this strategy on long-term cardiopulmonary function have not been reported.

Methods
Twelve patients who underwent one-stage posterior corrective operation using the apical correction and global balance strategy from February 2014 to January 2020 were recruited. The inclusion criteria comprised severe and rigid scoliosis (Cobb angle >90°, flexibility <30%) and a minimum follow-up duration of 2 years. Spinal radiographic parameters were measured before surgery, after surgery and at the last follow-up. The static pulmonary function testing (PFT) and dynamic cardiopulmonary exercise testing (CPET) were performed preoperatively and at the last follow-up. During the operation, two rods were implanted into the concave side: the short rod for apical correction and the long rod for global balance. A third rod was implanted on the convex side for support.

Results
The major curve was corrected from 101.6±12.1° to 54.6±17.8° and remained stable at the last follow-up (2.3% correction loss). No neurologic injury, pulmonary complication, implant failure or pseudoarthrosis was detected during the follow-up. A significant improvement in pulmonary function with the increases in the correction of the major thoracic curve was demonstrated by the forced expiratory volume in 1 second ($p < 0.001$), forced vital capacity ($p = 0.009$), and total lung capacity ($p = 0.019$). CPET revealed improvement in peak oxygen intake ($p = 0.042$) and oxygen saturation ($p = 0.006$), while the work rate and heart rate showed no significant improvement at the last follow-up.

Conclusion
Apical correction and global balance is a safe and effective surgical strategy and can improve cardiopulmonary function in patients with severe and rigid scoliosis at long-term follow-up.



Typical example of ACGB

2C. CLINICAL AND RADIOGRAPHIC OUTCOMES FOLLOWING COMPLEX SPINE RECONSTRUCTION IN NEUROFIBROMATOSIS WITH SEVERE SPINAL DEFORMITY

Kwadwo Poku Yankey, MD; Derrick Owusu Nyantakyi, MPH; Arthur Sackeyfio, MD; Irene A. Wulff, MD; Oheneba Boachie-Adjei, MD; Paul D. Sponseller, MBA; Sumeet Garg, MD; Brenda A. Sides, MA; Amer F. Samdani, MD; David B. Bumpass, MD; Burt Yaszay, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD; Munish C. Gupta, MD

Hypothesis
Complex Surgical Spine Reconstruction in severe neurofibromatosis patients is challenging and is likely to result in major complications

Design
Prospective observational multi center cohort

Introduction
Neurofibromatosis (NF) associated spine deformity is an uncommon but highly risky deformity with high complication rates. We present a series of NF patients with curves >100° or treated with 3CO.

Methods
Data of 12 consecutive NF patients from a multi-centre study group who underwent complex spine reconstruction as a result of neurofibromatosis associated deformity (>100° or treated by 3CO). Analysis included demographic, clinical, preoperative, intraoperative, and postoperative complications. SRS-22 scores were used to compare pre-and postoperative functional outcomes

Results
12 patients with NF had 2 yr f/u after spine fusion. Mean age was 14±2.9 years. Mean BMI was 19.8 ± 4.7 kg/m^2. Kyphoscoliosis (6), Kyphosis (2), and Scoliosis (4) were the deformity types. 7/12 had HGT. 7 pts had VCR, 5 pts had PCOs. Mean EBL for VCR vs PCOs was 1336±515 ml vs 1230±290 ml, p= 0.689. Mean OR Time for VCR vs PCOs was 506±178 min vs 417±180 min, p= 0.414. Comparing same treatment groups (VCR vs PCOs), avg. Pre-Op Corr. Cobb was 87±21 vs 117±9.2, p= 0.014, and avg. Sag. Cobb was 112±29 vs 81±39, p=0.144. For immediate post-op (1st erect), avg. Corr. Cobb was 39.3±19 vs 59±18, p= 0.100 and avg. Sag. Cobb was 53.9±15 vs 54±32, p=0.980. For 2 yr f/u, avg. Corr. Cobb was 38.3±14 vs 56.5±19, p=0.09 and avg. Sag. Cobb 56.3±19 vs 74±23, p= 0.208. Two patients with pre-op motor deficits improved at 1 yr f/u. 1 pt had NND (8.3%) post-op but recovered by 1 yr f/u. 2/12 (16.7%) had post-op pulmonary complications. 2/12 patients (16.7%) had revision on account of implant-related complication. No pseudoarthrosis, blindness and death recorded. HRQoL scores assessed with SRS-22 showed improvement at 2yr f/u

Conclusion
Complex reconstruction resulted in significant curve improvement in both coronal and sagittal planes in NF-associated spine deformity. Interestingly, the surgery resulted in the recovery of 2 pts who had pre-op motor deficits. SRS outcomes improved in all patients after 2yr f/u

Table 1: Comparing Intra operative parameters and radiographic outcomes of NF patients treated with VCR and those not treated with VCR			
	VCR (n=7)	PCO (n=5)	p-value
EBL	1336±515 ml	1230±290 ml	0.689
OR Time	506±178 min	417±180 min	0.414
Pre-Op			
Corr. Cobb Angles	87±21	117±9.2	0.014
Sag. Cobb Angles	112±29	81±39	0.144
Immediate Post Op (1st Erect)			
Corr. Cobb Angles	39.3±19	59±18	0.100
Sag. Cobb Angles	53.9±15	54±32	0.980
2 yr f/u			
Corr. Cobb Angles	38.3±14	56.5±19	0.09
Sag. Cobb Angles	56.3±19	74±23	0.208

Comparing Intra Operative Parameters and Radiographic Outcomes of NF Patients Treated with VCR and those not Treated with VCR

2D. CONCURRENT MANAGEMENT OF CONGENITAL SCOLIOSIS AND ACCOMPANYING COMPENSATORY CURVES WITH SELF SLIDING PEDICLE SCREW FIXATION IN THE GROWING SPINE

Hamisi M. Mraja, MD; Tunay Sanli, MA; Ugur Tasci, MD; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Hypothesis
Congenital severe and rigid scoliosis can be treated with three-column osteotomy(3CO) & short segment fusion at the apex of the deformity and accompanying compensatory curve(CC)can be managed with growth guidance technique using sliding pedicle screws (SPS)above and/or below the apical region in the growing spine

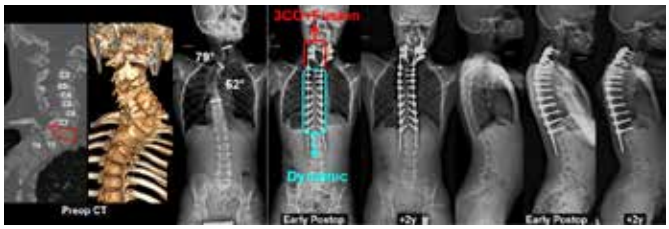
Design
Case series

Introduction
The treatment of severe and rigid congenital scoliosis with accompanying compensatory curves is challenging in immature spine. These complex cases require a treatment method which will correct deformity, allow lung development and spinal growth. For such cases we perform 3CO at the apex the deformity and short segment fusion and perform dynamic fixation with growth guidance technique using SPS to control CC and allow spinal growth

Methods
5(3M/2F) pts, age 5.4 (2-12) yrs were evaluated. 3CO was performed at the apex of the deformity and short segment fusion (2 level above and below osteotomy level) was performed for congenital scoliosis and dynamic fixation was performed with SPS with muscle-sparing technique along the CC performed in all patients. Preop, postop and f/up x-rays were evaluated

Results
Mean f/up was 33.3 m(24-58). PVCR was performed in 5 pts and short segment fusion(2 levels above and below) was performed. Indications congenital cervico-thoracic scoliosis (1pt),congenital kyphoscoliosis(2pts) and congenital scoliosis due to hemivertebra(2pts). The levels of 3CO were at T2 in 1pt, T4 in 1 pt, T6,7,8 (3 levels) in 1 pt, T11 in 1pt and T12 in 1pt. Dynamic instrumentation was performed with a mean of 6(3-11) levels for the CC. Congenital scoliosis of 59°(32-108) was corrected to 14.2°(4-33) with 76% correction rate. CC of 38°(22-62) was corrected to 8°(2-24°) with 78% correction rate. Mean increase in T1-T12 length was 0.71mm and 1.05mm for T1-S1 height per month. None of the pts had neurological impairment. Fusion was achieved at 3CO level in all pts. There was no rod breakage or spontaneous fusion along the CC

Conclusion
Surgical treatment of the severe congenital scoliosis/ kyphoscoliosis is complex and challenging in the growing spine. 3CO (PVCR) with short segment fusion at the apex of the deformity and growth guidance technique using sliding pedicle screws with muscle sparing technique along the CC provided deformity correction, allowed lung development and spinal growth.



Figure

3A. A NOVEL TWO STAGE SURGICAL APPROACH ALLOWS FOR PRESERVATION OF MOTIONS SEGMENTS AT THE LUMBOSACRAL JUNCTION IN PATIENTS UNDERGOING LONG POSTERIOR THORACOLUMBAR FUSION

Micheal Raad, MD; Kevin C. Mo, MHA; Kevin Y. Wang, BS; Floreana N. Kebaish, MD; *Khaled M. Kebaish, MD*

Hypothesis
In some patients with adult spinal deformities (ASD) a long posterior spinal fusion (PSF) to the pelvis, may be avoided by extending the instrumentation to the Ilium temporarily without arthrodesis at the lumbosacral junction.

Design
Retrospective Case Series

Introduction
Fusion of the mobile lumbosacral segments is usually required to allow for deformity correction and to prevent distal junctional failure in long fusion constructs. This has been shown to negatively affect outcomes in young adults. Therefore, we present a novel two-stage hybrid approach to achieve spinal deformity correction while preserving some lumbosacral motion segments.

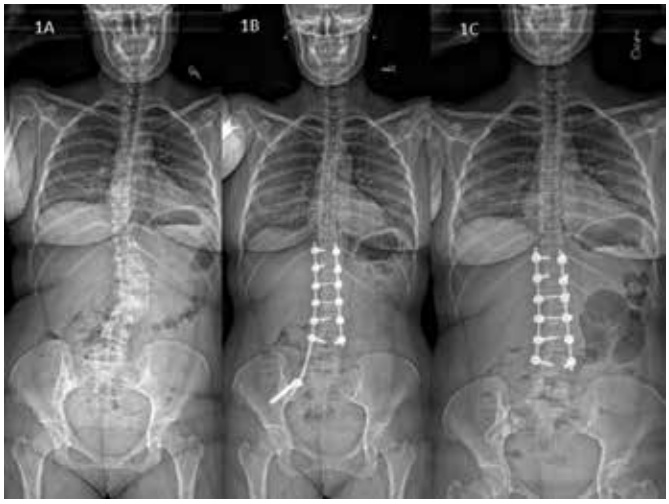
Methods
This is a retrospective case series of adult patients undergoing surgery for ASD with long PSF at a single institution between 2018 and 2021. Patients demographics, surgical variables and complications were recorded. Full-length standing EOS films were used to provide radiographic measurements preoperatively, postoperatively and at final follow-up.

Results
7 were included in the analysis. Mean time to removal of the distal hybrid fixation was 4.8 months (R: 3.5 –

CASE DISCUSSION ABSTRACTS

6.5). Mean follow up time was 7.8 months (R: 5 – 12). Indication for surgery was severe thoracic/thoracolumbar kyphosis in 3 patients, scoliosis in 3 patients and distal junctional disease in 1 patient. 4 patients were revision. Mean preoperative T4-T12 kyphosis was: 50° (R: 24° - 99°), SVA was 2.7 cm (-2.5 – 10.4), C7PL was 1.8 cm (R: 0 – 4.1), major cobb angle was 34° (R: 13° - 82°) and L4-S1 lordosis was 55° (R: 40° - 76°). Postoperatively: T4-T12 kyphosis 30° (R: 19° - 43°), SVA was 1.8 cm (-2.4 – 3.6), C7PL was 2.4 cm (R: 0.6 – 4.3), major cobb angle was 15° (R: 1° - 44°) and L4-S1 lordosis was 42° (R: 35° - 62°). After removal of instrumentation: T4-T12 kyphosis 31° (R: 13° - 55°), SVA was 2.6 cm (-1.3 – 6.2), C7PL was 1.4 cm (R: 0 – 2.4), major cobb angle was 14° (R: 2° - 44°) and L4-S1 lordosis was 28° (R: 28° - 44°). None of the patients had any-instrumentation related complications or required reoperation. All patients reported improvement in back pain.

Conclusion
A Two stage surgical approach with temporary instrumentation without fusion at the Lumbosacral Junction allows sparing motion segments in patients undergoing long posterior thoracolumbar fusion without sacrificing radiographic correction



3B. DOES FUSION LENGTH MATTER? TOTAL HIP ARTHROPLASTY DISLOCATION AFTER EXTENSION OF LUMBOSACRAL FUSION WITHOUT CHANGE IN LUMBAR LORDOSIS

Christopher L. McDonald, MD; Daniel Alsoof, MBBS; Bassel G. Diebo, MD; Eren Kuris, MD; *Alan H. Daniels, MD*

Hypothesis
Even without changes in lumbar lordosis, extension of spinal fusion constructs to the thoracic spine and pelvis can lead to new-onset hip instability in well-positioned total hip arthroplasty.

Design
Case report.

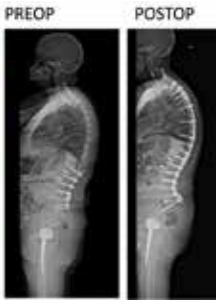
Introduction
Hip-spine syndrome is a complex challenge for orthopedic surgeons. This is a case of a 60-year-old female with a history of a total hip arthroplasty (THA) 3 years prior without any dislocation events and prior L1-S1 and C3-T2 posterior spinal fusion. The patient then underwent extension of the previous fusion construct to the cervical spine with sacropelvic fixation.

Methods
A chart and radiographic review was conducted to examine the patient's clinical history and presentation, treatment, and post-operative outcomes.

Results
Following the extension of spinal fusion, no appreciable change in lordosis (54.4° to 54.1°) or pelvic tilt (26.0° to 27.7°) was noted, although SVA increased from -20.9mm to 32.3mm. Five months following extension of her spinal fusion, the patient reported bending over and feeling a "popping" of her hip. Emergency department radiographs revealed a posterior left prosthetic hip dislocation which required sedation and closed reduction. Lab results did not show concern for infection, and imaging demonstrated no significant changes in spinopelvic parameters before or after her extension of fusion. At one month follow-up she was noted to have returned to her baseline level of mobility with use of a left hip abduction orthosis and thus far has had no other dislocation events.

Conclusion
This case uniquely demonstrates that, even with no change in lumbar lordosis or pelvic tilt and adequate acetabular cup position, extension of the fusion construct may predispose patients to dislocation. This may be due to an increased lever arm acting at the hip joint, thereby leading to instability. Further research is warranted to elucidate the risks of long-segment fixation including spinopelvic fixation with regards to THA dislocation.

	Preoperative Measurements	Postoperative Measurements
Pelvic Tilt	26.0°	27.7°
Pelvic Incidence	51.8°	51.5°
Lumbar Lordosis	-54.4°	-54.1°
PI-LL	-0.5°	-0.3°
SVA	-20.9 mm	32.3 mm
T1PA	9.13 °	17.28 °



3C. THE 'CANDY CANE' TECHNIQUE FOR CONSTRUCT AUGMENTATION AND CORRECTION OF SEVERE ANGULAR CHIN-ON-CHEST KYPHOSCOLIOSIS

Nitin Agarwal, MD; Kevin Patel, M.R.; Souvik Roy, BS; Alp Ozpinar; Nima Alan, MD; D. Kojo Hamilton, FAANS

Hypothesis
Posterior only approach can be successfully employed for the correction of chin-on-chest kyphoscoliosis.

Design
Case Report

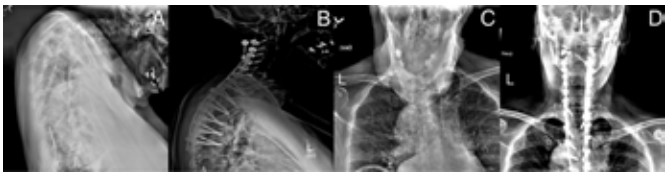
Introduction
Drawing inspiration from the previously described kick-stand rod procedure for correction of thoracolumbar scoliosis

and pelvic obliquity,4, 5 we developed the Candy Cane construct as a reliable technique for the correction of severe chin-on-chest deformity.

Methods
A 62-year-old male presented for neurosurgical evaluation complaining of progressive, diffuse weakness throughout his upper and lower extremities as well as muscle fatigue due to a chin on chest deformity since 2015. Preoperative lateral x-rays of the cervical spine demonstrated a C0–2 angle of 38 degrees. The C2-C7 lordosis was 11 degrees, demonstrating a progression in the deformity of the lower cervical spine. The cervical sagittal vertical axis (cSVA) was 8.1 cm. The chin-brow angle was 51 degrees, and the T1 slope was 58 degrees. A C2-T6 Candy Cane fusion with multiple posterior column osteotomies and a 3 rod construct was performed to correct this patient's severe angular chin-on-chest kyphotic deformity. This third rod was utilized to augment the structural integrity of the construct and assist with scoliosis correction. The third titanium rod was placed into this translaminar screw with three connectors to the right sided main rod. Gentle distraction was employed along the Candy Cane to assist with scoliosis correction thereby shielding the rostral cervical screws of the construct from additional stress during corrective maneuvers.

Results
At 1-year follow-up, upright radiographs demonstrate sustained correction, with a C0–2 angle of 37 degrees. The C2-C7 lordosis was 26°, demonstrating a 15° correction. The cervical sagittal vertical axis (cSVA) was 4.7 cm. The chin-brow angle was 25°, demonstrating a 26° correction. The T1 slope was 54°. The patient reported continued satisfaction with the operation and ability to perform activities of daily living.

Conclusion
A unique one-stage posterior approach was employed for the correction of chin-on-chest kyphoscoliosis along with construct augmentation with a third rod hooked into a supplementary C2 translaminar screw colloquially termed the cervical Candy Cane technique. This technique is a safe and effective method to resolve severe coronal and sagittal deformity in the cervical spine.



Films demonstrating severe angular kyphoscoliosis.

3D. THE USE OF CANNULATED REAMERS TO FACILITATE THORACIC DISCECTOMY VIA A MINIMALLY INVASIVE RETROPLEURAL THORACOTOMY APPROACH - SURGICAL TECHNIQUE AND EARLY OUTCOMES

Venu M. Nemani, MD, PhD; Jesse Shen, MSc; Rajiv K. Sethi, MD; Jean-Christophe A. Leveque, MD

Hypothesis
Using cannulated reamers to facilitate bone removal is a safe, efficient, and reproducible technique when performing a thoracic discectomy via a lateral thoracotomy approach

Design
Case series and surgical technique description

Introduction
The surgical treatment of thoracic disc herniations is technically challenging and can be performed via a variety of approaches. In the last decade, a minimally invasive retropleural thoracotomy approach has become more popular to treat this pathology. However, sufficient bone removal to safely perform the discectomy and spinal cord decompression is technically challenging with this technique using a burr or osteotomes due to the small incision and long working distance in the thoracic cavity and the proximity of the compressed thoracic cord.

Methods
This technique was used in seven consecutive patients that presented with thoracic myelopathy from a thoracic disc herniation. After a standard minimally-invasive retropleural approach to the lateral aspect of the thoracic spine, threaded guide wires were placed in the posterior aspect of the vertebral bodies adjacent to the affected disc space. Next, sequential cannulated reamers were passed over the guidewires to perform partial corpectomies around the affected disc space until the posterior cortical walls of the vertebral bodies were breached. The posterior annulus, posterior longitudinal ligament, and herniated disc material were then resected using Penfield dissectors and Kerrison rongeurs to complete the spinal cord decompression.

Results
All seven patients who underwent thoracic discectomy via this approach had stable or improved neurologic function post-operatively. There were no complications related to the use of the cannulated reamer technique.

Conclusion
The use of cannulated reamers provides a simple, effective, and efficient method for safe bone removal when performing a thoracic discectomy via a minimally invasive lateral thoracotomy approach. This is an easily reproducible technique using commonly available equipment.

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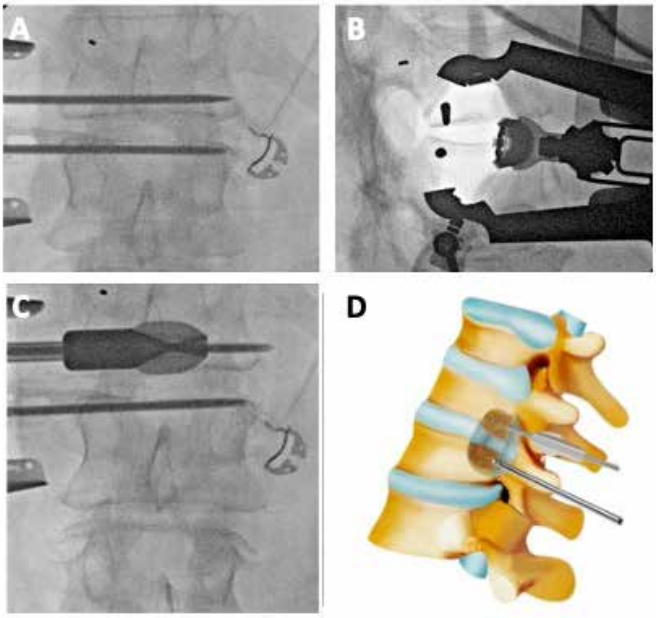


Panels A and B show placement of the guidewires in the thoracic vertebral bodies, just anterior to the spinal canal and above and below the targeted disc space. Panel C shows a cannulated reamer being passed over a guidewire. Panel D shows a schematic of the corpectomy resection cavity after passing the cannulated reamers.

PODIUM PRESENTATION ABSTRACTS

PODIUM PRESENTATION ABSTRACTS

1. RESULTS OF A PROSPECTIVE IDE ON VBT: CLINICAL AND RADIOGRAPHIC OUTCOMES OF ANTERIOR VERTEBRAL BODY TETHERING VERSUS POSTERIOR SPINAL FUSION

Carina Lott, MS; Catherine Qiu, MS; James Gordon, MS; Anthony Capraro, MBS; Divya Talwar, PhD; Benjamin Sinder, PhD; John (Jack) M. Flynn, MD; Jason B. Anari, MD; *Patrick J. Cahill, MD*

Hypothesis
Idiopathic scoliosis (IS) patients who undergo anterior vertebral body tethering (AVBT) may experience less curve correction and more revision procedures compared to patients who undergo posterior spinal fusion (PSF).

Design
A single-center, prospective, controlled FDA approved Investigational Device Exemption (IDE) Trial. Treatment was not blinded but was selected by the parent/guardian.

Introduction
In this study, we aim to compare clinical and radiographic outcomes of AVBT to the standard intervention, PSF patients treated at the same institution with a minimum of 2-year follow-up.

Methods
All twenty patients from a prospective FDA approved clinical IDE trial of AVBT and all 21 subjects who were enrolled in a prospective multicenter registry for AIS and underwent PSF at the same institution during the IDE enrollment period were included. IDE inclusion criteria were: Lenke 1 or 2, thoracic curve between 35-60°, lumbar curve ≤35°, and skeletally immature (Risser 0 or Sanders ≤4). Tether rupture was defined by ≥6° increase in angulation between adjacent screws. Demographic, clinical, and radiographic variables were compared between the two groups.

Results
There was a total of 20 patients in the AVBT group and 21 patients in the PSF group. Preoperatively, the PSF group was more skeletally mature (Table 1). The two groups had similar baseline health related quality of life and gender distributions (Table 1). The AVBT group had slightly smaller thoracic curves at baseline (51° vs 57°, p=0.013). Total surgical time was significantly longer for AVBT patients (Table 1). While both groups showed post-operative curve correction, the PSF group showed higher percent correction in the thoracic curve at first post-operative erect (65% vs 35%) and at final follow-up (61% vs 34%). 7/20 (35%) VBT case required revision surgery. Seven patients showed evidence of tether rupture; 4 underwent PSF to correct failure as their curve progressed into surgical range. One patient experienced an overcorrection of their curve and underwent revision of anterior spinal instrumentation. No revisions were required in the PSF group.

Conclusion
Patients who underwent AVBT showed less spine deformity correction and more revision procedures (35%) than patients who underwent PSF in 2 years of follow-up.

Table 1. Demographic, clinical, surgical, and radiographic outcomes of Anterior Vertebral Body Tethering (AVBT) and Posterior Spinal Fusion (PSF) patients at pre-operative, first post-operative (PO) erect, and final follow-up.

Variable	Anterior Vertebral Body Tethering (n=20)	Posterior Spinal Fusion (n=21)	p-value
Demographics			
Gender (Male/Female)	4 / 16	4 / 17	1
Menarche before surgery (n, %)	6 (30%)	15 (71%)	**0.013**
Age at surgery (years)	11.8 ± 1.94	14 ± 1.45	**<0.001**
Total SRS-22 score – pre-operative	4.1 ± 0.5	4 ± 0.5	0.701
Total SRS-22 score – final follow-up	4.3 ± 0.5	4.5 ± 0.4	0.14
Pre-operative Radiographic Measurements			
Thoracic curve (°)	51.1 ± 7.3	57.1 ± 7.6	**0.013**
Lumbar curve (°)	27 ± 6.8	32 ± 8.7	**0.046**
Bending thoracic (°)	21.3 ± 10.6	28.3 ± 14.9	0.128
Bending lumbar (°)	2.5 ± 9.8	13.8 ± 7.2	**<0.001**
Peri-operative Outcomes			
Length of stay (days)	3.6 ± 0.8	3.1 ± 0.9	**0.015**
Number of levels instrumented (n)	7 ± 0.7	10 ± 1.0	**<0.001**
Estimated blood loss (cc)	72.7 ± 36.7	311 ± 97.0	**<0.001**
Total surgical time (min)	231 ± 41.1	194 ± 25.5	**0.001**
First Post-operative (PO) Radiographic Measurements			
Thoracic curve (°)	33.3 ± 8.6	19.4 ± 8.2	**<0.001**
Lumbar curve (°)	20.3 ± 7.5	13.4 ± 8.6	**0.011**
Final Follow-up Radiographic Measurements			
Thoracic curve (°)	34.4 ± 14.6	22.6 ± 7.4	**0.003**
Lumbar curve (°)	22.2 ± 11.6	13.4 ± 6.8	**0.007**
Revision Surgery Required (n, %)	7 (35%)	0 (0%)	**<0.001**

Note: Values shown as either mean ± standard deviation (SD) or no (%)

2. VBT IN SKELETALLY IMMATURE PATIENTS: RESULTS OF A PROSPECTIVE US FDA IDE STUDY

A. Noelle Larson, MD; Smitha E. Mathew, MBBS; D. Dean Potter, MD; Todd A. Milbrandt, MD, MS

Hypothesis
At 2-year follow-up,VBT patients will demonstrate acceptable major curve correction indicating a successful outcome.

Design
Prospective cohort

Introduction
Vertebral body tethering(VBT) is a non-fusion surgical technique for scoliosis correction in skeletally immature individuals.We aimed to evaluate 2-year results of VBT performed under an FDA protocol to obtain insight to outcomes and complications.We defined growth modulation(progressive improvement in curve correction over time)following VBT as >5° improvement in Cobb angle at any 2 postop timepoints.

Methods
40 prospectively enrolled adolescent idiopathic scoliosis (AIS)patients underwent VBT for curves between 40°-70°, with Sanders 4 or less or Risser 2 or less.At minimum 2-year f/u, surgical results and radiographic outcomes including patient-reported outcomes were reviewed.

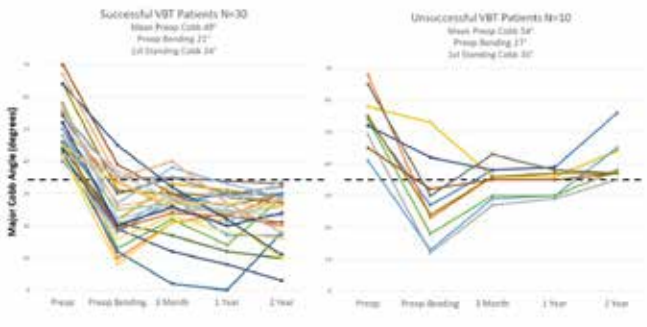
Results
Mean age at surgery was 13(range, 10-16)years. Mean number of levels instrumented was 8(range, 5-12), mean Risser was 0.6.Mean length of hospital stay was 3 days, EBL was 230 ml(range, 25-740),and operative time was 269 minutes. 44% correction of the major curve was achieved on 1st erect images(range 22-95%), which changed to 49% at 1 year, and 46% at 2 years(range,-10% to 93).Preop major Cobb improved on average from 51°(range,40-70) to 27°(3-56) at 2-years. Success at 2-years f/u was seen in 32 (80%)patients and correlated with mean Cobb angle of <35° on 1st erect imaging (p<0.001)(Fig). 12(46%)patients demonstrated growth modulation and those patients had significantly lower mean Cobb angle on 1st erect imaging than non-

PODIUM PRESENTATION ABSTRACTS

modulators(27° vs 35°,p=0.001).By 2 years, 2(5%) patients underwent repeat surgery(1 overcorrection treated with release, 1 lumbar curve progression after thoracic VBT treated with lumbar VBT).SRS satisfaction scores improved at 2-years f/u(p=0.0004),but other SRS domains only remained stable over time.At mean 3-year f/up, 1 additional lumbar tether was required after thoracic VBT, 1 implant removal, and 2 fusions had been performed, for a 5% fusion rate and overall 15% reoperation rate.

Conclusion

In Sanders 3 and 4 patients treated in the US under a prospective IDE, there was a 80% rate of successful outcomes at 2 years with overall 15% reoperation rate. The majority of correction was obtained at the time of surgery,and failure to obtain intraop correction as demonstrated on preop bending films was associated with a higher Cobb angle on 1st erect image and failure by 2 years.



3. IMPROVED OUTCOMES AFTER ANTERIOR VERTEBRAL TETHERING FOR AIS USING IDEAL VERSUS ACCEPTABLE INDICATIONS: A TWELVE-YEAR EXPERIENCE

John T. Braun, MD; David F. Lawlor, MD; Sofia Federico, Pre-medical student; Preetika Kulkarni, Pre-medical student; Jonathan Brodeur, BS; Brian E. Grottkau, MD

Hypothesis

Outcomes after Anterior Vertebral Tethering (AVT) for AIS will be better in patients with ideal vs acceptable indications. The accumulation of multiple risk factors in patients with acceptable indications will decrease the chance of a good/excellent outcome and increase the chance of complications and revision surgery.

Design

Retrospective 2010-2022

Introduction

Though AVT has been proposed as an alternative to fusion for AIS, ideal vs acceptable indications for this novel procedure have yet to be established. This study compared outcomes after AVT in AIS patients with ideal indications vs those with acceptable indications and 1, 2, or 3 risk factors. Overall complications were also reviewed.

Methods

Fifty-two consecutive AIS patients treated with AVT for T and TL/L curves 33-70° had 2-10 year F/U data. Four groups were analyzed: 1 group with ideal indications and no risk factors and 3 groups with acceptable indications and 1-3 risk factors. Ideal indications included 40-60° curves, 50% flexibility, and Risser 0-2. Those with risk factors failed to meet 1, 2, or 3 of these criteria. Radiographic outcomes were graded as excellent (E) ≤25°, good (G) 26-39°, fair (F) ≥40°, or poor (P) ≥50° or requiring fusion. Overall complications were also analyzed for all 179 patients treated over 12 years.

Results

Fifty-two patients (48F/4M) with 75 curves were treated with AVT. Ideal indications patients (n=4) demonstrated 100% good/excellent (G/E) outcomes, 25% tether rupture, 0% revision surgery. Acceptable indications patients: 1 risk factor (n=33) had 88% G/E, 24% tether rupture, 9% tether revision, 9% fusion; 2 risk factors (n=14) had 57% G/E, 14% tether rupture, 7% revision, 14% fusion; 3 risk factors (n=1) had 0% G/E and 100% fusion for inadequate correction. Overall complications: 0/179 intra-op; 8/179 early post-op (4 tether ruptures/4 inadequate corrections); 14/52 (27%) late post-op (9 tether ruptures/3 overcorrections/4 inadequate corrections). Revision was required in 63% of early and 31% of late complications but late also required fusion in 38%.

Conclusion

Outcomes after AVT for AIS were better in patients with ideal vs acceptable indications. Though the chance of a G/E outcome was best in patients with ideal indications (100%), this dropped steadily with the accumulation of 1 (88%), 2 (57%), or 3 (0%) risk factors (p<0.001). The risk of complications and revision surgery, especially fusion, was also the lowest in patients with ideal indications but steadily increased with the accumulation of risk factors.

4. REDEFINING THE DIAGNOSIS OF TETHER FAILURE IN VERTEBRAL BODY TETHERING: A BIOMECHANICAL ANALYSIS

Ogulcan Guldeniz, MS, BS; Christopher C. Yip, MBBS; Wanis Nafo, PhD; *Kenneth M. Cheung, MD, MBBS, FRCS*

Hypothesis

Investigating the mechanical behavior of the vertebral body tether under tension can help rationalise a new definition for radiological diagnosis of tether failure.

Design

Mechanical testing

Introduction

Tether failure is a common complication of Vertebral Body Tethering, which is diagnosed based on the inter-screw angle. However, this method has only been proven to be 56% accurate [1]. It is known that the material of tether, PET, has a high degree of stretch before it fails. In line with that, our clinical studies showed that more tether breakages could be identified using an increase in inter-screw distance as opposed to angle [2]. The aim of this study is to carry out mechanical testing on the tethers and to define the amount of elongation the tether can undergo before failure, therefore providing a rational definition for tether rupture based on an increase in the inter-screw distance beyond the elongation limit.

Methods
Tensile tests with 20%/min strain rate were conducted on tether samples from one manufacturer by using a mechanical testing frame. Cauchy stress-stretch curves were investigated.

Results
The mean Cauchy stress and stretch value among the samples at the point of rupture was 282MPa and 28%, respectively. There was no significant difference between the tether samples tested. The tether applied almost zero reaction force during the first 3-5% elongation (slack stretch). The standard 450N applied during the surgery to establish correction was determined to be causing 10-12% elongation on the tether. A constant modulus of ~1GPa was measured.

Conclusion
Fracture stresses were ~50% lower, and stretches were ~100% higher than the data in the literature, which indicates the likelihood of a failure under relatively lower loads. Residual stresses on the tether left by the 450N may lead to creep or fatigue failure. The 5% slack stretch may lead to inadequate correction if not eliminated during the surgery. We calculated that after the standard 450N applied to the tether the remaining total stretch (15-18%) before rupture corresponds to 13-16% of the inter-screw distance, and therefore, suggest that tether rupture can be defined by an increase in the inter-screw distance beyond this limit. We propose that an increase in inter-screw distance would make better sense than an increase in inter-screw angle, as rupture may not be associated with a change in angle.

5. WHAT HAPPENS AFTER A VERTEBRAL BODY TETHER BREAK: INCIDENCE, LOCATION, AND PROGRESSION WITH 5-YEAR FOLLOW-UP

Michael Yang, MD; Steven W. Hwang, MD; *Amer F. Samdani, MD*; Alejandro Quinonez, BS; Maureen McGarry, BBE; Brandon J. Toll, BA; Harsh Grewal, FACS, FAAP; Joshua M. Pahys, MD

Hypothesis
Vertebral body tether (VBT) breakage can be characterized radiographically by change in inter-screw angle (ISA). We predict that VBT breaks occur with greater frequency in the lumbar spine and distal to the apex but do not progress.

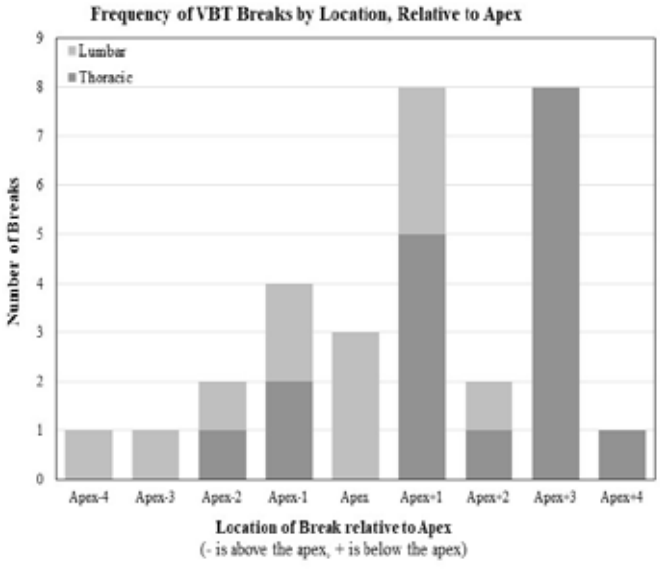
Design
Single-center retrospective

Introduction
Up to 48% of VBT cases have a reported break, but risk factors and progression are poorly reported. We sought to identify what ISA change defines a break and establish risk factors for breakage and progression.

Methods
72 patients with minimum 5-year follow-up who underwent VBT were reviewed with ISA collected. 20 patients (12 thoracic, 8 lumbar) had a presumed VBT break defined by ISA change >5°. We analyzed timing and location of VBT breakage and associated risk factors. ISA was also collected for a subset of patients with surgically confirmed broken VBTs (n=8).

Results
In surgically confirmed VBT breaks, the avg. ISA change was 8.1° and segmental Cobb change was 13.6°, with high correlation (r=0.82). Of 59 patients with thoracic VBT, 12 had 18 breaks (4 had multiple breaks); none occurred before 1 year, 39% between 1-2 years, and 61% between 2-5 years. 83% of thoracic VBT breaks occurred below the curve apex ($p<0.05$). Timing of breakage post-op moderately correlated with more distal breaks (r=0.35). Age, gender, BMI, Risser score, and % curve flexibility were not associated with VBT break; % correction at first erect radiograph trended toward significance (60.2% for breaks vs. 52.2% for non-breaks, p=0.054). There was moderate correlation between ISA change and segmental Cobb change (r=0.37). For all thoracic VBT breaks, ISA did not progress, but the total Cobb progressed 4° after break and another 6° at last follow-up. Of 13 patients with lumbar VBT, 8 had 12 breaks (1 break: n=4; 2 breaks: n=4), 8% occurring within 1 year, 50% between 1-2 years, and 42% between 2-5 years; 58% of lumbar VBT breaks occurred at the apex or distal. For lumbar VBT breaks, the total Cobb progressed 8° after break and 5° at last follow-up. Lumbar VBTs (62%) were more likely to have breaks than thoracic (20%) ($p<0.05$). 2 patients had revision surgery after tether breakage.

Conclusion
VBT breakage occurs with greater frequency in the lumbar (62%) vs. thoracic spine (20%). With 5-year follow-up, the ISA did not progress after a break, but 9 patients (45%) had total curve progression averaging 13° and 2 required revision surgery.



6. TETHER BREAKAGE IN VERTEBRAL BODY TETHERING IS BETTER EXPLAINED BY INTER-SCREW DISTANCE THAN INTER-SCREW ANGLE

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Welborn, MD; Amer F. Samdani, MD; Michael G. Vitale, MPH; Ron El-Hawary, MD; *Kenneth M. Cheung, MD, MBBS, FRCS*

Hypothesis
Increase in inter-screw distance can identify more tether breakages than inter-screw angle.

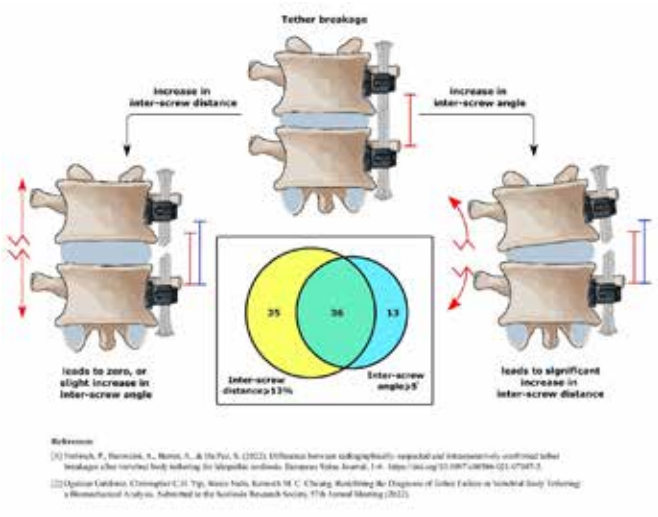
Design
Retrospective analysis of prospectively collected multicentre cohort data

Introduction
Tether breakage in Vertebral Body Tethering (VBT) has been defined as a 5° increase in inter-screw angle. However, Trobisch et al. showed that only 56% of tether breakages could be identified using this rule [1]. As tensile tests by Guldeniz et al. suggest that tether breakage occurs when it elongates more than 13-15% of its original length [2], we propose that an increase in distance between the 2 screw heads of more than 13% is a more rational indicator of tether breakage.

Methods
To test our hypothesis, 6 subjects with 43 instrumented segments with confirmed tether status by computed tomography (CT) were reviewed and compared with radiographic segmental inter-screw angle and distance. Furthermore, 131 subjects were analysed to compare the incidence of tether breakage based on inter-screw angle and distance. All subjects had Adolescent Idiopathic Scoliosis and a minimum of 2-year follow-up.

Results
Mean age at surgery was 12.7 ± 1.4 years and the mean number of instrumented levels were 7.4 ± 0.7. The mean preop Cobb was 50 ± 9° and at latest follow up was 31 ± 11°. Of the 43 instrumented segments with CT images, tether was ruptured in 2 segments. Radiologically the inter-screw distance was increased by 16% and 18%, while none of the intact segments had ≥13% increase. Using this new definition in the larger cohort, 71 subjects with 140 segments had broken tethers, while if ≥5° in inter-screw angle was used, only 49 patients with 58 segments could be identified.

Conclusion
Tether rupture may not lead to loss of correction and therefore an increase in inter-screw angle (Fig 1). Thus, we propose a novel and rational method of determining tether rupture on radiographs based on biomechanical data [2] and confirmation in a CT-validated cohort. Increase in inter-screw distance ≥13% is able to determine tether rupture after surgery and has the potential to identify more cases than by the use of inter-screw angle. Further validation will be needed in larger cohorts with clinically or radiologically proven tether breakages.



Fate of tether failure could result in an increase in inter-screw distance and/or angle.

7. RISK OF REPEAT SURGERY 10 YEARS AFTER POSTERIOR SPINAL FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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Hypothesis
The revision rates for fusion surgery in AIS at 10 years of follow up is low

Design
Retrospective review of multicenter prospective data

Introduction
The most frequently cited causes for revision surgery after AIS fusion surgery include pseudarthrosis, infections, junctional failure, progression of the deformity in the adjacent segments, neurological complications, mechanical- and implant-related problems. We sought to determine the incidence of repeat surgery 10 years following posterior spinal fusion surgery in AIS patients

Methods
Patients enrolled in multicenter, prospective AIS registry with minimum 10-year follow-up were evaluated. All index surgeries were performed from 2000-2010 at one of nine North American hospitals by specialized scoliosis surgeons. Variables included patient demographics, Lenke classification, surgical variables and Scoliosis Research Society (SRS)-22 outcome scores at baseline, one year, two years, five years and ten years after surgery. All revision surgeries were evaluated to determine etiology, type, and the impact of the surgery on the patient's patient-reported outcomes

Results
A total of 249 patients with minimum 10 years of follow-up were included of which 6.8% (n=17) required a second surgery. Mean age at index surgery was 15.4 years. Females accounted for 76% of the cases. Mean follow-up was 14.5 years and mean time to revision was 58.8 months. The causes for revision were infection (n=6), prominent implants or junctional problems (n=5),

implant malposition (n=3), neurological deficits (n=2), and pseudoarthrosis (n=1). Via correlation analysis, SRS scores for revised patients were compared to those who did not require a revision surgery. Baseline scores consistently correlated with all subsequent SRS scores (albeit, only weakly, with r values ranging from 0.18 to 0.29) in patients not requiring revision surgery. Among the 17 revision patients, moderate-to-strong (r = 0.64) and strong (r = 0.73) correlations were identified between the baseline SRS-22 score and scores at one- and two-year follow-up, respectively, as well as a moderate correlation (r = 0.45) at five-year scores

Conclusion
This study documented a 6.8% overall re-operation rate 10 years following posterior fusion for AIS. The most frequent reasons for revision were infections, prominent implant or junctional problems, misplaced instrumentation, neurological deficits and pseudoarthrosis

Time from surgery to revision	Number of patients	Causes
<2 years	5	Misplaced instrumentation (n:3); Infection (n:1); Neurologic (n:1)
2-5 years	3	Infection (n:2); Prominent implants (n:1)
5-10 years	8	Junctional problems (n:4); Infection (n:3); Broken implants (n:1)
>10 years	1	Neurological deficit (n:1)

8. IN ADOLESCENT IDIOPATHIC SCOLIOSIS, DO ALL INSTRUMENTATION-RELATED COMPLICATIONS REQUIRE REVISION SURGERY?

Stephen Plachta, MD; *Steven W. Hwang, MD*; Amer F. Samdani, MD; Michael Yang, MD; Suken A. Shah, MD; Firoz Miyanji, MD; Peter O. Newton, MD; Harms Study Group; Joshua M. Pahys, MD

Hypothesis
Instrumentation related complications following spinal fusion for AIS may not require revision.

Design
Retrospective review of a prospectively collected multicenter database

Introduction
Instrumentation related complications following spinal fusion for AIS are frequently treated with surgical revision, but a paucity of literature exists on their management. We sought to determine whether revision surgery is necessary following an instrumentation related complication.

Methods
We queried AIS patients undergoing spinal fusions with a minimum 2-year follow-up for instrumentation-related complications. Instrumentation complications were subdivided into: broken instrumentation (BRK, n=37, screw/rod fracture), loss of fixation (LOF, n=68, screw pull-out/dislodged instrumentation), instrumentation prominence (PM, n=26), and other (n=17, misplaced/ junctional issues). Demographic, radiographic, and surgical factors were compared between patients treated with revision surgery (RS) or conservative therapy (CT). Student t-test, X2 and Fisher's exact tests were performed for comparison

Results
141/5144 (3%) patients had 148 complications with a mean follow-up of 59 ± 8 months. 68 patients (46%) underwent RS. Complications were detected on average between 2- and 5-year visits. There was no difference in baseline demographics, radiographic variables, and time to diagnosis or follow-up in any of the groups. In BRK (p=0.03) and LOF (p=0.0002), patients who presented with pain were more likely to have RS. In LOF, patients undergoing revision had a higher BMI (p=0.025), more lumbar curves (p=0.002), more reported pseudarthrosis (p=0.017), and more often involved distal fixation (p=0.03). There were no radiographic differences between groups at any follow-up time. SRS scores were similar across all subgroups, except the BRK-RS at 5 years had better SRS scores in all domains except satisfaction (p<0.05, n=17). On subgroup analysis including only patients with at least 2 year follow-up after complication diagnosis, there were no differences between RS and CT groups with respect to outcomes except improved lumbar curve correction (p<0.05) in the BRK and LOF RS groups.

Conclusion
Half of patients with instrumentation-related complications can be observed without radiographic progression, especially in the absence of pain. However, SRS scores may be better in patients undergoing revision surgery for broken instrumentation.

Instrumentation Complications (n=148)				
		Observe	Surgery	p value
I: Broken Instrumentation (n=37)		N=26	N=11	
	BMI	21.8±3.8	19.8±2.7	p=0.1
	% with pain @ presentation	3/27 (10%)	5/11 (50%)	p=0.03
	Lenke Class	2.2±1.7	1.6±1.3	p=0.3
Coronal curvature (°)		53.5±16.5	51.1±15.6	p=0.67
Time to Diagnosis (mo)		34±32.4	28.6±21	p=0.56
Time to Revision after dx (mo)			36±24	
Follow-up after complication dx (mos)		27±35	31±37	p=0.79
Total Follow-up (mo)		62.6 ± 38	60.2±40	p=0.86
SRS @ 5 Years	Pain	3.7 ± 1.2	4.65 ± 0.34	p=0.02
	Self Image	4 ± 0.88	4.65 ± 0.35	p=0.05
	General Fx	4.3 ± 0.57	5 ± 0	p=0.006
	Mental Health	3.8 ± 0.83	4.75 ± 0.38	p=0.01
	Satisfaction	4.2 ± 0.90	4.65 ± 0.25	p=0.18
	Total	3.9 ± 0.76	4.75 ± 0.24	p=0.007
II: Loss of Fixation (n=68)		N=34	N=34	
	BMI	22±4.4	26±8.4	p=0.025
	% with pain @ presentation	6/34 (20%)	21/34 (60%)	p=0.002
	Lenke Class	1.97±1.6	3.35±1.8	p=0.002
Thoracic % Correction		55±11%	52±13%	p=0.3
Time to Diagnosis (mo)		18.8±16.6	18.4±20.4	p=0.9
Time to Revision (mo)			22.8±24.5	
Follow-up after complication diagnosis		29.4±38	22.98 ± 19.35	P=0.38
Total Follow-up (mo)		47.4 ± 41.8	41.4±29.4	p=0.5
MC Location Failure		No Dif	DISTAL	p=0.03
SRS @ 5 Years	Pain	3.95 ± 0.82	4.25 ± 0.89	p=0.45
	Self Image	4.1 ± 0.55	4.46 ± 0.70	p=0.27
	General Fx	4.12 ± 0.8	4.68 ± 0.56	p=0.11
	Mental Health	3.85 ± 0.87	4.1 ± 1.14	p=0.59
	Satisfaction	4.25 ± 0.53	4.6 ± 0.6	p=0.21
	Total	4 ± 0.67	4.4 ± 0.66	p=0.23

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9. NON-FUSION VERSUS FUSION SURGERY IN PEDIATRIC IDIOPATHIC SCOLIOSIS: WHAT TRADE-OFFS IN OUTCOMES ARE ACCEPTABLE FOR THE PATIENT AND FAMILY

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Hypothesis
Patients and families have specific values that drive decisions regarding fusion vs. non-fusion surgery for treatment of idiopathic scoliosis.

Design
Prospective survey study.

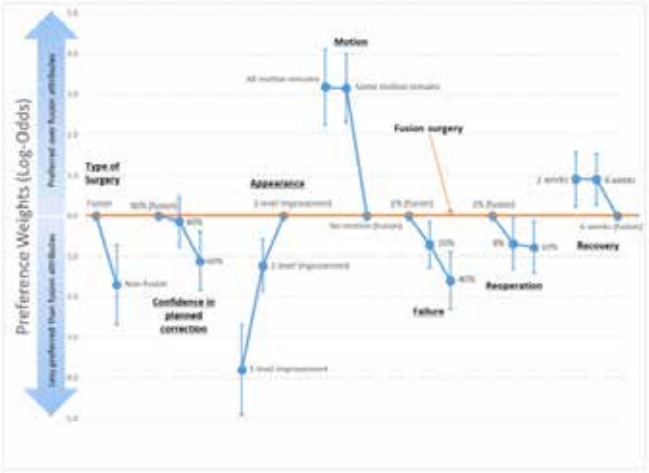
Introduction
Vertebral body tethering and other non-fusion techniques are increasing in popularity. Since there is limited physician consensus on which patients most benefit from non-fusion strategies, much of the decision-making is left to patient and parents, who must select a treatment based on their values. We sought to understand patient and family preferences regarding attributes of fusion vs. non-fusion surgery that drive these choices.

Methods
Patients/families were recruited from 7 pediatric spine centers and asked to complete a survey-based choice experiment jointly developed with the U.S. FDA to evaluate patient preferences. Choices between experimentally-designed alternatives were analyzed to estimate the relative importance of outcomes and requirements associated with the options (attributes). The attributes considered by respondents included appearance, confidence in planned correction, spinal motion, device failure, reoperation and recovery period. Inclusion criteria were age 10-21, idiopathic scoliosis patients considering surgery or patients who had undergone scoliosis fusion or non-fusion surgery. Preference weights were estimated from the expected changes in choice given changes in the attributes.

Results
A total of 320 respondents completed the survey (116 patients, 89 parents, and 115 parent/patient couples). Mean patient age was 15 years (83% female). 215 were enrolled prior to surgery, 65 after fusion and 42 after non-fusion surgery. Appearance and motion were found to be the most important drivers of choice. For the entire cohort, fusion was preferred over non-fusion. For preoperative patients, the most important attributes were preservation of spinal motion and appearance. Preoperative patients and patients with previous fusion surgery tended to prefer fusion surgery. Patients with previous non-fusion surgery were very concerned about spinal motion, less concerned about correction, and tended to prefer non-fusion surgery.

Conclusion
Scoliosis patients and families value appearance and preserved spinal motion and, to a lesser extent, reoperation rates when considering fusion vs. non-fusion surgery.

Figure
The horizontal line at 0 represents the attribute levels associated with fusion surgery. Preference weights show the relative value of each attribute based on survey results (higher weights indicate greater preference for attribute performance level). For example, respondents preferred motion and faster recovery time (positive preference weights above zero). All other attributes were below the line, showing that they are less preferred than the attributes associated with fusion surgery.



10. LONG TERM QUALITY OF LIFE OUTCOMES FOR THORACIC AIS PATIENTS WITH OR WITHOUT FUSION: A MINIMUM OF 15-YEAR FOLLOW-UP STUDY

Amanda Liu, BS; *Kenny Y. Kwan, MD*

Hypothesis
Patients who underwent thoracic fusion had similar long-term quality of life than those without.

Design
Retrospective.

Introduction
Patients who underwent thoracic fusion for at adolescence may suffer from immobile spinal segments but were believed to have a good long-term quality of life outcomes. Patients who underwent non-operative treatment and did not reach the surgical threshold at the end of skeletal maturity were believed to have normal quality of life. The aim of this study was to compare these two cohorts at a minimum of 15 year follow-up and report their quality of life.

Methods
49 AIS patients with at least 15 years of follow-up were recruited. Patient were classified into thoracic fusion (TF) group or non-operative (NO) group. Thoracic rotation range of motion (ROM) was measured, radiographic and 8 health-related quality of life (HRQOL) questionnaires were collected.

Results
28 patients in TF group had mean Cobb of 50°±11.7° at the time of surgery, and 21 patients in NO group had mean Cobb of 27.7°±10.2° at skeletal maturity. The mean age at recruitment was 34.8 years (range 24-55), and the mean follow-up was 16 years (15-25). At final follow-up, the Cobb was 25.8°±11.7° in the TF group, and 34.1°±13.2° in the NO group, indicating a mean of 6.4°±7.2° progression. Standing and supine Cobb (34.5°±13.6° vs 21.1°±11.9°, p<.001) in the NO group showed the spine remained mobile. There was no significant difference in clinical thoracic rotation ROM between the two

groups. 2 patients (7.1%) in the TF group reported limitation to ADL, while 26 patients (92.9%) reported no limitation to ADL. 1 patient (4.8%) in NO reported inability to perform ADL, and 20 patients (95.2%) reported no limitation to ADL. TF group exhibited higher SRS22 scores compared with NO group (4.1±.7 vs 3.6±.6, p=0.007). The Quality of Life Profile for Spine Deformities (QLPSD) showed poorer overall quality of life for TF group (27.4±7.2 vs 22.4±8, p=.029). The State Anxiety Scale (S-Anxiety) of State-Trait Anxiety Inventory (STAI) showed clinically significant symptoms of anxiety compared with the NO group (44.7±11.7 v 35.9±12.8, p=.017). However, TF patients showed lower level of misconception scores than NO group (7.1±2.3 vs. 8.1±2.1, p=.017).

Conclusion
TF AIS patients had higher SRS22 but poorer overall quality of life and higher levels of anxiety than NO patients in long term follow-up.

11. CLINICAL, RADIOLOGICAL, AND HRQOL OUTCOMES AFTER SELECTIVE THORACIC FUSION WITH MINIMUM 20-YEAR FOLLOW-UP: ASSESSMENT OF THE DEGENERATIVE CHANGES OF UNFUSED LUMBAR SPINE WITH MRI STUDY

Azmi Hamzaoglu, MD; *Meric Enercan, MD*; Hamisi M. Mraja, MD; Halil Gok, MD; Ozcan Kaya, MD; Ugur Tasci, MD; Tunay Sanli, MA; Onur Levent Ulusoy, MD; Ayhan Mutlu, MD; Selhan Karadereler, MD

Hypothesis
The magnitude of residual lumbar curve (RLC) may affect the long-term clinical and radiologic outcomes in selective thoracic fusion (STF).

Design
A retrospective study.

Introduction
The aim of this study is to evaluate the clinical, radiological outcomes and long-term behavior of the lumbar curve in AIS patients treated with selective thoracic fusion and assess the disc degeneration (DD) and facet joint degeneration (FJD) of the unfused lumbar spine with MRI at the end of minimum 20 years follow up.

Methods
AIS patients treated with STF and having minimum 20 years follow up were included. Preoperative, postoperative, and final follow up radiographs were reviewed. All patients had lumbar MRIs at the final follow up in order to evaluate DD and FJD of the unfused lumbar spine. Clinical evaluation was done by using SRS22r and Numerical Rating Scale (NRS).

Results
21 AIS (21 F) patients with mean age 36,2 (32-45) years and mean follow up was 22,8 (20-30) years. MT was corrected from 53,8° to 16° (70,3% correction rate), spontaneous lumbar curve correction rate was 57,9% (38° to 16°). Coronal, sagittal parameters, residual lumbar curve and lowest instrumented vertebra (LIV) angulation were stable over time. Median grade of lumbar DD was 2 (1-4) and lumbar FJDs was 2 (1-4). Residual lumbar curve more than 20° (area=0,734) was correlated with DD of unfused segments (r=0,62; p<0,01), decrease in total SRS22r score (U=11,0; p<0,05) and SRS pain domain (U=0,0; p<0,05). LIV angle more than 10° (area=0,703) was correlated with FJD at LIV+1 level (r=0,477; p<0,05). Mean SRS22r sub-total score was 4,42 and NRS was 1,4 at final follow up. Mean patient satisfaction was 4,72 at final follow up.

Conclusion
Selective thoracic fusion provides satisfactory clinical and radiological outcomes at minimum 20 years follow up. Spinal balance and spontaneous lumbar curve correction were well maintained over time. The degree of disc and facet joint degeneration in unfused segments was higher in patients who had residual lumbar curve > 20° and LIV angle > 10° compared to those with residual lumbar curve < 20° and LIV angle < 10°. Patient satisfaction(4,72/5) was high at the end of 20 years follow up.

12. SRS-SELF IMAGE IN ADOLESCENT IDIOPATHIC SCOLIOSIS AT 10 YEAR FOLLOW-UP: AS GOOD AS IT GETS?

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Hypothesis
SRS-Self Image scores will change over 10 years following AIS surgery.

Design
Retrospective cohort

Introduction
Self image is a critical component of adult and pediatric spinal deformity surgeries. Few correlations have been found between deformity magnitude and patient-reported Self Image measures in AIS. Whether patients remain satisfied or become dissatisfied with their appearance over time is not known.

Methods
A multi-center, prospective AIS registry was queried for patients treated with spinal fusion. Mixed effects models estimated change in SRS-22r Self Image from baseline to 1yr, 2yr, 5yr, and 10yr. All enrolled patients contributed data to the mixed effects models and Bonferroni correction was applied. 1yr and 10yr SRS-Self Image scores were compared and patients were classified as better/unchanged/worse where the minimum detectable measurement difference (0.3) defined categories. Baseline demographic data, SRS-Mental Health scores, and 1yr deformity data including radiographic, shoulder height, scoliometer, and trunk shift measurements were compared between groups using parametric and nonparametric tests as appropriate. Significance was defined as p<0.05.

Results
4597 were enrolled, 2044 were eligible for 10yr follow-up, 229 (11%) had 10yr follow-up; 162 had 1yr and 10yr data. Mean improvement at 10yrs from baseline was 1.0

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(95% CI: 0.9-1.1) point. SRS-Self Image did not change from 1yr to 10yrs (all p>0.05). Forty (25%) had SRS-Self Image worsening from 1yr to 10yrs, 36 (22%) improved, and 86 (53%) were unchanged. Patients who worsened over 10 years had lower preop SRS-Self Image than those who remained unchanged over 10 years (3.3 vs 3.7, p=0.007) but were not different than those improving over 10 years. One year SRS-Self Image scores were not different across groups. Radiographic parameters were not different at all time points (TABLE). SRS-Mental Health scores were not different at baseline.

Conclusion
While SRS-Self Image scores were unchanged in the majority of patients (53%) with 1yr and 10yr data, nearly 20% of patients reported worsening Self Image at 10yrs. Patients who worsened had lower preop SRS-Self Image scores at baseline, though no radiographic or Mental Health measures were different at baseline or follow-up. This underscores the complexity of this patient reported measure.

	Mean Difference from Ten-Year (Difference, 95% CI)	SRS-Self Image [mean(SD)]	Main Thoracic Coronal Deformity [degrees, mean(SD)]	Lumbar Coronal Deformity [degrees, mean(SD)]
Preoperative	1.0 (0.9-1.1)*	Better 3.4 (0.5) Unchanged 3.7 (0.6)* Worse 3.3 (0.7)*	Better 47 (16) Unchanged 50 (14) Worse 50 (15)	Better 40 (12) Unchanged 39 (13) Worse 41 (14)
One-Year	0.1 (-.1-0)	Better 3.9 (0.5) Unchanged 4.6 (0.4) Worse 4.6 (0.4)	Better 17 (6) Unchanged 18 (8) Worse 19 (9)	Better 16 (8) Unchanged 15 (8) Worse 16 (10)
Two-Year	0.0 (-0.1 – 0)	Better 4.2 (0.6) Unchanged 4.6 (0.4) Worse 4.4 (0.7)	Better 16 (6) Unchanged 18 (8) Worse 20 (10)	Better 16 (6) Unchanged 15 (9) Worse 16 (8)
Five-Year	0.0 (-0.1 – 0)	Better 4.6 (0.3) Unchanged 4.6 (0.5) Worse 4.2 (0.7)	Better 16 (7) Unchanged 19 (8) Worse 19 (9)	Better 16 (7) Unchanged 16 (8) Worse 16 (10)
Ten-Year	Ref.	Better 4.7 (0.4) Unchanged 4.7 (0.3) Worse 3.7 (0.5)	Better 19 (7) Unchanged 21 (8) Worse 21 (8)	Better 17 (9) Unchanged 18 (17) Worse 17 (11)

13. OUTCOMES OF OPERATIVE TREATMENT FOR ADULT SPINAL DEFORMITY (ASD): A PROSPECTIVE, MULTICENTER ASSESSMENT WITH MINIMUM 3-YEAR FOLLOW-UP

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Introduction
Current literature has primarily focused on 2-yr outcomes for operative ASD treatment. Given the invasiveness, complications, and cost of these procedures, assessment of longer-term durability is important. The aim of this study was to assess minimum 3-yr outcomes and complications of ASD surgery.

Methods
Operatively treated ASD patients were assessed at baseline, follow-up, and through mailings. Patient-reported outcomes measures (PROMs) included: ODI, SRS-22r, SF-36 mental and physical components scores (MCS/PCS), and numeric rating scale (NRS) for back and leg pain. Complications were classified as periop (≤90 days), delayed (90 days to 2 yrs), and long-term (≥2 yrs). Analyses focused on patients with >3-yr follow-up

Results
Of 569 ASD patients, the 427 (75%) with minimum 3-yr follow-up (mean=4.1 yrs, SD=1.1 yrs, range=3 to 9.6 yrs) had a mean age of 61 yrs (SD=14) and 75% were women. Operative treatment included a posterior approach in 426 (99%), with a mean of 12 (SD=4) fusion levels. All PROMs improved significantly from baseline to last follow-up (p<0.001) (Table). Degradations in some outcome measures were observed between 2-yr and last follow-up, but the magnitudes were modest and arguably not clinically significant. The percentages of patients reaching at least 1 MCID improvement was 49% for ODI, 59% for PCS, 67% for SRS Pain, 69% for SRS Appearance, 64% for SRS Activity, 42% for SRS Mental, 80% for back pain NRS, and 49% for leg pain NRS. Overall, 277 (65%) patients had at least one complication, including 185 (43%) periop, 118 (27%) delayed, and 56 (13%) long-term. The 142 patients who did not achieve 3-yr follow-up were similar to study patients based on demographics, deformity, and baseline PROMs and had similar rates and types of complications.

Conclusion
This multicenter, prospective analysis demonstrates that operative treatment for ASD provides significant improvement of HRQL at minimum 3-yr (mean 4.1-yr) follow-up, suggesting that the benefits of surgical treatment for ASD remain durable at longer follow-up than provided by previous reports. Collectively, these findings should prove useful for patient counseling, cost-effectiveness assessments, and efforts to improve the safety of care.

Hypothesis
Operative treatment for ASD significantly improves health-related quality of life (HRQL) at minimum 3-yr follow-up.

Design
Multicenter, prospective cohort study

Comparison of baseline, 2-year follow-up, and last follow-up (minimum 5-year, mean 4.1-year) clinical outcomes parameters for 427 adult spinal deformity patients treated surgically.[1]

Outcome Parameter	Baseline Mean (SE)	2-Yr FU Mean (SE)	Last FU Mean (SE)	Mean Difference 2-Yr to Last FU (95% CI)	P-value[2] (BL vs 2-Yr)	P-value[2] (BL vs Last FU)	P-value[2] (2-Yr vs Last FU)
ODI	45.3 (0.8)	28.1 (1.0)	30.5 (1.1)	+2.3 (0.3, 4.3)	**<0.001**	**<0.001**	**0.02**
SF-36							
PCS	30.9 (0.5)	39.3 (0.6)	38.4 (0.6)	-0.9 (-1.9, 0.02)	**<0.001**	**<0.001**	0.06
MCS	45.6 (0.7)	51.5 (0.6)	50.5 (0.6)	-1.0 (-2.1, 0.2)	**<0.001**	**<0.001**	0.13
SRS-22r							
Total Score	2.74 (0.03)	3.66 (0.04)	3.58 (0.04)	-0.09 (-0.15, -0.02)	**<0.001**	**<0.001**	**0.006**
Activity	2.83 (0.05)	3.56 (0.05)	3.46 (0.05)	-0.10 (-0.18, -0.01)	**<0.001**	**<0.001**	**0.02**
Pain	2.33 (0.04)	3.44 (0.06)	3.36 (0.06)	-0.08 (-0.19, 0.02)	**<0.001**	**<0.001**	0.19
Appearance	2.38 (0.04)	3.59 (0.05)	3.53 (0.05)	-0.06 (-0.15, 0.02)	**<0.001**	**<0.001**	0.20
Mental	3.41 (0.05)	3.87 (0.04)	3.75 (0.04)	-0.12 (-0.21, -0.03)	**<0.001**	**<0.001**	**0.003**
Satisfaction	2.73 (0.06)	4.12 (0.05)	4.09 (0.05)	-0.03 (-0.12, 0.06)	**<0.001**	**<0.001**	1.00
NRS Scores							
Back Pain	7.13 (0.11)	3.63 (0.16)	3.84 (0.16)	0.21 (-0.08, 0.50)	**<0.001**	**<0.001**	0.24
Leg Pain	4.91 (0.17)	2.65 (0.15)	2.97 (0.16)	0.32 (0.003, 0.65)	**<0.001**	**<0.001**	**0.047**

[1]SE=standard error, FU=follow-up, CI=confidence interval, ODI = Oswestry Disability Index, SF = Short-Form, SD = standard deviation, SRS = Scoliosis Research Society, NRS = numeric rating scale
[2]Repeated measures within subjects analysis of variance

14. CLINICAL OUTCOMES OF CORRECTIVE FUSION SURGERY FROM THE THORACIC SPINE TO THE PELVIS FOR ADULT SPINAL DEFORMITY AT 1, 2, AND 5 YEARS POSTOPERATIVELY

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Hypothesis
Patient-reported outcomes (PROs) may be maintained in the med- to long-term after corrective fusion surgery for adult spinal deformity (ASD), but some cases may worsen.

Design
Retrospective cohort study.

Introduction
PROs up to 2 years after corrective fusion surgeries for ASD have been well-studied, but there are few reports of mid- to long-term results. The purpose of this study is to investigate whether PROs were consistent at 2 and 5 years after corrective fusion surgery from the thoracic spine to the pelvis in patients with ASD and to analyze whether revision surgery affected long-term outcomes.

Methods
We retrospectively analyzed patients with ASD who underwent corrective fusion surgery from the thoracic spine to the pelvis between 2010 and 2015. We investigated radiographic parameters and PROs (Scoliosis Research Society 22r [SRS-22r], Oswestry Disability Index [ODI]) pre-operatively and at 1, 2, and 5 years post-operatively, and the correlations between PROs at these time points. We also compared changes in PROs at 5 years in patients who underwent revision surgery and those who did not.

Results
A total of 131 patients who underwent corrective fusion surgery from the thoracic spine to the pelvis were analyzed. The PROs at 1 and 5 years after surgery showed significant correlations in all SRS-22r domains [function (r=0.620), pain (r=0.577), self-image (r=0.563), mental health (r=0.589), subtotal (r=0.663), and ODI (r=0.654)]. The PROs at 2 and 5 years after surgery showed significantly strong correlations in all domains [function (r=0.715), pain (r=0.678), self-image (r=0.653), mental health (r=0.675), subtotal (r=0.741), and ODI (r=0.746)]. There were no significant differences in the change in PROs at 5 years in any domain in patients who underwent revision surgery (all P>0.05).

Conclusion
One-year post-operative PROs improved significantly. Two-year PROs correlated strongly with 5-year post-operative PROs, indicating that 2-year PROs can predict longer term outcomes. The need for revision surgery did not influence the mid- to long-term clinical outcomes of corrective fusion surgery for ASD. The results of this study showed that short-term outcomes at 2 years after corrective fusion surgery for ASD are maintained in the long term, as is the case with surgical treatment for lumbar degenerative spondylolisthesis.

15. DIFFERENCE IN IMPACT OF SPINAL FUSION ON ACTIVITY OF DAILY LIVING BETWEEN US AND JAPANESE ADULT SPINAL DEFORMITY PATIENTS

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Hypothesis
Impact of spinal fusion on ADL is different among US and JP ASD patients.

Design
Multicenter retrospective analysis.

Introduction
Spinal correction surgery for adult spinal deformity patients (ASD) provides pain relief in exchange for trunk stiffness. The impact of spinal fusion may be different among patients with different lifestyle. The purpose of this study was to elucidate the difference of impact of spinal fusion on ADL in ASD between US and Japan (JP).

Methods
Among 252 operative ASD (173 US/79 JP, > 5 levels, minimum 2y follow), propensity-score matching was preformed between US and JP for age, gender, number of fused segments and pelvis fusion. Sixty patients in each ethnicity were matched (US/JP: age 67.1±8.6/67.0±7.0y, female 78.3/83.3%, number of fused segments 10.7±2.8/10.5±2.7, pelvis fusion 78.3/75.0%). Impact of spinal fusion on ADL was evaluated with Lumbar Stiffness Disability Index (LSDI) in US and its modified version in JP at baseline (BL) and at final follow-up (FU). Degree of disability was categorized into 3 levels (1: none, 2: minimal, 3: significant) in 7 questions (Q1 wear pants, Q2 put on socks, Q4 toileting, Q5 pick-up items, Q6 get in/out of bed, Q7 get in/out of a chair, Q9 get in/out of an automobile) of LSDI which were common to JP version. Differences in the distribution of disability level between BL and FU were evaluated with Chi-squared test.

Results
In US, there was no significant change in disability level at FU in Q1, 2, 4, 5, 6, 9 whereas significantly improved

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in Q7. In JP, significant deterioration of disability level was observed in Q1, 2, 4, however none improved at FU. SRS-22 score was significantly improved at FU in both ethnicity with equivalent degree (BL/FU: US activity 3.0/3.7, pain 2.6/3.6, appearance 2.5/3.7, mental 3.4/3.9, total 2.9/3.8, JP activity 2.6/3.4, pain 3.0/3.8, appearance 2.0/3.4, mental 2.6/3.4, total 2.4/3.5).

Conclusion
Spinal correction surgery provides similar benefits to ASD patients evaluated with SRS-22 both in US and JP, however its impact on ADL is different which may be due to differences in lifestyle.

LSDI	US							JP						
	BL			FU				BL			FU			
Disability level	1 (%)	2 (%)	3 (%)	1 (%)	2 (%)	3 (%)	p	1 (%)	2 (%)	3 (%)	1 (%)	2 (%)	3 (%)	p
Q1	8.3	40.0	51.7	8.3	33.3	58.3		59.3	16.9	23.7	34.5	24.1	41.4	*
Q2	11.7	40.0	48.3	11.7	26.7	61.7		59.3	16.9	23.7	22.4	17.2	60.3	*
Q4	35.0	38.3	26.7	40.7	39.0	20.3		69.5	15.3	15.3	42.1	35.1	22.8	*
Q5	11.7	31.7	56.7	8.3	40.0	51.7		40.4	19.3	40.4	31.0	17.2	51.7	
Q6	10.0	46.7	43.3	22.0	52.5	25.4		50.0	29.5	20.5	60.4	15.1	24.5	
Q7	16.9	39.0	44.1	28.8	55.9	15.3	*	62.7	20.3	16.9	68.4	12.3	19.3	
Q9	11.9	40.7	47.5	20.3	50.8	28.8		55.9	18.6	25.4	60.0	13.3	26.7	

Table Distribution of disability level at baseline and follow-up.
Disability level: 1 none, 2 minimal, 3 significant.
*p<0.05, BL vs. FU with Chi-squared test.

16. DOES PERIOPERATIVE TERIPARATIDE IN OSTEOPOROTIC PATIENTS HELP INCREASE BONE DENSITY, AND DECREASE MECHANICAL COMPLICATIONS – MINIMUM 2-YEAR RADIOLOGICAL STUDY MEASURING HOUNSFIELD UNITS

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Hypothesis
If patients are on Teriparatide for at least one year in conjunction with surgery, their lumbar spine bone density will improve.

Design
A systematic review of a prospective data registry

Introduction
Osteoporosis is common amongst elderly patients undergoing Adult Spinal deformity correction. Low bone density increases risk of fracture and mechanical hardware failure. The use of Teriparatide reduces complications due to osteoporosis

Methods
A prospectively collected data registry of 274 patients who underwent CMIS correction of ASD (Cobb angle>20 or SVA>50mm or (PI-LL)>10) From Jan 2011 to Jan 2020 was analyzed. Patients who were placed on PTH analogues for one year in conjunction with surgery were included for the study. 47 patients were identified. 41 patients who had pre-op and two-year post-operative CT scans for review of the Hounsfield units in the lumbar spine were included for this study. Hounsfield units were measured on L3 Level for all patients before and after surgery on pre-op and post-op CT scans.

Results
Mean age of patients was 70 (52-84, SD 7). Mean follow-up was 66 (24-132, SD 33).The mean pre-op L3 Hounsfield unit of 151 (52-396, SD 85) significantly improved to 178 (62-420, SD 95) at the 2-year post-op CT scans ($p<0.05$).There was no screw loosening or screw pull out. There were 2 patients with PJK/PJF (4.8%). Both these patients hadn't completed their Teriparatide treatment: one only took Teriparatide for 3 months (PJK at 2-year post-op) and the other one took it only for 1 month (PJK at 1-year post-op). Only 5 patients (12.2%) did not show any increase in Hounsfield units in their pre-op density lumbar vertebrae after completing their PTH analogous course.

Conclusion
The incidence of Teriparatide failing to increase bone density in our series was low at 12.2% (n=5). This study shows that Teriparatide is a useful tool in increasing bone density and decreasing mechanical complications when used in conjunction with surgery.

17. NORMALIZING LUMBOPELVIC AND THORACOLUMBAR ALIGNMENT REDUCES MECHANICAL COMPLICATIONS IN ADULT SPINAL DEFORMITY

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Hypothesis
Normalizing L1PA and T4-L1PA relationship in long-segment ASD fusions will reduce reoperation for mechanical complications (MC).

Design
Retrospective cohort

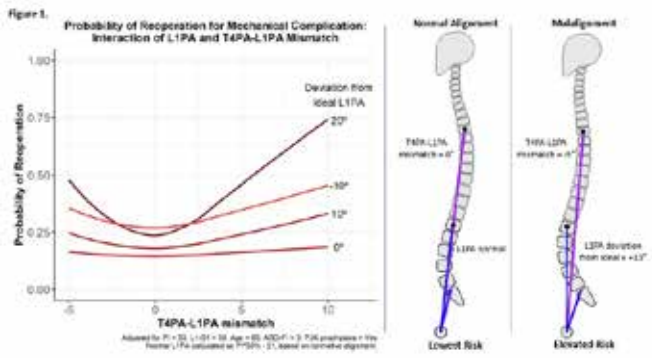
Introduction
The relationship between optimal alignment and mechanical complications is evolving through concepts of magnitude and distribution of sagittal plane contours. The L1 pelvic angle (L1PA) accounts for lordosis magnitude and distribution and is strongly associated with pelvic incidence (PI). In normal adult spines, the T4 pelvic angle (T4PA) is within 4°of L1PA. The effect of aligning ASD reconstructions to normal, unfused adults is unknown.

Methods
A multi-center, prospective ASD registry was queried for patients fixed from T1-T5 to the sacrum with 2yr radiographic follow-up. Ideal sagittal alignment was defined from normal spines: L1PA = PI x 50% - 21°; and T4PA-L1PA mismatch < 4°. MCs were defined as proximal junctional failure, rod fracture or pseudarthrosis. Covariates included age, PI, ASD-Frailty Index (FI), PJK prophylaxis; and 6wk PI-LL, L1PA, and T4PA-L1PA mismatch. Logistic regression was used to determine the association between L1PA and T4PA-L1PA mismatch, and the probability of MC reoperation while adjusting for covariates. To determine the synergistic effect of 'over- 'and 'under-correction' of lumbopelvic alignment, L1PA and T4PA-L1PA mismatch were assessed as a nonlinear interaction. Model performance

was measured by the C-statistic.

Results
364 patients were identified; 88 lacked 2yr follow-up (excluded). Of 276 included: 83% were female; mean age was 62.5 (9.7), ASD-FI 3.6 (1.5); 51% had PJK prophylaxis performed; and 17.8% had a reoperation for MC. Achieving a normal L1PA with an aligned T4PA offered the lowest probability of MC reoperation (nonlinear interaction of L1PA deviation and T4PA-L1PA mismatch was strongest predictor, $p < 0.05$, AUC = 0.75). Deviation from normal L1PA ('over - 'or 'under-correction') was associated with higher risk of reoperation (Fig 1).

Conclusion
Restoration of lumbopelvic alignment and thoracolumbar alignment as measured by L1PA and T4-L1PA mismatch result in the lowest probability for MC after long ASD reconstruction. Restoration of L1PA alone reduces MC in the setting of T4-L1PA mismatch. These results support the concepts of sagittal plane measures and distributions as drivers of MC after ASD fusion.



18. THE IMPORTANCE OF THORACOLUMBAR JUNCTIONAL ANGLE IN DEVELOPMENT OF ACUTE PROXIMAL JUNCTIONAL KYPHOSIS IN ADULT SPINAL DEFORMITY SURGERY

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Hypothesis
This study aimed to investigate the association between thoracolumabr junctional angle (TLA) and the development of acute proximal junctional kyphosis (PJK) following adult spinal deformity (ASD) surgery.

Design
Retrospective observational cohort study

Introduction
Various risk factors and prevention methods have been suggested for the development of PJK. However, no study has identified a single variable associated with the development of PJK, and the results of many studies are conflicting. A recent study has reported that PJK may be more accurately interpreted as a pathological variant on the spectrum of reciprocal change following spine realignment surgery. In this context, changes in the TLA would play a pivotal role in the reciprocal changes following spine realignment surgery, thereby leading to the development of PJK.

Methods
According to the development of acute PJK within 6 months after surgery, the patients were divided into PJK + and PJK - groups. The TLA and spinopelvic radiologic parameters were compared between the PJK + and PJK groups. A multivariate logistic regression model was used to identify the risk factors for acute PJK. The receiver operating characteristic (ROC) curves of the regression models were used to investigate the cut-off values of significant parameters needed so that PJK would not occur.

Results
The ΔTLA in the PJK + group was significantly larger than in the PJK- group (-6.6 ± 8.3 and -2.5 ± 9.0, respectively. P = 0.014). Multivariate logistic regression analysis identified that age, postoperative PI-LL, ΔTLA, and postoperative thoracolumbar slope (TLS) were significant risk factors for acute PJK. The risk of developing PJK was higher when the postoperative PI-LL was less than 5.1, the ΔTLA was larger than -4.03, and the postoperative TLS was larger than -9.58°.

Conclusion
The present study highlights that extensive correction of TLA and LL should be avoided in ASD patients. Overcorrection of TLA > -4.03° could result in higher odds of acute PJK.

19. PROXIMAL JUNCTIONAL FAILURE (PJF) IN PRIMARY THORACOLUMBAR FUSION/FIXATION TO THE SACRUM/PELVIS FOR ADULT SYMPTOMATIC LUMBAR SCOLIOSIS (ASLS): LONG-TERM FOLLOW-UP OF A PROSPECTIVE MULTICENTER COHORT OF 160 PATIENTS

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Hypothesis
Risk factors predictive of PJF following primary surgery for ASLS are identifiable and avoidable.

Design
Retrospective review of prospectively-collected data

Introduction
PJF is a severe form of proximal junctional kyphosis that often warrants revision. Previous reports on PJF have been limited by heterogeneous cohorts and relatively short follow-up. The objectives of this study were to identify risk factors for PJF and assess its long-term incidence and revision rates in a homogenous patient population.

Methods
We reviewed data from ASLS-1, an NIH-sponsored multicenter prospective study. Inclusion criteria were: age ≥40 yrs with ASLS (Cobb >30o and ODI >20 or SRS-22 <4.0 in pain, function or self-image) and primary TL fusion/fixation to the sacrum/pelvis of >7 levels. PJF was defined as postop proximal junctional angle (PJA) change ≥20°, fracture of UIV or UIV+1 with ≥20% vertebral body height

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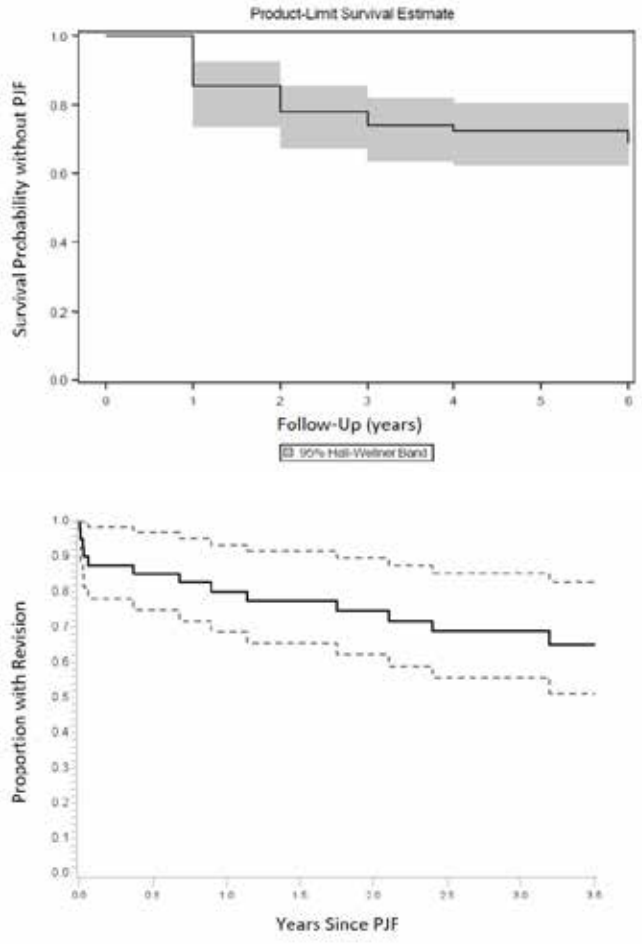
loss, anterolisthesis of UIV/UIV+1 ≥3mm, and/or UIV screw dislodgment.

Results
160 patients were included (mean age 61 yrs; 141 women) with mean follow-up of 4.3 yrs (range: 0.1-6.1 yrs). 46 patients (28.7%) developed PJF at a median of 0.92 yrs (IQR: 0.14-1.23 yrs) postop (Figure). PJF rates at 1, 2, 3, and 4 yrs were 14.4%, 21.9%, 25.9%, and 27.4%, respectively. On univariate analysis, factors associated with PJF included greater age (p=0.03), greater BMI (p=0.03), worse baseline PROMs (ODI; SRS-22r; SF-36 PCS; all p<0.04), greater use of posterior column osteotomies (p=0.004), and worse postop TK (p=0.0031) and PJA (P<0.001). Use of UIV hooks was protective against PJF (p=0.03). On regression analysis (without postop measures), factors associated with PJF were greater BMI (OR=1.077, 95%CI=1.007-1.153, p=0.03), lower preop PJA (OR=0.607, 95%CI=0.407-0.906, p=0.01), and greater preop TK (OR=1.362, 95%CI=1.082-1.715, p=0.009). Patients with PJF had worse PROMs at last follow-up (ODI; SRS-22r subscore and self-image; SF-36 PCS; all p<0.04). 16 (34.8%) PJF patients were revised; PJF recurred in 3.

Conclusion
In this population of primary ASLS patients, the PJF rate was 28.7% at mean 4.3-yr follow-up with a revision rate of 34.8%. Higher risk of PJF was associated with greater age and BMI, use of posterior column osteotomies, lower preop PJA, and greater preop TK. Use of UIV hooks was protective against PJF.



20. SURGICAL CORRECTION OF CORONAL MALALIGNMENT (CM) IMPROVES CLINICAL OUTCOMES IN A LARGE COHORT OF ADULT SPINAL DEFORMITY (ASD) PATIENTS

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Hypothesis
Correction of CM >20mm improves significantly clinical outcomes after ASD surgery

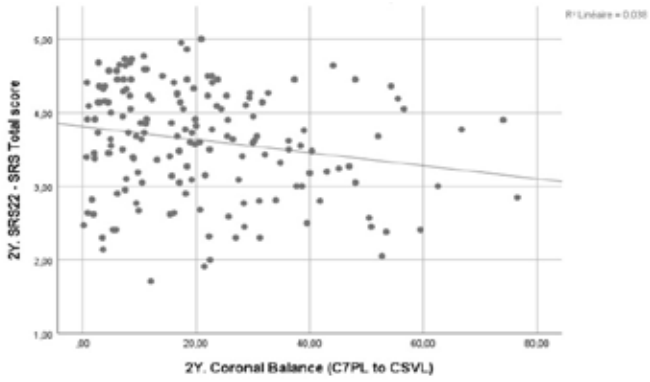
Design
Retrospective study based on a prospective multicenter cohort of patients who underwent ASD corrective surgery and had pre-operative CM of more than 20mm (CM>20mm)

Introduction
CM after ASD surgery is correlated with poor functional outcomes. Previous studies showed that coronal realignment leads to significant improvements in Patient-Reported Outcomes Measures (PROMs) for severe CM. If associated with global tilt (GT) correction, CM correction also improves PROMs. This study aims to evaluate the correlation between CM correction and functional outcome improvements at 2-year minimum follow-up

Methods
258 surgical patients were included with a preoperative CM>20mm and at least 2 years follow-up. Correlation studies between the Central Sacral Vertical Line (CSVL) malalignment and functional score (ODI, SRS22r and SF36) were undertaken. Factors influencing PROM improvements that reach Minimum Clinically Important Difference (MCID) were studied in a multivariate analysis.

Results
There was a statistically significant correlation between CM and SRS22r total score. Post-operative CM>20mm was correlated with a worse quality of life for all subdomains of the SRS22r but only with standing in ODI and body pain in SF36 questionnaires. Conversely, CM<20mm, a greater pelvic incidence and preoperative lumbar lordosis, greater sagittal plane correction were observed in the SRS 22r improvement group in univariate analysis. In multivariate analysis, a post-operative CM<20mm resulted in 3.5 times greater chance to obtain SRS22r questionnaire improvements that reached MCID (>0,77 over 5 points). Multivariate analysis showed that in addition to postoperative CM<20mm, good physical status (ASA), GT and pelvic fixation correlated independently with SRS22r improvement

Conclusion
CM correlates independently with PROMs especially SRS22r questionnaire. CM correction to less than 20mm is independently correlated to SRS22 total score improvement that reached MCID, OR= 3,5; ODI and SF36 are less affected. As a result, CM<20mm may be considered as a reasonable target to aim to in ASD surgery.



Scatter plot showing correlation between SRS22 total score and CSVL

21. OUTCOMES AFTER CORONAL ALIGNMENT CORRECTION IN PATIENTS WITH TRUNK SHIFT TOWARDS THE CURVE CONVEXITY

Michael Dinizo, MD; Karnmanee Srisanguan, BS; *Tina Raman, MD*

Hypothesis
ASD patients with coronal malalignment shifted to the convexity of the major curve, have a higher rate of persistent coronal malalignment, and unplanned revision at two year follow up.

Design
Retrospective review of prospectively collected single center database.

Introduction
Patients with coronal malalignment with trunk shift towards the convexity of the main coronal curve, and oblique takeoff at the lumbosacral junction, present a unique problem for deformity correction.

Methods
1039 ASD patients (Age: 46 ± 23 y; mFI: .4 ± .7; Levels: 10.0 ± 4.2), with > 5 levels fused for thoracolumbar scoliosis were divided into 3 groups, as proposed by Bao et al.: type A: CSVL < 3 cm (n=881); type B: CSVL > 3 cm, C7 plumb shifted to scoliosis' concavity (n=126); type C: CSVL > 3 cm, C7 plumb shifted to scoliosis' convexity (n=30). Outcomes evaluated were coronal alignment and fractional curve correction, and rate of revision surgery at two year follow up.

Results
Type C patients more often had fractional curves, with significantly greater preoperative magnitude (15.7° Type C, 12.9° Type B, 9.6° Type A, p<0.0001). Postoperatively, Type C patients continued to have persistently greater fractional curves (7.4° Type C, 6.7° Type B, 5.6° type A, p=0.026), and worse coronal malalignment (37.8 mm Type C, 34.1 mm Type B, 17.0 mm type A, p<0.0001), though equivalent results with regards to improvement in sagittal alignment, lumbar lordosis, pelvic tilt, and Cobb angle of the major curve. There was a higher rate of neurologic complications in the Type C patients, specifically related to TLIF or PSO procedure performed. ALIF procedure in the Type C patients did not confer significant improvement in fractional curve correction, or any radiographic parameter of deformity correction, compared with TLIF procedure. There was no difference in rates or rod fracture, pseudarthrosis, adjacent segment disease, proximal junctional kyphosis, or reoperation for recurrent or persistent malalignment between the three groups at two year follow up.

Conclusion
At 2 year follow up, Bao Type C coronal malalignment patients continue to have worse coronal deformity and fractional curve magnitude compared with type A and B patients. There was no difference seen between the groups with respect to rod fracture, pseudarthrosis, persistent malalignment, or revision surgery rates.

22. DEFINING SPINOPELVIC ALIGNMENT IN ADULT POPULATION OVER 60 YEARS OLD: PROSPECTIVE ANALYSIS OF 214 VOLUNTEERS

Sung Hyun Noh, MD; Yoon Ha, MD, PhD; Sang Hyun Kim, PhD; Pyung Goo Cho, PhD; Kyung Hyun Kim, PhD

Hypothesis
As you age, degenerative changes progress.

Design
prospective study

Introduction
The values of the surgical target angle and ideal sagittal balance that have been published so far are the results of a study targeting patients over 18 years of age. Therefore, most patients in adult spinal deformity surgery are currently in their 60s or older, and it is unreasonable to apply these values to patients in their 60s or older. The purpose of this study is to prospectively analyze adult patients to obtain the ideal sagittal balance value at age 60 or older.

Methods
A total of 214 people over the age of 60 participated in the study. Questionnaires related to HRQOL were administered. Spino-Pelvic parameters were measured by whole spine X-rays. Radiographical evaluation was conducted on the lateral planes and HRQOL questionnaires (Oswestry Disability Index [ODI]) were completed. Radiographical parameters demonstrating highest correlation with HRQOL values were evaluated to determine thresholds predictive of ODI more than 20.

Results
Two hundred fourteen consecutive patients (mean age, 71.3 yr) were enrolled. There were 131 people with an ODI value of less than 20 (Minimal-ODI group) and 83 people with an ODI value of 20 or more (Moderate-ODI group). Moderate-ODI group had greater pelvic tilt (PT) (28±13.7° vs 19.9±13.9°, P < 0.05), greater T1 pelvic angle (T1PA) (33.6±15° vs 23.7±14.6°, P < 0.05), and greater pelvic incidence/lumbar lordosis PI/LL mismatch (PI-LL) (45.2±30.7 vs 31.7±36.1, P < 0.05) than Minimal-ODI group. Moderate-ODI group demonstrated greater disability on ODI measures compared with Minimal-ODI (ODI = 25.3±4.3 vs 11.8±5.4, P < 0.05). Pearson analysis demonstrated that among all parameters, PT,

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T1PA, and PILL correlated most strongly with disability for both Minimal-ODI and Moderate-ODI groups (P < 0.001). Logistic regression models demonstrated threshold radiographical spinopelvic parameters for ODI more than 20 to be: PT 15° or more (area under curve (AUC) = 0.820), T1PA 17° or more (AUC = 0.888), PI – LL 16° or more (AUC = 0.842).

Conclusion
Prospective analysis of consecutively enrolled age 60 or older patients proved that PT, T1PA, and PI-LL can predict patient disability and provide evaluation guides for appropriate treatment decisions. Threshold values for moderate disability (ODI > 20) included: PT 15° or more, T1PA 17° or more, and PI – LL 16° or more.

23. VARIATION OF GLOBAL SAGITTAL ALIGNMENT PARAMETERS ACCORDING TO GENDER, PELVIC INCIDENCE AND AGE

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Hypothesis
Global sagittal alignment parameters may vary according to age and spinopelvic morphology.

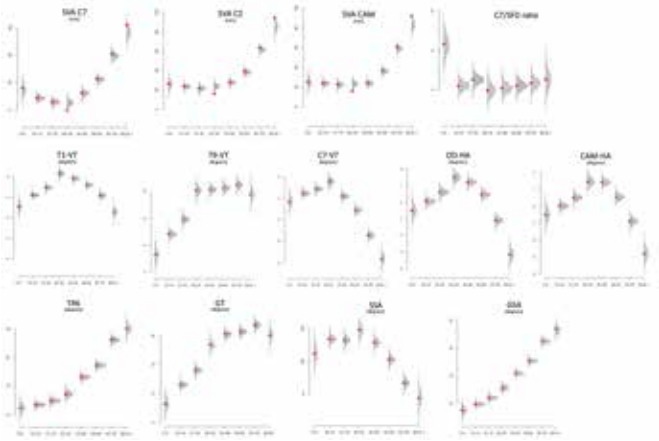
Design
Retrospective cross-sectional study.

Introduction
The aim was to describe existing global sagittal alignment parameters across ages and to analyze differences according to gender and pelvic incidence (PI).

Methods
Radiographs of 2599 individuals (5-93 years) were analyzed. Translation parameters were: Sagittal Vertical Axis (SVA)-C7, SVA-C2, SVA-Center Acoustic Meatus (CAM), C7/Sacro-Femoral Distance (SFD) ratio. Inclination parameters were: C7-, T1- and T9-Vertical Tilt (VT), Odontoid-Hip Axis (OD-HA), OD-CAM. Pelvic compensation parameters were: T1-Pelvic Angle (TPA), Global Tilt (GT), Spino-Sacral Angle (SSA). Global sagittal alignment (GSA) was considered among formulae. The distribution of parameters was analyzed using a Bayesian inference. Correlations with spinopelvic parameters were investigated.

Results
SVA-C7, SVA-C2, SVA-CAM were larger in males and high PI, and increased significantly after 50 years (Pr>0.9999). C7/SFD decreased during growth and was larger in low PI (Pr=0.951). There was no correlation with spinopelvic parameters. Age-related variations of inclination parameters were non-significant. T1-VT and T9-VT increased with PI and were significantly larger in high PI (Pr>0.95). C7-VT was significantly larger in low PI (Pr>0.9999). OD-HA and OD-CAM were constant and increased after 80 years. TPA and GT increased with PI (Pr>0.9999) and age after 35 years (Pr>0.9999). SSA decreased non-significantly after 50 years. TPA correlated with PI (ρ=0.6130) and pelvic tilt (PT) (ρ=0.8375). GT correlated with PI (ρ=0.5961) and PT (ρ=0.8996). SSA correlated with sacral slope (ρ=0.9026). GSA was larger in high PI (Pr>0.9999) and increased after 35 years (Pr>0.9999). GSA correlated with PT (ρ=0.7732).

Conclusion
Translation parameters increase with age, more prominently in males and high PI. Variations of inclination parameters are smaller. Pelvic compensation parameters and GSA increase with age and are closely related to PT and spinopelvic morphology.



Distribution of global alignment parameters by age groups

24. CAN AI IDENTIFY PATTERNS OF COMPLEX ADULT SPINAL DEFORMITY WITH DISTINCT PERIOPERATIVE OUTCOMES?

Renaud Lafage, MS; Mitchell Fourman, MPhil; Shay Bess, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Christopher P. Ames, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis
AI-based unsupervised patterns of ASD are associated with specific 30-day adverse events.

Design
Retrospective analysis of a multi-center prospective database

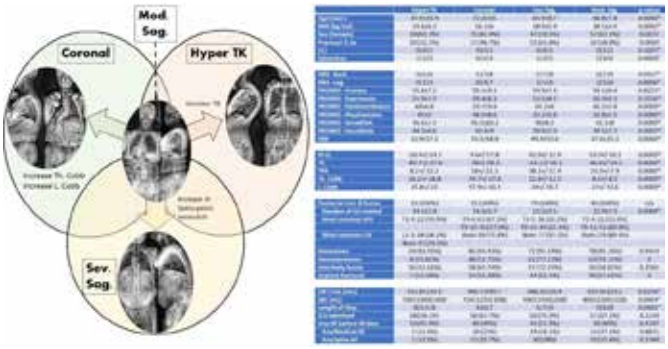
Introduction
"Adult spinal deformity" (ASD) refers to multiple types of spinal deformity. This study used a prospective multicenter database of patients with "complex" surgical ASD to derive a data-driven deformity classification and assess if such patterns have distinct clinical outcomes.

Methods
The "complex surgical ASD" dataset included severe deformity, surgical complexity, or advanced age with multilevel fusion. An unsupervised cluster analysis allowing for 10% outliers was used to identify different deformity patterns. Perioperative outcomes were compared using

ANOVA, Kruskal-Wallis, and Chi-Squared analyses, with $p < 0.05$ considered significant.

Results
Four deformity patterns were derived from 286 surgical patients (Figure). Hyper-TK (HTK) patients were the youngest (48±20), with the lowest disability (ODI 32.9±17.1) and pain scores (median NRS back=6, leg=1). Severe-Coronal (SC) had moderate disability (ODI 33.5±18.8), functional impairment (PCD: 34.4±12.3), and pain scores (median NRS back=7, leg=4). Severe-Sagittal (SS) had higher BMIs (28.9±5.9) and levels of disability (ODI 49.3±15.6), and low appearance scores (2.3±0.7). Finally, the Moderate group (Mod, 68.8±7.8 yo) had the highest PROMIS pain interference sub-scores (65.2±5.8), high levels of disability (ODI 47.6±15.3) and back pain (NRS back=7), and poor quality of life (SRS total 2.8±0.6). Thirty-day adverse events were equivalent. HTK and SC had the longest constructs, but fusion to the pelvis was most common in Mod (89.4%) and SS (97.5%). SC had more osteotomies per case (median 11 IQR 6.5 to 14), longer OR times, and a higher rate of 30-day implant-related complications (5.5%). SS and HTK were more likely to require a 3CO (43% and 32.3%, resp). SS were more likely to require interbody implants (29.1%) and operative wound debridement (7.6%). HTK patients had shorter hospital stays.

Conclusion
AI identified 4 distinct patient clusters of surgically treated ASD patients, each with 1) a unique spinal deformity pattern, 2) distinct pathognomonic health deficits, 3) consistent surgical treatment across 11 centers, and 4) characteristic perioperative complications and hospital stays.



25. SAGITTAL MALALIGNMENT AFFECTS CAPACITIES OF ADAPTATIONS TO WALK FASTER

Krystel Abi Karam, MS; Rami Rachkidi, MD, MSc; Karl Semaan, MS; Eddy Saad, MS; Marc Fakhoury, MS; Maria Saadé, BS; Elma Ayoub, BS; Celine Chaaya, BS; Ali Rteil, BS; Elena Jaber, BS; Elio Mekhael, BS; Nabil Nassim, BS; Abir Massaad, PhD; Virginie Lafage, PhD; Wafa Skalli, PhD; *Ayman Assi, PhD*

Hypothesis
Sagittal malalignment in ASD affects kinematic adaptations to walk faster.

Design
Prospective

Introduction
Adult Spinal Deformity (ASD) has a major impact on quality of life (QOL). It was reported that sagittal malalignment affects patients' walking. Fast gait is considered a challenging daily activity and a predictive tool for falls. The aim was to assess kinematic adaptations to walk faster in ASD.

Methods
116 primary ASD (51±19y, 86F), age and sex-matched to 66 controls, filled QOL questionnaires and underwent biplanar X-rays. ASD were divided as: 47 with sagittal malalignment (ASD-Sagittal: high SVA, PT and/or PI-LL), 41 with only hyperkyphosis (ASD-HyperTK: TK>60°) and 28 with only frontal deformity (ASD-Frontal: Cobb>20°). All subjects underwent gait analysis at spontaneous and fast speed, with calculation of 3D lower limb and trunk kinematics. Differences of kinematic parameters between fast and spontaneous speed walking were reported as needed adaptations to walk faster.

Results
When transitioning from spontaneous to fast speed walking, control subjects increase their range of motion (ROM) of the pelvis in the frontal and horizontal planes as well as their hips and knees ROM. In addition, they fully extend their knees at specific moment of the gait cycle, all of which lead to increase their cadence and walking speed. While patients in the ASD-HyperTK and ASD-Frontal groups had almost similar patterns to controls, patients in the ASD-Sagittal group did not sufficiently increase their pelvic ROM in the frontal (0 vs 4°) and horizontal (2 vs 6°) planes, neither their hip flexion ROM (4 vs 8°) compared to controls. They also failed to fully extend their knees (2 vs -2°) and to increase their cadence (28 vs 32 step/min, all $p<0.05$). Their insufficient increase of walking speed (0.4 vs 0.6m/s) was correlated to the alteration of ODI (r=-0.3) and SF-36 physical component (r=0.4, fig.1).

Conclusion
Sagittal malalignment has a major impact on the adaptation of walking from spontaneous to fast speed. Patients with sagittal malalignment seem to have exhausted their pelvis, hip and knee mobility, which limit them to increase their cadence and walking speed when asked to walk faster. These kinematic adaptations were related to their deteriorated QOL outcomes.

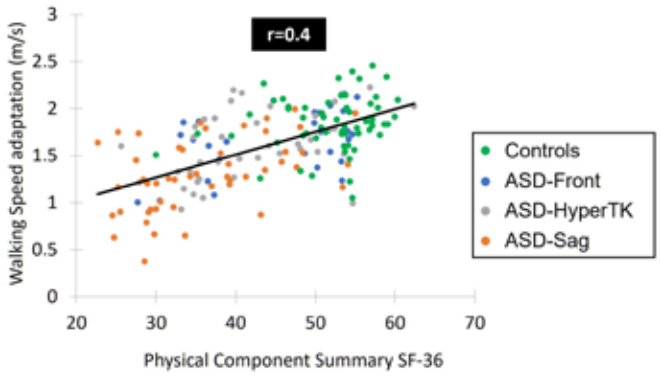


Fig.1: Correlation between increase of walking speed and SF-36 physical outcome in ASD and controls trying to walk faster.

PODIUM PRESENTATION ABSTRACTS

26. ASD WITH HIGH PELVIC RETROVERSION DEVELOP CHANGES IN THEIR ACETABULAR ORIENTATION DURING WALKING

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Hypothesis
ASD with increased pelvic retroversion present changes in their acetabular orientation during walking.

Design
Prospective

Introduction
Pelvic retroversion, used as compensatory mechanism in ASD, can be related to changes in acetabular orientation and therefore the development of hip osteoarthritis, especially during daily life activities that are known to increase joint loading. The aim of this study was to investigate the relationship between pelvic retroversion and changes in acetabular orientation in ASD during walking.

Methods
90 primary ASD (52±20y, 70F) age and sex matched to 37 controls underwent 3D gait analysis and full-body biplanar X-rays with the reflective gait markers still in place. Spinopelvic, postural and acetabular parameters were calculated from 3D skeletal reconstructions (Fig. 1a). Then, 3D bones were registered on each gait frame to compute the dynamic value of radiographic parameters during walking. PT adjusted to PI was calculated (adj. PT=0.37*PI-7°). Patients having a high adjusted PT (>2SD in controls) were grouped as ASD-highPT, otherwise as ASD-normalPT. Between group comparisons of radiographic parameters in static and dynamic parameters were investigated.

Results
26/90 patients were classified as ASD-highPT. They had a radiographic PT of 31° (ASD-nomalPT: 13°, controls: 10°, p<0.001). On static radiographs, ASD-highPT showed more severe postural malalignment than ASD-normalPT: SVA=61 vs 6mm, ODHA=5 vs 3°, PI-LL=20° vs -13° and L1L5=18 vs 50° (all p<0.001). During gait, ASD-highPT presented a higher pelvic retroversion of 29° (ASD-normalPT & controls: 16°) along with a higher acetabular anteversion of 24° (ASD-normalPT & controls: 20°), external acetabular coverage of 38° (ASD-normalPT & controls: 29°) and posterior acetabular coverage of the femoral head of 30% (ASD-normalPT & controls: 26%), all p<0.05 (Fig. 1b).

Conclusion
ASD patients with severe pelvic retroversion showed increased acetabular anteversion, external acetabular coverage and posterior acetabular coverage of the femoral head during walking. These changes in acetabular orientation, computed during walking, are known to cause hip osteoarthritis. This is the first study to describe the relationship between spinal deformity and the risk of developing hip osteoarthritis in ASD with increased pelvic retroversion.

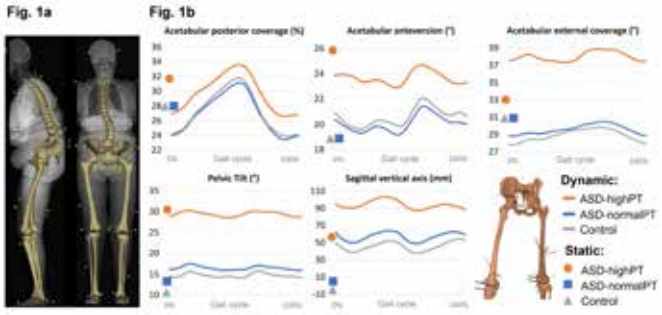


Fig. 1- Postural and acetabular parameters in ASD during walking.

27. SAGITTAL MALALIGNMENT INCREASES RISKS OF TRIPS AND FALLS DURING STAIR STEP ASCENT AND DESCENT

Marc Fakhoury, MS; Krystel Abi Karam, MS; Karl Semaan, MS; Eddy Saad, MS; Maria Saadé, BS; Elma Ayoub, BS; Celine Chaaya, BS; Ali Rteil, BS; Elena Jaber, BS; Elio Mekhael, BS; Nabil Nassim, BS; Abir Massaad, PhD; Virginie Lafage, PhD; Wafa Skalli, PhD; *Rami Rachkidi, MD, MSc*; Ayman Assi, PhD

Hypothesis
Patients with sagittal malalignment present kinematic alterations when using stair step making them prone to trips and falls.

Design
Prospective

Introduction
Adults with spinal deformity (ASD) are known to have quality of life (QOL) deterioration and limitation in their daily life activities. Motor function impairment were detected in these patients during walking and sitting and standing movement. Climbing stairs is a fundamental and challenging daily life activity that is essential for patient's autonomy. The aim was to evaluate kinematic alterations in ASD when using stair steps.

Methods
112 primary ASD (52±20y, 84F), age and sex-matched to 34 controls, filled QOL questionnaires and underwent biplanar X-rays. ASD were divided into 3 groups: 44 with sagittal malalignment (ASD-Sag: PT>25°, SVA>5cm and/or PI-LL>10°), 42 with only thoracic hyperkyphosis (ASD-HyperTK: TK>60°), 26 with only frontal deformity (ASD-Front: Cobb>20°). All participants underwent 3D motion analysis while ascending and descending a stair step. Kinematic parameters of the lower limbs and spine were calculated.

Results
During stair step ascent, ASD-Sag exhibited an increased thorax flexion (20 vs 5°) compared to controls, in addition to a rigid and decreased dynamic lumbar lordosis L1L3-L3L5 (7 vs 14°), associated with an increased range of motion (ROM) of the distal lordosis (15 vs 10°). ASD-Sag had an increased sagittal pelvis ROM (11 vs 8°) and knee flexion ROM (77 vs 87°). They also showed a lack of ankle dorsiflexion (19 vs 24°) and an increased external foot rotation (-14 vs -12°, all p<0.05). Similar patterns were shown while descending the stair step. ASD-HyperTK

and ASD-Front had almost similar patterns to controls. The physical component of the SF-36 was negatively correlated to thorax flexion (r=-0.5) and ODI was positively correlated to distal lordosis ROM (r=0.4,fig.1).

Conclusion
When climbing the stair step, ASD with sagittal malalignment were unable to adapt their proximal lumbar lordosis, therefore they recruited their distal lordosis in order to ensure the forward shift of their body center. They showed a decreased knee mobility and a lack of dorsiflexion, making them more prone to trips and falls. They had to rotate their foot externally to increase their stability. These kinematic alterations were related to their deteriorated QOL outcomes.

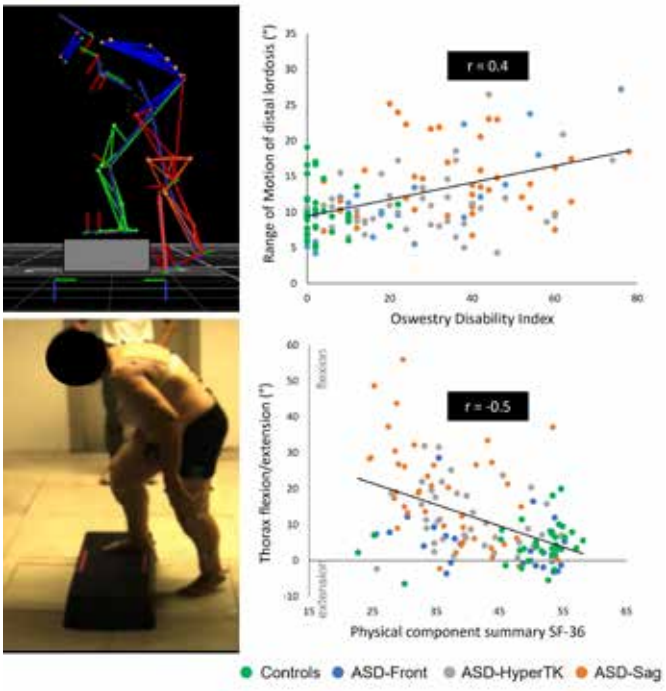


Fig.1: Correlations between altered kinematics and QOL outcomes during stair step climbing.

28. PERIOPERATIVE COMPLICATIONS IN ADULT SPINE DEFORMITY SURGERY: CLASSIFICATION AND PREVENTION STRATEGIES

Go Yoshida, MD, PhD; *Louis Boissiere, MD*; Sigurd H. Berven, MD; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); Yukihiro Matsuyama, MD, PhD

Hypothesis
Previous studies of perioperative complications of adult spinal deformity (ASD) surgery showed significant variability in complication rates, classifications, risk factors, and prevention strategies.Understanding the reasonable classification and prevention strategies are important to treat ASD patients.

Design
Narrative review

Introduction
We aimed to determine the best literature on classifications of, risk factors for, and prevention strategies for perioperative complications in spinal deformity surgery.

Methods
A literature search was conducted in the PubMed/MEDLINE database to identify studies reporting perioperative complications of spinal deformity surgery, their classifications, risk factors, and prevention strategies. Search terms included "perioperative complications", "Scoli-RISK-1", and "adult spinal deformity". The Scoli-RISK-1 study was a multicenter prospective study organized and conducted via the AO Spine Knowledge Forum platform to assess surgical outcomes of spinal deformity surgery.

Results
The overall perioperative complication rate ranged from 12.8% to 52.2%. Reporting of patient- and procedure-related complications in previous studies varied by time (within 30 days, 6 weeks, 2 months, or 3 months after surgery), types (medical vs. surgical, neurologic vs. non-neurologic), or severity (minor vs. major). Risk factors for perioperative medical complications included age, body mass index, osteoporosis, frailty, comorbidities, preoperative medication, smoking habit, alcohol intake, etc. Perioperative surgical complications mostly depend on procedure-related factors. The Spine Adverse Events Severity System (SAVES) or ISSG-AO classification system had potential impact of preoperative planning, intervention severity on costs and outcomes or patients counseling. Taking reference from the Clavien-Dindo classification of surgical complications, the AO Spine Deformity Knowledge Forum developed a classification for complications of spinal deformity surgery via a Delphi exercise.

Conclusion
Classification of perioperative complication is important for understanding the impact of complications on patients. Further research should aim to determine the correlation between the new complication classification and patient outcomes in spinal deformity surgery. Various pre-, intra-, and postoperative strategies should be implemented to prevent perioperative complications.

29. THE ISSG-AO COMPLICATION INTERVENTION SCORE, BUT NOT MAJOR/MINOR DESIGNATION, IS CORRELATED WITH LENGTH OF STAY

Joseph Wick, MD; Andrew Blandino, PhD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Han Jo Kim, MD; Peter G. Passias, MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton, FAANS; Michael P. Kelly, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; *Eric O. Klineberg, MD*; International Spine Study Group

Hypothesis
The International Spine Study Group-AO (ISSG-AO) Adult Spinal Deformity (ASD) complication classification system has improved correlation with hospital length of stay (LOS) and discharge disposition than the major/minor classification system.

PODIUM PRESENTATION ABSTRACTS

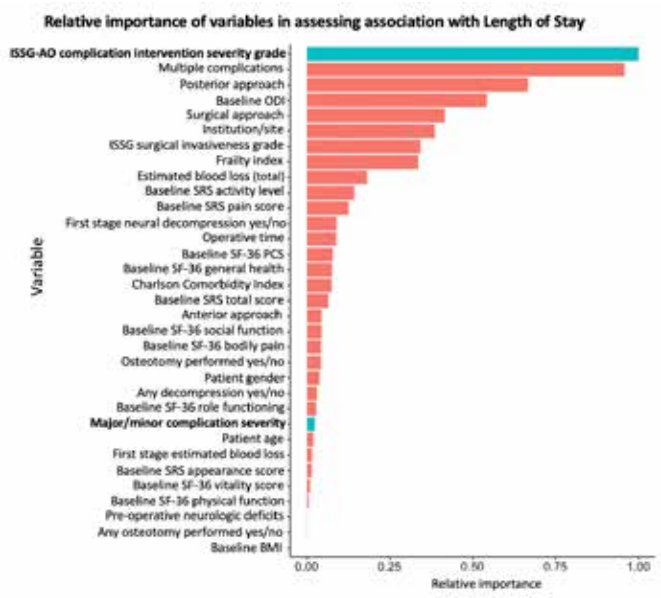
Design
Retrospective

Introduction
ASD surgical complications are often classified as major or minor. In contrast, the ISSG-AO system's granular description of ASD complications includes classification of interventions to address complications by level of invasiveness: grade 0 (none); grade 1, mild (eg medication change); grade 2, moderate (eg ICU admission); grade 3, severe (reoperation).

Methods
Patients age ≥18 in the multicenter ISSG database with in-hospital complications following ASD surgery were identified. Complications were classified with the major/minor and ISSG-AO systems, and correlated with LOS and discharge disposition. If multiple complications occurred, analyses were based on the most severe complication. To adjust for multiple confounders, an ensemble-based machine learning algorithm (conditional random forest) was utilized to identify relative importance of variables in association with LOS and discharge disposition.

Results
490 patients (73.6% female, median age 64.8) at 19 sites were included; 218 had discharge disposition data. 64.9% of complications were major, and 35.1% were minor. By ISSG-AO classification, 20.4%, 66.1%, 6.7%, and 6.7% were grades 0-3, respectively. Complication severity classified by the ISSG-AO system correlated significantly with LOS (p= 3.4e-6); major/minor classification did not correlate with LOS. In conditional random forest analysis, ISSG-AO classification had the greatest relative importance when assessing correlation across multiple variables with LOS. Discharge disposition was analyzed separately due to limited number of patients with disposition data. Neither classification system correlated with discharge disposition.

Conclusion
The ISSG-AO system may identify specific complications associated with prolonged LOS. Targeted interventions to avoid or reduce these complications may improve ASD surgical quality.



Conditional random forest analysis bar chart. Bars demonstrate covariates' relative importance in association with LOS, including ISSG-AO and major/minor complication classification.

30. EVALUATION OF ABBREVIATED ADULT SPINAL DEFORMITY SURGICAL ADVERSE EVENT PREDICTION TOOLS IN ADULT SYMPTOMATIC LUMBAR SCOLIOSIS

James Wondra, BS; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christopher P. Ames, MD; Ferran Pellisé, MD, PhD; Alba Vila-Casademunt, MS; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Jacob Greenberg, BS; Lawrence G. Lenke, MD; Keith H. Bridwell, MD

Hypothesis
ASD prediction models for major complication, readmission, and reoperation will perform better than chance in a cohort of adult symptomatic lumbar scoliosis (ASLS) patients.

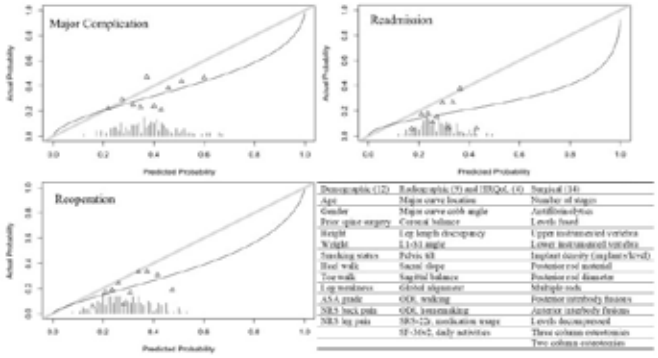
Design
Retrospective cohort

Introduction
Prediction models estimating the probability of major complication(MC), readmission(RA), and reoperation(RO) were created for ASD using a combined ISSG-ESSG cohort. Abbreviated models were created to minimize the data-burden while maintaining prediction accuracy. We evaluated these models in surgical patients from the prospective ASLS-1 study.

Methods
Patient data were obtained for operative patients from the ASLS-1 trial with a minimum of 2yr follow-up. 39 predictive factors (12 demographic, 9 radiographic, 4 HRQOL, 14 surgical, FIGURE) were retrieved and entered into web-based prediction models for MC/RA/RO. Calculated probabilities were compared with actual event rates. Discrimination and calibration were analyzed using receiver operative characteristic area under the curve (ROC/AUC where 0.5=chance, 1=perfect) and calibration curves(Brier scores, were 0.25=chance, 0-perfect). 95% confidence intervals are reported.

Results
169 of 187 (90%) surgical patients completed 2-year follow up(90% F, Means: age 59.7yrs, C7SVA +28mm, 11 levels fused, lumbar Cobb 55 degrees, EBL 2206mL) . The observed rate of major complications was 41.4% with model predictions ranging from 13%-68% (mean 38.7%). Reoperation was 20.7% with model predictions ranging from 9%-54% (mean 30.1%). Hospital readmission was 17.2% with model predictions ranging from 13%-50% (mean 28.5%). Model classification for all three outcome measures was better than chance for all (AUC = MC 0.6 (0.5-0.7), RA 0.6(0.5-0.7), RO 0.6(0.5-0.7)). Calibration was better than chance for all, though best for RA and RO (Brier Score = MC 0.22, RA 0.16, RO 0.17). The models tended to overestimate the probability of MC, RA, RO (FIGURE)

Conclusion
ASD prediction models for major complication, readmission, and reoperation performed better than chance in a cohort of adult lumbar scoliosis patients, though the homogeneity of ASLS inclusion criteria affected calibration and accuracy. Model optimization require samples with the breadth of outcomes (0-100%), supporting the need for homogenous and heterogenous cohorts like ASLS and ISSG-ESSG. Personalized prediction models may improve decision-making for the patient and surgeon alike.



31. A ROUGH ROAD TO RECOVERY: THE IMPACT OF COMPLICATIONS AFTER ADULT SPINAL DEFORMITY SURGERY ON SPECIFIC HEALTH RELATED QUALITY OF LIFE DOMAINS

Breton G. Line, BS; Shay Bess, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Jeffrey L. Gum, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Alan H. Daniels, MD; Munish C. Gupta, MD; D. Kojo Hamilton, FAANS; Michael P. Kelly, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Eric O. Klineberg, MD; International Spine Study Group

Hypothesis
Postoperative complications requiring surgery will negatively impact specific health domains.

Design
Retrospective review of prospective multicenter ASD study.

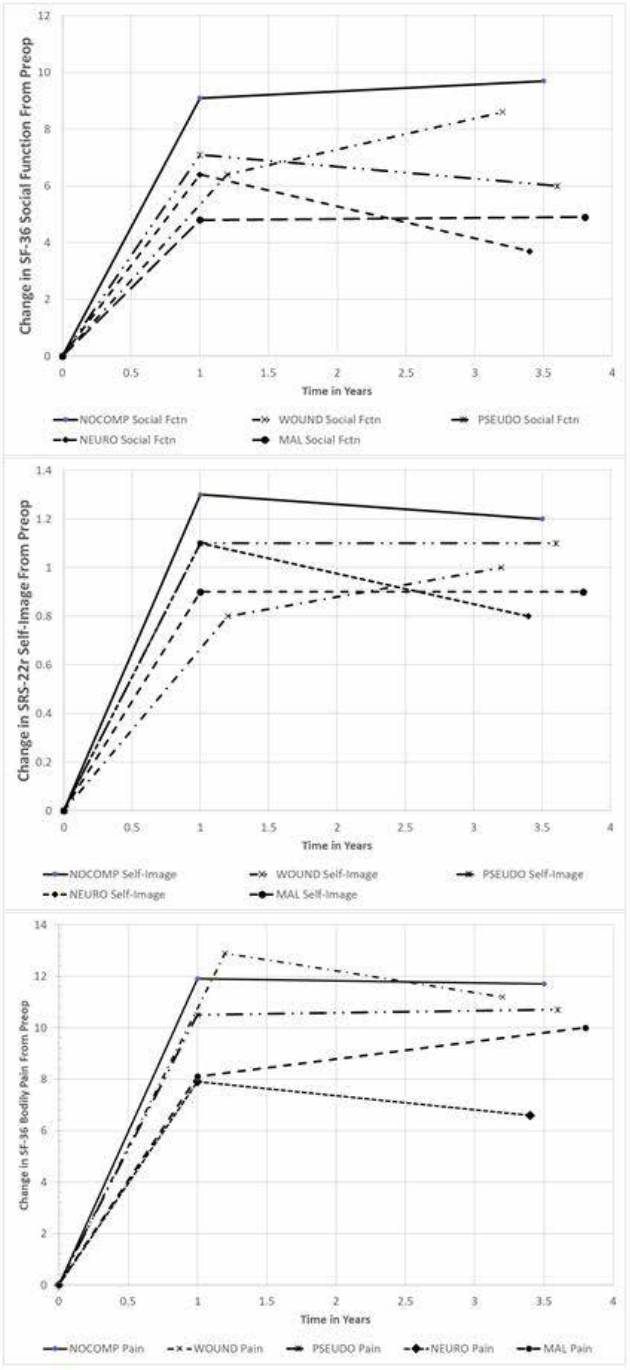
Introduction
Previous reports indicate postoperative complications have minimal impact on long-term outcomes after ASD surgery. Little data has evaluated the impact of complications on specific heath domains during postoperative period. Study purpose is to evaluate the impact of specific complications on patient reported health domains compared to patients with no complications.

Methods
Surgically treated ASD patients enrolled into a multi-center study were assessed for postop complications requiring surgery including wound (WOUND), pseudoarthrosis (PSEUDO), neurologic (NEURO), and malalignment (MAL) and matched to patients with no complications (NOCOMP) using inverse probability weighting for demographic, radiographic and surgical variables. Health domains for SRS-22r, and SF-36 were evaluated at regular time intervals, domain scores normalized to the date of revision surgery, and compared to patients with no complications at minimum 2-year follow-up.

Results
566 of 1130 ASD patients, mean follow-up 3.6 years, were evaluated. WOUND (n=12) had worse SF36 general health, physical function, social function, and vitality domains compared to NOCOMP (n=390; $p<0.05$). PSEUDO (n=64) had worse SRS-22r physical function and SF-36 social function than NOCOMP ($p<0.05$). NEURO (n=28) had worse SRS-22r function, SF-36 bodily pain and social function than NOCOMP ($p<0.05$). MAL (n=72) had worse SRS-22r pain, function, and self-image and worse SF-36 bodily pain, physical and social function than NOCOMP ($p<0.05$).

Conclusion
Counter to previous reports, postoperative complications requiring surgery uniquely impact specific health domains compared to ASD patients with no complications. Social function was negatively impacted for all complications, while wound complications negatively impacted patient perceived vitality and patients with malalignment requiring surgery reported worse self-image. These data highlight new findings that postoperative complications have a negative impact on specific aspects of ASD quality of life that can undermine the potential benefits of ASD surgery.

PODIUM PRESENTATION ABSTRACTS



32. IN ADULT SPINAL DEFORMITY SURGERY, ARE ALL MECHANICAL COMPLICATIONS CREATED EQUALLY?

Hani Chanbour, MD; Steven G. Roth, MD; Matthew E. LaBarge, BS; Jeffrey M. Hills, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; *Scott Zuckerman, MD*

Hypothesis

In adult spinal deformity (ASD) surgery, although mechanical complications are often regarded as a single entity, significant intergroup differences exist among each type.

Design

Retrospective case-control study

Introduction

Though mechanical complications after ASD surgery have been well studied, less is known regarding when and how each type of mechanical complication occurs. We sought to: a) describe the time course of each mechanical complication, and b) compare each mechanical complication type with regards to radiographic measurements, and preoperative patient-reported outcomes (PROs).

Methods

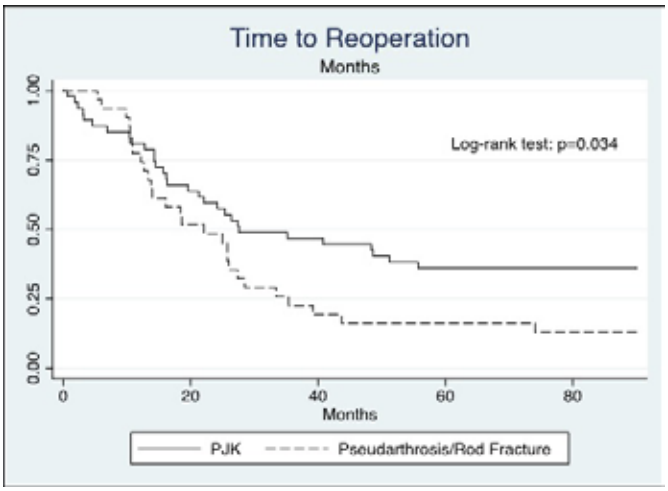
A single-institution case-control study was undertaken of patients undergoing ASD surgery from 2009-17. Exposure variables included patient demographics, operative variables, radiographic measurements, and preoperative PROs, including ODI, NRS-Back/Leg, and EQ-5D. The primary outcomes were occurrence of a mechanical complication and time to complication. Due to overlapping occurrence, rod fracture and pseudarthrosis were grouped into one category.

Results

145 patients underwent ASD surgery, all with 2-year follow-up. 30(63.8%) patients with proximal junctional kyphosis (PJK) required reoperation at a median of 16.3 months, and 27(87.1%) patients with pseudarthrosis/rod fracture underwent reoperation at a median of 18.4 months. Time to reoperation significantly differed between the two groups (log-rank test;p=0.034). Distal junctional kyphosis (DJK) (N=3; 2 reoperation) and implant-failures (N=4; 0 reoperations) were rare. Patients with PJK had significantly lower Hounsfield Units preoperatively compared to those with pseudarthrosis/rod fracture (138.2±43.8 vs 160.3±41.0,p=0.038), more prior fusions (51.1% vs 25.8%,p=0.026), fewer instrumented vertebrae (9.2±2.6 vs 10.7±2.5,p=0.013), higher postoperative thoracic kyphosis (46.3±12.7 vs 34.9±10.6,p<0.001), and higher spine sagittal alignment (SVA) (80.7±72.1 vs 51.9±57.3,p=0.081). No differences were seen in preoperative PROs.

Conclusion

Patients with pseudarthrosis/rod fracture had higher rate of reoperation compared to patients with PJK, though patients with PJK required reoperation slightly sooner. The results of this single-institution, pilot study suggest that even though mechanical complications are often analyzed as a single group, important differences may exist between them.



Graphical display of Log-rank test of time to reoperation in PJK and Pseudarthrosis/Rod fracture

33. TIME-DEPENDENT INTERPRETATION OF MECHANICAL COMPLICATIONS USING COX REGRESSION AND SURVIVAL ANALYSIS

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Hypothesis
Risk assessment for mechanical complications should be time-dependent

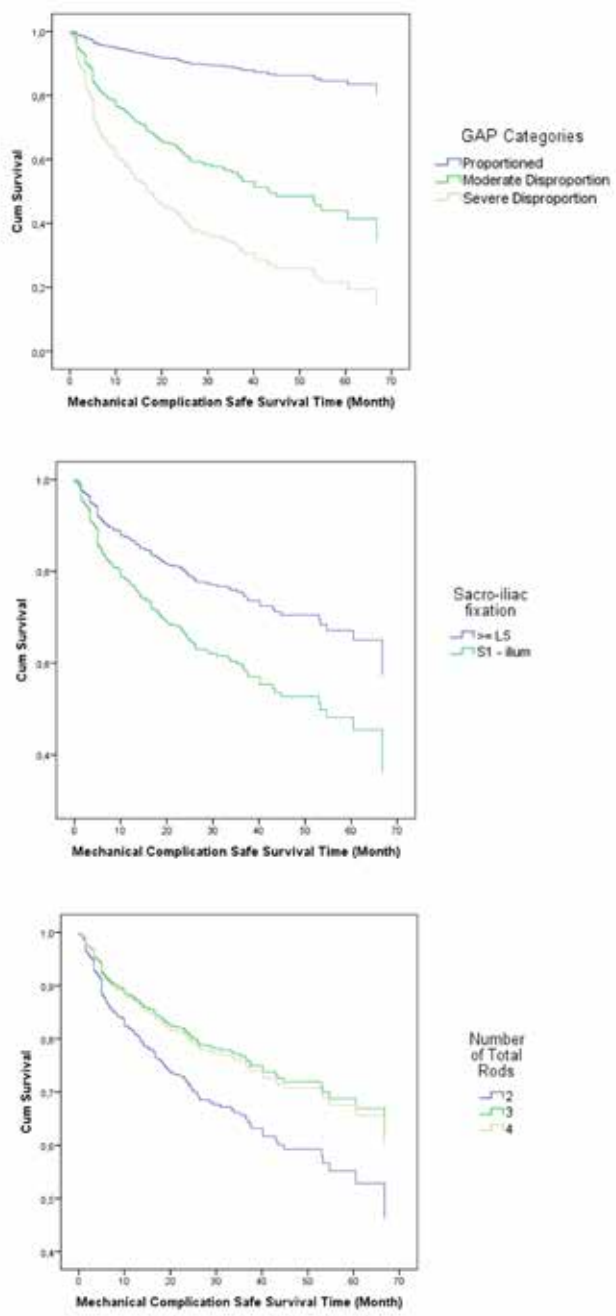
Design
Retrospective analysis of prospectively collected data

Introduction
Risk factors associated with mechanical complications after ASD surgery are multifactorial and plentiful (>60 have been suggested). Duration of follow-up emerges to be one of the most important determinants. Thus, factors affecting the occurrence and timing of mechanical complications should be assessed together in multifactorial Cox regression and survival models.

Methods
Patients having ≥4-levels of posterior spinal fusion were included. Univariate tests included 66 factors derived from preoperative (25 history, demographic, radiographic), operative (32 technique and implant-related data), and postoperative (9 radiographic) data. To avoid multicollinearity, correlations were assessed guided by clinical expertise. Multivariate Cox proportional hazards models were created to estimate survival time probabilities and predict independent factors affecting the occurrence and timing of mechanical complications.

Results
697 patients (551F, 146M, 53±19 years) with a mean follow-up of 29.5 (1.5-94) months were included. 29 factors were identified as significant and near significant ($p<0.25$), and were included in multivariate analysis. Sagittal plane reconstruction quantified by the postoperative GAP Score, sacroiliac fixation, age, postoperative T10-L2 sagittal angle, the number of levels fused and the number of rods were most important factors. Moderately and severely disproportioned states displayed 4.9 (95% CI 3.1-7.8) and 8.7(95% CI 5.4-14), times higher Hazards Ratios, respectively ($p<0.001$). Patients with sacroiliac fixation experienced 1.8 greater odds of incurring a mechanical complication compared to thoracolumbar fusions ($p=0.01$). Rates of mechanical complications increased as age ($p=0.004$), the number of levels fused ($p=0.002$) and postoperative T10-L2 sagittal angle ($p=0.009$) increases. Using double-rod constructs decreased the likelihood of incurring a mechanical complication ($p=0.029$).

Conclusion
The postoperative GAP Score, sacroiliac fixation, age, postoperative T10-L2 sagittal angle, the number of levels fused and the number of rods were the most important factors affecting both the occurrence and timing of mechanical complications after adult spinal deformity surgery.



34. PROXIMAL JUNCTIONAL KYPHOSIS IS A COMPENSATION FOR POST-OPERATIVE NEGATIVE C2-FH IN ASD PATIENTS: A CROSS-SECTIONAL STUDY

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Hypothesis
the thoracic spine may compensate with PJK when the immediate post-operative C2-FH was not ideally restored in adult spinal deformity (ASD).

Design
a cross-sectional study

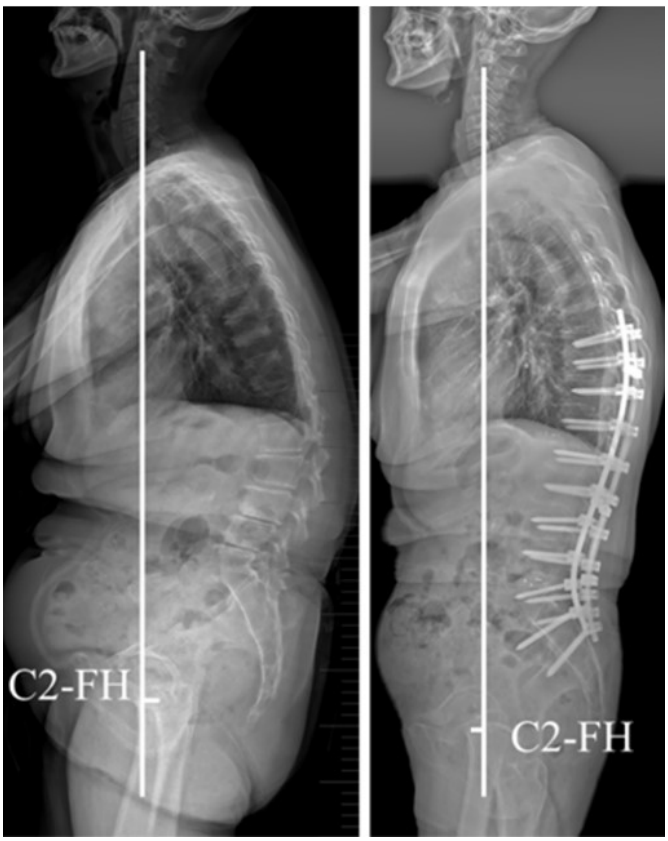
Introduction
Recently, the global sagittal alignment parameter C2-FH

(defined as the distance between the femoral heads to the C2 vertical line) was found to be constant in both sitting and standing positions for asymptomatic individuals. Thus, the consistent C2-FH may be used as a surgical target for the sagittal restoration of ASD.

Methods
The inclusion criteria were as follows: ASD patients over 45 years old; Cobb angle >30°; with posterior spinal correction surgery; at least 2 years follow-up. C2-FH was defined as the distance between the femoral heads to the C2 vertical line. All participants were divided into two groups according to the occurrence of PJK at the last follow-up: PJK group and non-PJK group.

Results
68 ASD patients, with a minimum follow-up of 2.5 years, were included. PJK was found in 24 patients (35.3%) while the rest 44 patients remained no sagittal malalignment. Immediately post-operative C2-FH showed significant difference between PJK group and non-PJK group (p= 0.015). However, at the last follow-up, C2-FH showed no significant difference between PJK and non-PJK group and the mean value of C2-FH in both groups was approximately -1cm, indicating that ASD patients could develop various compensatory mechanisms to maintain sagittal global balance. The AUC was 0.84 (95%CI: 0.68 to 0.97), indicating the well effectiveness of ROC curve and cut-off value in predicting occurrence of PJK in ASD patients. Based on the ROC curve, the optimal cut-off value of C2-FH as indicators for occurrence of PJK was – 42.3mm.

Conclusion
Immediate postoperative negative global malalignment (C2-FH<-42.3mm) may predict proximal junctional kyphosis in ASD patients. The normal value of C2-FH, -1cm, may be the target of global sagittal compensation, and PJK is a compensatory mechanism.



C2-FH is defined as the distance between the femoral heads to the C2 vertical line.

35. THE INFLUENCE OF LIGAMENT BIOMECHANICS ON PROXIMAL JUNCTIONAL ANGLE AND FAILURE IN PATIENTS WITH ADULT SPINAL DEFORMITY

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Hypothesis
Ligament biomechanical properties will be associated with Proximal Junctional Kyphosis (PJK) and failure (PJF).

Design
A prospective observational study

Introduction
It is unknown whether the biomechanics of the posterior ligamentous complex (PLC) are impaired in individuals undergoing surgery for adult spinal deformity (ASD). Characterizing these properties may improve our understanding of PJK (defined as proximal junctional angle (PJA) of >10deg from UIV-1 to UIV+2), as well as PJF (symptomatic PJK requiring revision).

Methods
Intraoperative biopsies of PLC were obtained from 32 consecutive spinal fusions for ASD (>4 levels). Ligament peak force, tensile stress, tensile strain, and elastic modulus (EM) were measured with a materials testing system. Biomechanical properties and tissue dimensions were correlated with age, gender, BMI, vitamin D level, osteoporosis, sagittal alignment, PJA and change in PJA preoperatively (PRE), within 3 months (3MO), and at 1 year (1YR) post-op.

Results
Mean(SD) PLC peak force was 207.8(100.6)N, tensile stress was 3.3(1.5) MPa, tensile strain was 1.9(1.2) mm/mm, and EM was 7.1(5.1) MPa. Mean PLC length was 5.9(2.6) mm, thickness was 3.8(1.5) mm, and width was 17.7(4.7) mm. Longer and thinner ligaments were associated with greater PJA change at 3MO (r=0.38, p=0.04; r=0.34, p=0.08 respectively), and thinner ligaments were associated with greater PJA change at 1YR (r=0.57, p=0.01). Greater EM was associated with greater 3MO (r=0.43, p=0.03) and 1YR (r=0.54, p=0.03) PJA. Age was associated with 3MO PJA (r=0.41, p=0.03). EM remained related to PJA when correcting for age (p=0.01). 5 had change in PJA of >10 from PRE to 1YR while PJA change from 3MO to 1YR was 0.6(3.6). EM was significantly higher in individuals who required revision surgery within 1YR (16.2 (9.7) MPa) versus those who did not (6.5(3.6) MPa, p=0.003; Figure). Neither PRE sagittal alignment nor 3MO change was related to change in PJA or need for revision surgery(p>0.10). At 1YR, 3 had PJF (2 for PJK, 1 discitis).

Conclusion
Biomechanical properties of the PLC may be associated with higher risk for proximal failure. Ligaments that are longer, thinner and less elastic are associated with higher postoperative PJA. Furthermore stiffer EM of the ligament is associated with the need for revision surgery.

Table:

Mean(SD)	Pre-op	3-months	1 year
PJA (Deg)	8.4 (7.8)	14.6 (11.0)	13.7 (10.3)
SVA (mm)	58.7 (56.3)	19.7 (32.6)	9.7 (29.6)
PT (deg)	24.9 (10.8)	21.9 (8.4)	20.5 (7.7)
PI (deg)	54.6 (14.9)	57.1 (13.8)	45.1 (41.2)
LL (deg)	-30.2 (27.1)	-47.4 (20.9)	-49.2 (15.3)
PI-LL mismatch	13.5 (34.9)	7.1 (10.6)	-3.1 (38.8)

Table

36. DOES THE USE OF POSTOPERATIVE BRACE PLAY A PROTECTIVE ROLE FOLLOWING ADULT DEFORMITY SURGERY?

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Hypothesis
Braces used postoperatively after adult deformity surgery (ADS) protect from early (≤2 years) mechanical complications and reinterventions

Design
Matched cohort study

Introduction
There is a high prevalence of mechanical complications and reinterventions after ADS. We wondered if postoperative braces could help decrease these events from happening.

Methods
From a prospective adult deformity multicenter database, we selected operated patients, fused to the pelvis, with more than 6 instrumented levels, and 2 years of follow-up. 380 patients were separated into two groups (Brace -3 months full-time TLSO- vs NoBrace) and then matched according to age, gender, and frailty. We studied demographic, intraoperative, preoperative and postoperative spinopelvic parameters (RSA, RPV, RLL, LDI). Both groups were compared regarding complications and reinterventions in the first 2 postoperative years, using univariate and multivariate analysis.

Results
We analyzed 359 patients, with a mean age of 65.3±8.9 years, frailty index (0.43±0.15), mostly females (84%). 224 patients wore a postoperative brace (B) and 135 did not (NB). Both groups were homogeneous regarding the set matched variables (age, gender, frailty). They showed no difference in: surgical approach, the number of instrumented levels, implant density, interbody fusion, number and type of osteotomies, and postoperative spinopelvic alignment. They differed (P<0.05) in: Pelvic incidence -PI (B:58°±13 vs NB:54.5°±13), BMI (B:25.8±4 vs NB:27.4±5), upper instrumented vertebra -UIV (B:81.7% T8-L1 the rest T2-T7 vs NB:76% T8-L1), and the use of multiple rods (B:47.3% vs NB:18.5%). Univariate analysis showed a higher rate of mechanical complications (B:27.2% vs NB:39.8%; P=0.014) and reinterventions (B:17.4% vs NB:26.7%; P=0.037) when not using a brace. Bracing had a tendency to delay the onset of complications (B:625d vs NB:471d; P=0.059). However, multivariate analysis selected the use of multiple rods as that the only independent factor protecting against mechanical complications (OR:0.38; CI95%:0.22-0.64) and reinterventions (OR:0.41; CI95%:0.216-0.783) at 2 years follow-up.

Conclusion
The use of postoperative braces contributed to preventing mechanical complications and reinterventions in the first two years, when combined with other measures. However, it did not show a predominant role on its own.

PODIUM PRESENTATION ABSTRACTS

	Brace	No brace	P	Test
Number	224	135		Student-t
Demographic				
Age (yrs)	65.9±8.5	64±9.6	0.118	M-Whitney U
Frailty Index	0.42 ± 0.14	0.45±0.16	0.102	Student-t
Gender	82.1% F	86.7% F	0.259	Chi2
BMI	25.8±4	27.4±5	**0.001***	Student-t
Radiographic				
Pelvic Incidence (°)	58.1±13.1	54.5±13	**0.013***	Student-t
Postop RPV (°)	-7.3±7.1	-7.8±7.5	0.57	Student-t
Postop RSA (°)	11.8±9	11.4±10	0.66	Student-t
Postop RLL (°)	-11.4±10.9	-11.8±12.4	0.76	Student-t
Postop LDI (%)	0.77±0.25	0.74±0.22	0.43	Student-t
Intraoperative				
Surgical approach	91.1% Posterior 8.9% Double	86.7% Posterior 13.3% Double	0.106	Chi2
Levels fused	10.8±3.3	11±3.5	0.857	M-Whitney U
Implant density	1.79±0.28	1.76±0.25	0.078	M-Whitney U
Interbody fusion	67.4% yes	58.5% yes	0.089	Chi2
Osteotomies	66.5% yes	68.9% yes	0.642	Chi2
Type of osteotomy	75% 2CO 25% 3CO	75.6% 2CO 24.4% 3CO	0.986	Chi2
UIV	81.7% T9-L1 18.3% T2-T7	72.6% T9-L1 27.4% T2-T7	**0.043***	Chi2
Number of Rods	52.7% 2-rods 47.3% multiple	81.5% 2-rods 18.5% multiple	**0.000***	Chi2
2-yr Adverse Events				
Mechanical complications	27.2% yes	39.8% yes	**0.014***	Chi2
Reinterventions	17.4% yes	26.7% yes	**0.037***	Chi2
Days till complication	625.9±591	471.8±380.5	0.059	Chi2
Type of complication				
Screw failure	8.6%	13.2%	0.739	Chi2
Rod breakage	41.4%	39.6%		
PJK	50%	47.2%		

RPV: relative pelvic version ; RSA: relative sagittal alignment ; RLL: relative lumbar lordosis ; LDI: lumbar distribution index; UIV: upper instrumented vertebra.

Table 1. Comparison between the use of postoperative Brace vs No Brace

37. LOWER HOUNSFIELD UNITS AND SEVERE MULTIFIDUS SARCOPENIA ARE INDEPENDENT PREDICTORS OF INCREASED RISK FOR PROXIMAL JUNCTIONAL KYPHOSIS AND FAILURE FOLLOWING THORACOLUMBAR FUSION

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Hypothesis
Lower Hounsfield units (HU) at upper instrumented vertebra (UIV) and severe multifidus sarcopenia will be independent predictors of an increased risk of proximal junctional kyphosis (PJK) and proximal junctional failure (PJF).

Design
Retrospective cohort study

Introduction
The purpose of the present study was to determine demographic and radiographic variables that predict an increased risk of PJK or PJF following thoracolumbar fusion.

Methods
We retrospectively reviewed a cohort of patients greater than 50 years of age who underwent posterior instrumented fusion with pelvic fixation and a construct that terminated proximally between T10 to L2 between the years 2013-2020 and had at least 2 years of postoperative follow-up. Patients were subdivided into three groups: (1) no PJK or PJF, (2) PJK without PJF, and (3) PJF. These subgroups were then compared based upon demographics, preoperative and 1-year postoperative sagittal alignment parameters, bone mineral density (BMD), and paraspinal sarcopenia. We utilized student's T-test and ANOVA to compare means within and between groups, respectively. Multivariable analyses were performed to determine risk factors for PJK and PJF. P values <0.05 were considered significant.

Results
We identified 150 patients for inclusion in this study with a mean age of 67.0 years and an average follow-up of 32 months. The subgroup of patients with no PJK/PJF demonstrated a significantly higher HU at the UIV (148.3±34.5) than patients who developed PJK (117.8 ±41.9) or PJF (118.8 ±41.8; P<0.001). There was a much higher rate of severe multifidus fatty infiltration observed in patients who developed PJF (78.9%) or PJK (76.0%) than in patients who did not develop PJK/PJF (34.0%; P<0.001). Furthermore, no patient that developed PJK or PJF had normal multifidus quality. Multivariate analysis identified both mean UIV HU (0.80, 95% CI 0.69-0.93; P<0.001) and moderate-severe multifidus sarcopenia (5.40, 95% CI 1.8-16.1; P<0.001) as independent predictors of increased risk of PJK and PJF.

Conclusion
Patients with lower mean HU at the UIV and a higher degree of multifidus fatty infiltration are at increased risk of PJK and PJF following thoracolumbar fusions that terminate proximally between T10 and L2.

38. HOUNDSFIELD UNITS THRESHOLDS ARE ASSOCIATED WITH PJK, MAJOR INTRAOPERATIVE BLOOD LOSS, AND IMPLANT COMPLICATIONS AFTER ASD SURGERY

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Hypothesis
Houndsfield Units below thresholds on spinal CT are predictive of increased complications following surgery for Adult Spinal Deformity (ASD)

Design
Retrospective Analysis.

Introduction
As ASD prevalence increases in our ever-aging population there is a concomitant increase in poor bone quality. Additional diagnostic modalities such as a DEXA can add cost, delay diagnosis, and can be an additional insurance hurdle. Some studies suggest HU's can be utilized as a proxy for frailty, but it is unclear if this is useful in risk stratification. Our goal was to evaluate the relationship between bone health as measured by HU's and PJK, blood loss, and implant complications, and identify a HU threshold for each complication.

Methods

ASD patients who had Houndsfield Units (HU) measured in the spine were identified from a multicenter database. HU at L1, upper instrumented vertebrae (UIV), and total averages were assessed. Threshold linear regression with Bayesian information criteria was utilized to identify optimal cut-offs for predicting PJK within 2 years, high blood loss (>2100mL, top 25% by volume), or any implant complications within 90 days. Each complication was assessed with a separate multivariable logistic regression controlling for a priori known risk factors.

Results

Of 527 patients included, the mean age was 61±14. Mean L1 HU was 154.59±87, UIV HU was 175.1±304, and total average HU was 165±168. Threshold regression analysis identified that a cut-off of ≤140.33 was optimal for predicting high blood loss, ≤99.75 was optimal for predicting implant complications within 90 days of surgery, and ≤125 was optimal for predicting PJK within 2 years. On multivariable analysis, L1 HU less than 140 was associated with 1.57x higher odds of high blood loss (P=0.032). Total average HU less than 100 was associated with a 3.6x higher odds of having an implant related failure within 90 days of surgery (P=0.035). UIV HU less than 125 was associated with 2.78x higher odds of PJK within 2 years of surgery (P=0.01).

Conclusion

Bone health as measured by HU appears to be an independent predictor of PJK, high blood loss, and implant complications after ASD surgery. It also parallels frailty in prediction of PJK and can potentially be used as a proxy for frailty assessment. This can be easily measured and could help with risk stratification in the future.

Intraoperative Blood Loss	Total	HU>140	HU≤140	p-value
	N=527	N=270	N=257	
Major Blood Loss (>2100 mL)	**152 (28.9%)**	**66 (24.4%)**	**86 (33.6%)**	**0.021**
Blood Loss (mL)	**1746 (1537)**	**1604 (1289)**	**1896 (1751)**	**0.029**
Implant Complication before 90 days	Total	HU>100	HU≤100	p-value
	N=527	N=461	N=66	
Any Implant Complication	**14 (2.7%)**	**8 (1.7%)**	**6 (9.1%)**	**<0.001**
Interbody Dislocation	2 (0.4%)	2 (0.4%)	0 (0.0%)	0.59
Implant Loosening or Dislocation	3 (0.6%)	2 (0.4%)	1 (1.5%)	0.27
Prominence	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Rod Breakage	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Rod Dislocation	2 (0.4%)	1 (0.2%)	1 (1.5%)	0.11
Screw Breakage	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Screw Loosening	**3 (0.6%)**	**1 (0.2%)**	**2 (3.0%)**	**0.004**
Screw Medial Breach	6 (1.1%)	4 (0.9%)	2 (3.0%)	0.12
Screw Nerve Impingement	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Screw Vascular Impingement	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Proximal Junctional Kyphosis before 2 years	Odds ratio	P>|z|	CI Lower	CI Upper
HU of UIV < 125	**2.78**	**0.01**	**1.27**	**6.07**
Frailty Index > 0.31	**4.11**	**0.01**	**1.39**	**12.11**
> 63 years old	**4.76**	**0**	**1.69**	**13.38**
Female	**3.22**	**0.04**	**1.04**	**9.99**
Preop TK > 46 degrees	**3.9**	**0**	**1.57**	**9.67**
<10 levels fused	**3.46**	**0.03**	**1.14**	**10.51**
PJK Prophylaxis	0.72	0.44	0.31	1.68
Surgeon	0.99	0.71	0.95	1.04

39. ARE SUPPLEMENTAL-ROD CONSTRUCTS (SRCS) ASSOCIATED WITH INCREASED RATES OF PJK/PJF?

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Hypothesis

Increasing construct stiffness in ASD surgery with SRCs will increase PJK/PJF rates

Design

Retrospective review of prospective, multicenter ASD database

Introduction

The utilization of SRCs has become increasingly popular in ASD surgery. Increased construct stiffness, in theory, is more durable by reducing rod fracture and pseudoarthrosis. There is concern that these forces are translated more proximal increasing PJK/PJF.

Methods

Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with available baseline (BL), 2-year (2Y) radiographic, HRQOL data, and complete construct details were included. All pts had > 5 level fusion to S1/Pelvis. SRCs were defined as constructs with supplemental rods (Srod) spanning ≥3 levels to avoid inclusion of satellite rods. Pts were divided into SRC vs noSRC. Rod diameter, material, and UIV/LIV were determined for each Srod. Radiographic parameters and PJK/PJF rates were compared between each cohort.

Results

Of 1330 pts eligible, 997 (74.9%) had complete 2Y f/u. Of these, 488 meet inclusion criteria. The majority where female (78%) with a mean age of 64.2 yrs, 12.0 levels fused and 20% undergoing 3-CO. Mean EBL was 1763ml, 66% had an interbody fusion, and 63% a decompression. The proportion of pts with SRCs has increased over time with 168 (34%) pts total. Distally, the Srod crossed the Lumbar-Sacral junction (pelvis) 26.8% of the time, ended at

PODIUM PRESENTATION ABSTRACTS

S1 39.9%, L5 12.6%, and L4 9.3% of the time. Proximally, the Srod crossed the TL junction the majority of the time (56.3%) but was rarely above T8 (4.9%). CoChrome (CC) was the dominant (65%) material, followed by Ti (19.7%), and SS (14.8%) with 5.5mm the most common diameter (67.1%), followed by 6.35mm (21.7%), and 6.0mm (11.2%). Pts with SRCs had worse baseline LL-PI (26.3° vs 19.6°, p-0.000), PT (28.3° vs 25.4°, p-0.002), T1PA (29.6° vs 24.3°, p-0.000), and SVA (10.0 vs 6.9cm, p-0.000). There was no difference in PJK (45.8% vs 42%, p-0.431) or PJF (3.0% vs 3.0%, p-0.852) rates. Number of Srods, material, diameter, or UIV had no influence. The distance of Srod from UIV did not influence PJK/PJF rate.

Conclusion
SRCs are increasing in ASD surgery. This increased construct stiffness has a theoretical concern of increasing PJK/PJF rates. Despite pts with SRCs having worse baseline radiographic parameters the addition of Srods does not appear to independently increase the PJK/PJF risk.

40. IS HIGH-DOSE TRANEXAMIC SAFE IN SPINE SURGERY? A SYSTEMATIC REVIEW AND META-ANALYSIS

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Hypothesis
Compared to low-dose (LD) tranexamic acid or placebo, high-dose (HD) tranexamic acid is not associated with a greater risk of medical complication

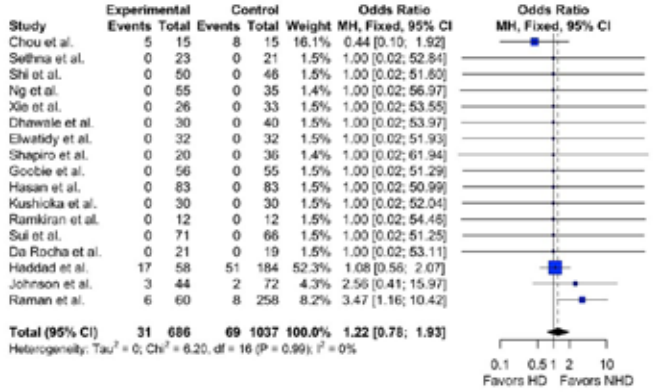
Design
Systematic review and meta-analysis

Introduction
If the risk of medical complication is similar, the justification to use HD TXA depends on whether it provides a clinically significant reduction in blood loss compared to LD. Single-center series may be underpowered to detect event rates or differences in outcomes.

Methods
The PubMed database was searched through December 2021 for studies in which HD TXA (defined as a loading dose ≥30 mg/kg or 2 g) was given intravenously before spine surgery. Pooled complication rates were calculated. Meta-analyses were performed for outcomes of interest reported by at least two comparative studies. Articles were evaluated for risk of bias and strength of evidence assessments were given for each conclusion.

Results
23 studies involving 2,331 patients were included, with a highest initial bolus of 100 mg/kg. The pooled medical complication rate were 3.2% (peds), 8.2% (adults). Using LD (any other TXA regimen) or placebo as the reference, meta-analysis showed no difference in medical complications (Figure 1) or VTE (n=1158, OR 1.27 [95% CI, 0.61 to 2.63]; p=0.528; I2=0%). No seizure occurred in any HD patient. Compared to LD, HD TXA was associated with fewer periop transfusions (n=505, OR 0.28 [95% CI, 0.082 to 0.96]; p=0.043; I2=76%) and a lower transfusion volume (n=434, WMD -228 mL [95% CI, -377 to -78.0]; p = 0.003; I2 = 0%). Effect sizes were greatest in populations with the largest blood loss.

Conclusion
Compared to LD TXA or placebo, there is strong evidence that HD is not associated with an increased risk of medical complications. Compared to LD, there is moderate evidence that HD reduces allogeneic transfusions. These conclusions only apply to similar patients to those in the reviewed studies (i.e. no hematologic, cardiac, or renal conditions). Future research should focus on procedures with large expected blood losses, aiming to determine the exact risk-benefit relationship in patients with various medical conditions and describe the in vivo pharmacokinetics of TXA during spine surgery.



Forest plot describing medical complications. To calculate odd ratios for zero-value cells, a Mantel-Haenszel test was performed. NHD; Not High Dose = LD or placebo.

41. NEW ONSET CENTRAL DIABETES INSIPIDUS (CDI) IN PEDIATRIC POSTERIOR SCOLIOSIS FUSIONS

Kyle Hardacker, MD; Doris M. Hardacker, MD

Hypothesis
Increasing the TXA dosage results in an increase in the incidence of CDI.

Design
Retrospective chart review

Introduction
CDI is a rare disorder characterized by renal excretion of large volumes of dilute urine, plasma volume contraction, hypernatremia and serum hyperosmolality. CDI occurs frequently after pituitary surgery and traumatic brain injury and has been rarely reported after significant spinal cord trauma. CDI occurring in pediatric surgery during spinal fusion has only been sporadically reported and to date there is only one reported case of CDI with a documented suppressed vasopressin level that developed during spine fusion for idiopathic scoliosis in a pediatric patient. CDI presenting during anesthesia has been related to medications commonly used in anesthesia such as propofol, dexmedetomidine, sevoflurane, ketamine and opioids. Our scoliosis surgery protocol uses total intravenous anesthesia (TIVA) with infusions of remifentanil, propofol, ketamine and tranexamic acid (TXA) (loading dose 10 mg/kg, maintenance at 1 mg/kg/hour, later increased to 5 mg/

kg/hour). Since increasing the TXA dosing, there have been several cases of intraoperative CDI marked by sudden development of polyuria. We did not have any documented cases of CDI prior to TXA use or at the lower dose of 1mg/kg/hour.

Methods
Retrospective review of posterior scoliosis surgery cases performed by three different surgeons between March, 2012 and November, 2017.

Results
9 cases out of 599 PSFs were diagnosed with intraoperative CDI. 5/9 of these curves were idiopathic and females predominated. Mean urine output prior to TXA infusion was 1.1 ml/kg/hour and increased to 4.2 ml/kg/hour within 1-3.5 hours of the start of TXA infusion. Concomitantly, plasma sodium increased from 137 ± 3.2 mEq/L to 142 ± 3.5 mEq/L. All responded to vasopressin infusion with TXA continuation or cessation of TXA alone. No cases of postoperative CDI were seen. Group 1 (TXA at 1 mg/kg/hr) had 0/363 cases. Group 2 (TXA at 2-5mg/kg/hr) had 9/236 cases. A Fisher's exact test for comparing the Group 1 Rate (0%) vs. Group 2 Rate (3.8%) had a significant p-value of <0.001.

Conclusion
This is the first reported series of intraoperative CDI development in pediatric deformity surgery utilizing TXA infusion. The evidence suggests a dose-dependent association between TXA and CDI. Recognition and treatment of this complication is paramount.

42. COMPLEX ASD PATIENTS RECEIVING HIGH-DOSE TXA HAVE SIGNIFICANTLY LOWER BLOOD LOSS COMPARED TO LOW-DOSE TXA WITHOUT INCREASED THROMBOEMBOLIC COMPLICATIONS

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Hypothesis
Complex ASD patients who Receive High-dose TXA will have decreased blood loss compared to those who receive low-dose TXA

Design
Retrospective Review

Introduction
Tranexamic acid (TXA) is commonly used to lower blood loss in ASD surgery. Despite widespread use of TXA in ASD surgery, there is a lack of consensus regarding the optimal dosing intraoperatively.

Methods
265 ASD patients in a multi-center prospective study were retrospectively analyzed. Patients were separated into three cohorts by TXA regimen: 1) low-dose patients had ≤20mg/kg loading dose with ≤2mg/kg/hr maintenance dose 2) medium-dose patients had 20-50 mg/kg loading dose with 2-5 mg/kg/hr maintenance dose. 3) high-dose patients had ≥50mg/kg loading dose with ≥5mg/kg/hr maintenance dose. Major or minor blood loss was defined as above or below the 90th percentile of our cohort respectively. Multivariable analysis controlled for levels fused, BMI, platelets, Hgb, OR time, 3CO, and radiographic alignment.

Results
54 (20%) patients received low-dose regimen, 133 (50%) received medium-dose and 80 (30%) received high dose. Mean blood loss was 1,551±1,295 ml, intraoperative units RBCs 1.52±2, and perioperative units RBCs 2.3±2.3. Mean major blood loss was 4,566±1,516ml and minor blood loss 1,236±755ml. Compared to the low-dose group, patients in the high-dose group had 77.8% decreased odds of major blood loss (OR 0.222; P=0.007), decreased blood loss (Coef. -540.92ml; P=0.019), units transfused intraoperatively (Coef. -.739 units; P<0.001), and units transfused perioperatively (Coef. -0.328 units; P=0.025). Compared to medium-dose group, the high-dose group had less units transfused intraoperatively (Coef. -.59 units; P<0.001) and perioperatively (Coef. -.42 units; P<0.001) with no difference in blood loss. There was no difference between the medium and low dose groups in blood loss or units transfused. There was no association between high-dose TXA regimen and increased rates of DVT, PE, or any medical complication before six weeks. No patients had a seizure.

Conclusion
In this multicenter prospectively collected database, ASD patients receiving high-dose intraoperative TXA have decreased odds of major blood loss, less RBC transfusions intraoperatively, and 540ml less blood loss compared to low dose TXA, without additional risk of seizure or thromboembolic complications.

PODIUM PRESENTATION ABSTRACTS

43. A MODIFIED ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOL IN PERIOPERATIVE CARE OF ADOLESCENTS IDIOPATHIC SCOLIOSIS (AIS)

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Hypothesis
We hypothesize that our modified ERAS protocol will lead to reduced length of stay, pain perception, and opioid consumption in AIS patient with posterior spinal fusion (PSF).

Design
Retrospective cohort study.

Introduction
ERAS is an approach for standardization of perioperative care aimed at improving patient outcomes. The aim of this study is to determine if Length of Stay (LOS) differed by protocol type (ERAS vs. non-ERAS [N-ERAS]) in patients undergoing surgery for AIS. The secondary objectives were to assess differences in pain intensity and opioid consumption by protocol type over time, and to identify predictors of LOS.

Methods
Patient characteristics were compared between groups using independent t-tests and chi square tests. Differences in LOS by protocol type were assessed using regression adjusting for age, sex, body mass index (BMI), pre-surgical Cobb angle, number of levels fused, and year of surgery. Similar models were used to identify predictors of LOS. Linear mixed models were used to assess differences in pain and opioid used over time by protocol type.

Results
59 patients from ERAS group were compared to 81 patients from N-ERAS group. 17 patients were excluded from protocol-specific analysis due to partial exposure to ERAS protocol. Patients were comparable in their baseline characteristics with regards to weight, height, number of levels fused and coronal Cobb angel. Median LOS was 3 days (IQR = 3-4) for the ERAS group, compared to 5 days (IQR = 4-5) for the N-ERAS group (p<.001). The ERAS group had a significantly lower adjusted rate of stay (RR=.75; 95% CI = 0.61-0.91) (Figure 1). The ERAS group had significantly lower average pain on post-operative days 0 (least squares mean [LSM] 2.73 vs. 4.37, p<.001), POD1 (LSM 3.2 vs. 4.4, p<.001), POD2 (LSM 4.4 vs. 4.7, p=0.028) and POD5 (LSM 2.9 vs. 4.4, p=.038). At each time point, the ERAS group had lower opioid consumption (mg/kg/24h) (all p<.001). LOS was predicted by the number of protocol elements received; those receiving two (RR=1.50 95% CI = 1.05-2.15), one (RR = 1.47; 95% CI = 1.10-1.195) or none (RR = 1.59, 95% CI = 1.21-2.09) had significantly longer rates of stay than those receiving all four.

Conclusion
Adoption of modified ERAS based protocol for patients undergoing PSF for AIS led to significant reduction in LOS, average pain scores, and opioid consumption.

	Rate Ratio[a]	95% Confidence Limits		p value
		Lower	Upper	
ERAS (vs. N-ERAS)	0.746	0.613	0.906	0.003
Age	0.996	0.943	1.051	0.877
Pre-operative Cobb angle	0.999	0.992	1.005	0.715
Female sex	0.956	0.737	1.239	0.731
BMI	1.006	0.984	1.027	0.613
Levels fused	1.045	0.986	1.108	0.141
Year of surgery	1.206	0.998	1.458	0.053

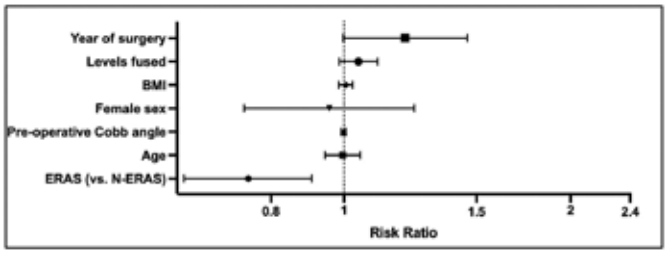

Figure 1 - Predictors of Length of Stay

44. LIPOSOMAL BUPIVACAINE IN THE CONTINUOUS IMPROVEMENT OF MULTIMODAL PAIN MANAGEMENT FOLLOWING POSTERIOR SPINAL FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

Karen Sacks, RN; Ali Asma, MD; Robert S. Lang, MD; Petya Yorgova; Kenneth J. Rogers, PhD; *Suken A. Shah, MD*

Hypothesis
Addition of Liposomal bupivacaine(LB) to multimodal pain management regiment will decrease need for oral morphine equivalents , hospital stay and improve early ambulation

Design
Retrospective analysis of prospectively collected data

Introduction
Intraoperative methadone and recent adjustments in our non-opioid protocol medications minimized the frequency of PCA dosing, allowing as needed doses of oral/IV pain to start immediately post. LB has been shown to reduce opioid consumption and length of stay (LOS) in children undergoing spinal fusion (PSF) surgery

Methods
Following IRB approval, the electronic medical records (EMR) of 45 children with the diagnosis of AIS who underwent PSF were reviewed. Patients are divided into three groups: Group A: Intermittent PCA multimodal regimen Group B: PRN pain meds multimodal regimen Group C: PRN pain meds multimodal regimen + LB All patients received preoperative gabapentin, celecoxib, acetominophen and intraoperative methadone 0.1-0.2 mg/kg. All groups received postop gabapentin, clonidine, valium, acetominophen and ketorolac per standard protocol. Group A had intermittent morphine PCA. For Group B and C, oxycodone or morphine choice was linked in EMR as needed doses. Group C also, received LB injections into erector spinae muscle prior to surgery closure. Oral morphine equivalents (OME) and valium use postop, pain scores (VAS), opioid related side effects, ambulation and length of hospital stay (LOS) were assessed.

Results
Data was analyzed using Bonferroni post hoc test, significance was assumed at P value< 0.05. Both groups were similar in demographics. Significant difference was observed between groups in OME and side effects (Table). Larger percentage of Group C used only oral opioids in the postop period. There was no significant difference between the groups in pain scores, valium use and LOS. Ambulation was significantly improved in Group C at 48 hours postop.

Conclusion
In this innovative pilot study, we observed that group C (lioposomal bupivocaine) showed better mobility and did not require IV morphine rescue in the post-op period. The use of a multimodal approach to pain management that includes liposomal bupivacaine has been found to be effective in opioid avoidance and improving ambulation postoperatively.

Parameter	Group A Methadone 0.1 mg/kg + PCA	Group B Methadone 0.1mg/kg + PRN Meds	Group C Methadone 0.2 mg/kg + PRN Meds	P value
No. of patients	15	14	16	—
Gender (M/F)	2/15	3/14	3/16	—
Age (years)	14 [10-20]	14 [13-17]	14 [11-19]	—
Weight (kg)	58 [34-105]	57 [48-78]	53 [38-113]	—
Height (cm)	160 [143-172]	160 [153-168]	160 [150-183]	—
Cobb Angle	51 [37-64]	52 [35-76]	52 [39-76]	—
Methadone (intraop dose)	0.084 ± 0.017	0.092 ± 0.016	0.20 ± 0.018	C vs A: 0.014* C vs B: 0.026*
OME (oral morphine equiv.)	116.39 ± 43.1	69.15 ± 41.67	40.50 ± 24.1	B vs A: 0.004* C vs A: 0.000*
Oral opioids only postop	n/a	5/14 (36%)	13/16 (81%)	—
Valium (mg/kg)	0.33 ± 0.17	0.316 ± 0.12	0.29 ± 0.15	NS
Emesis (no. of interventions)	1.47 ± 1.85	0.14 ± 0.36	0.25 ± 0.45	B vs A: 0.008* C vs A: 0.013*
PT ambulation – 48 hrs (distance in feet)	227 [0-500]	297 [75-500]	433 [300-700]	C vs A: 0.003* C vs B: 0.041*
Length of Stay (days)	2.41 ± 0.63	2.47 ± 0.59	2.1 ± 0.71	NS

Table

45. AIS POST-OPERATIVE RAPID RECOVERY PROGRAM: LIPOSOMAL BUPIVACAINE (LB) AND IV DEXAMETHASONE (D)

Amy L. McIntosh, MD; Christopher B. McLeod, MD; *Brandon A. Ramo, MD*

Hypothesis
We hypothesized the LB + D cohort would have lower VAS pain scores and post-operative consumption of morphine equivalents.

Design
Retrospective review of prospectively collected data, cohort comparison

Introduction
One goal of post-operative care pathways is to minimize narcotic usage. LB is an encapsulated local anesthetic that has a duration of action up to 72 hours. We compared two cohorts of AIS patients that underwent PSF.

Methods
The LB control cohort had local infiltration anesthesia (LIA) with a mixture of liposomal bupivacaine, bupivacaine HCL, and normal saline injected into the fascial and subcutaneous layers of the incision prior to wound closure. The study cohort had LIA with LB and received 3 doses of post-operative IV dexamethasone (LB + D) every 8 hours. Otherwise, the cohorts received the same multi-modal post-operative pain protocol (intravenous opioid with transition to oral opioid, as well as dexmedetomidine, acetaminophen, ketorolac, and diazepam).

Results
254 AIS patients underwent PSF. There were no preoperative statistically significant differences between the LB cohort (n =160) and the LB + D cohort (n = 94) when comparing average age (14.4 vs. 14.2 years), average BMI (22.0 vs. 21.7 kg/m2), preoperative major Cobb (61.4 vs. 64.0°). The LB + D cohort demonstrated lower VAS pain scores and consumed less morphine equivalents throughout their hospital course: 0-24 hrs. (1.8 vs. 1.5) (p=0.0005), (36.58 mg vs. 26.29mg) (p=0.00001); 24-48 hrs. (2.0 vs 1.6) (p=0.00001), (36.6mg vs 26.70mg) (p=0.00001), and 48-72hrs (22.52mg vs. 11.mg) (p=0.00001). The LB + D cohort's length of stay (LOS) was less (57.2 vs. 61.8 hrs.) (p = 0.0003). There were no (0/94) acute surgical site infections (SSIs) in the LB + D cohort.

Conclusion
LIA of LB with the addition of post-operative IV dexamethasone was associated with less consumption of post-operative morphine equivalents, lower VAS pain scores, and decreased LOS when compared to the LB only cohort.

46. THE COLLATERAL EFFECT OF ENHANCED RECOVERY AFTER SURGERY PROTOCOLS ON SPINE PATIENTS WITH NEUROMUSCULAR SCOLIOSIS

Niklas Tøndevold, MD; Thomas B. Andersen, DMSc; Tanvir J. Bari, MD; Martin Gehrchen, MD, PhD

Hypothesis
The effect of enhanced recovery after surgery (ERAS) may have collateral, positive effect on length of stay (LOS) in a different patient group than the group intended for ERAS.

Design
Prospective observational

Introduction
ERAS protocols are often specific to a specific type of surgery without assessing the overall effect on the ward. Previous studies have demonstrated reduced LOS with ERAS protocols in patients with adolescent idiopathic scoliosis (AIS), although the patients are often healthy and with few or no comorbidities. In 2018, we employed ERAS principles for patients undergoing AIS surgery with subsequent 40% reduced LOS. The current study aims to assess the potential collateral effect on LOS in patients surgically treated for neuromuscular scoliosis (NM) admitted to the same ward and treated by the same staff but without an ERAS protocol.

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Methods
All patients undergoing NM surgery two years before and after ERAS introduction (AIS patients) with a Gross motor function classification score of 4-5 were included. LOS, intensive care stay (LIS) and postoperative complications were recorded. Following discharge, all complications leading to readmission and mortality were recorded with minimum two year of follow-up using a nationwide registry.

Results
Forty-six patients were included; 20 pre-ERAS and 26 post-ERAS. Acrosse groups, there were no differences in diagnosis, preoperative curve size, pulmonary or cardiac comorbidities, weight, sex, or age. Mean LIS was also unchanged (1.2 vs 1.1;P=0.298). When comparing LOS, we found a 41% reduction in the post-ERAS group (11 vs. 6.5; P<.001) while the 90-day readmission rates were without any significant difference(45% vs. 34% P=.22) We found no difference in the 2 year mortality in either group.

Conclusion
The employment of ERAS principles in a relatively uncomplicated patient group had a positive, collateral effect on more complex patients treated in the same ward. We believe that training involving the caregiving staff is equally important as pharmacological protocols.

47. ACCURACY OF NON-INVASIVE HEMOGLOBIN (NHGB) MONITORING IN AN AIS POPULATION

Amy L. McIntosh, MD; Christopher B. McLeod, MD

Hypothesis
nHgb monitoring would correlate with invasive (i)Hgb measures in AIS patients undergoing PSFI

Design
retrospective review of prospective data

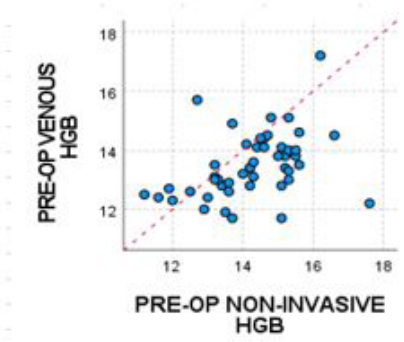
Introduction
Needle phobia and fear of blood draws is very common in children and adolescents. Noninvasive hemoglobin (nHgb) monitoring in children was first introduced in the Intensive Care Unit (ICU) setting. Later, our total joint arthroplasty colleagues demonstrated that nHgB monitoring was more efficient, less expensive, and preferred by patients compared into invasive hemoglobin (iHgb) monitoring. The purpose of this study is to identify the correlation between nHgb and iHgb monitoring which would allow a nHgb threshold to be determined. Patients with a nHgb level above that threshold would no longer require a blood draw, thus minimizing resource utilization, blood draw related anxiety, and pain during the postoperative period.

Methods
We enrolled 60 patients undergoing posterior spine fusion/instrumentation (PSFI) for AIS. Average EBL was 415cc, and 189 cc was returned via cell saver. 2/60 (3.3%) patients required an allogenic blood transfusion peri-operatively. nHgb and iHgb values were obtained within 60 minutes of each other at three separate time points (pre-operative, in Post-Anesthesia Care Unit (PACU), and POD 1 at 0700) iHgb and nHgb values were recorded. The results were retrospectively reviewed and analyzed. Paired t tests were utilized to compare mean (n/i)Hgb values. Pearson correlation coefficients were calculated at all three time points. ROC analysis was performed on the post-operative values to determine a threshold.

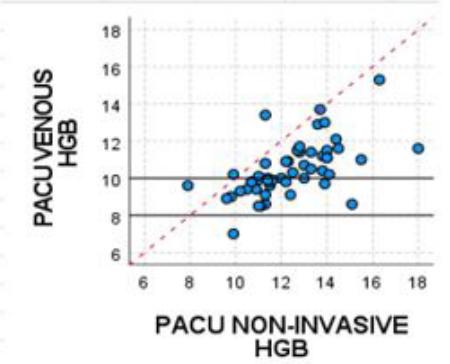
Results
There was a moderate positive correlation at all three time points (0.4, 0.59, 0.6) (p= 0.005, <0.001, <0.001). (Figures 1.) At all three timepoints, the mean nHgb value was 1-2 g/dL higher than the mean iHgb value, and this was statistically significant. At 0700 on POD1, a patient with a nHgb value of ≥10.8 g/dL had an iHgb value of >9.0 g/dL with 87% sensitivity.

Conclusion
Noninvasive Hgb monitoring was found to correlated with iHgb in pediatric AIS patients undergoing PSFI. Surgeons could consider screening AIS patients post-operatively with nHgb monitoring and only order iHgb measurement if the nHgb value is <10.8 g/dL resulting improvement in the patient experience.

Figure 1. Pre-op correlation between iHgb and nHgb



PACU correlation between iHgb and nHgb



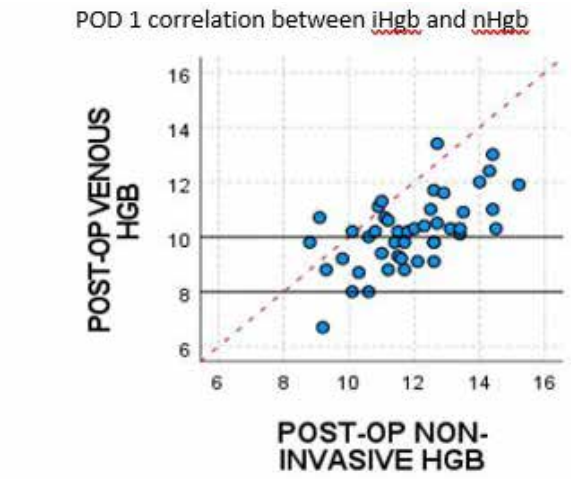


Figure 1: Pearson correlation coefficients Pre-op, PACU, and POD 1

48. COMING UP SHORT: ESTIMATED VERSUS CALCULATED BLOOD LOSS IN ADOLESCENT IDIOPATHIC AND NEUROMUSCULAR SCOLIOSIS SURGERY

Christina K. Hardesty, MD; Christopher Cheng, MD; Connie Poe-Kochert, RN; George H. Thompson, MD; Jochen P. Son-Hing, MD

Hypothesis
Blood loss is higher in neuromuscular scoliosis surgery compared to idiopathic scoliosis surgery. Blood loss is undercalculated using existing methods.

Design
Retrospective chart review

Introduction
Posterior spinal deformity surgery can be associated with substantial blood loss. Allogenic blood transfusion is an important tool for management of acute peri-operative anemia but has risks. Accurately characterizing risk factors and identifying strategies for minimizing blood loss improves operative planning. Previous literature uses estimated blood loss (EBL), which may underestimate bleeding, and are limited in their usage of new anti-fibrinolytics and elecrocautery that help minimize blood loss. We investigate the difference in blood loss in patients with idiopathic and neuromuscular scoliosis utilizing both EBL and a calculated blood loss (CBL) based on patient height, weight, and hemoglobin values.

Methods
Retrospective review was conducted of children who underwent posterior spinal fusion for scoliosis between June 2013 and January 2021. Estimated blood loss was determined from estimated intraoperative blood loss and measured postoperative drain output. Calculated blood loss was computed as described by Foss et al. All values were normalized based on vertebral levels fused and patient weight.

Results
Cohort included 224 children with adolescent idiopathic scoliosis (AIS) and 76 with neuromuscular scoliosis (NMS). EBL significantly underestimated total blood loss compared to CBL (882.2±447.1mL vs. 1315.0±375.1mL, P<0.001 in AIS; 1132.9±562.1mL vs. 1455.2±482.7mL, P<0.001 in NMS). CBL in patients with NMS was significantly higher than those with AIS (1455.2 ± 482.7mL vs. 1215.0 ± 375.1mL, P<0.001). Per-level CBL however was significantly lower in the NMS cohort, and in subgroup analysis was significantly less in patients with NMS requiring fusion to pelvis compared to those who did not.

Conclusion
EBL significantly underestimates blood loss compared to CBL. Patients with NMS undergoing surgical correction also have significantly greater blood loss than AIS counterparts. From this study, these differences appear to be driven by extent of fusion. Updated cutoffs and guidelines would be valuable for more accurate identification of patients at risk for requiring transfusion and determination of when to type and cross-match blood products prior to posterior spinal fusion for pediatric scoliosis.

Table 1: Database patient demographics and recorded peri-operative blood loss metrics

	Idiopathic (n=224)	Neuromuscular (n=76)	P-value	RR
Age (y)	14.3 ± 2.2	14.0 ± 2.9	0.30	-
Sex (M/F)	36/188	43/33	<0.001	-
Weight (kg)	57.2 ± 14.4	47.3 ± 16.8	<0.001	-
Height (cm)	160.0 ± 9.2	148.2 ± 19.6	<0.001	-
Levels Fused	11.8 ± 2.1	14.1 ± 1.9	<0.001	-
Intra-operative EBL (mL)	448.8± 257.7	558.4± 355.7	0.004	-
Post-operative EBL (mL)	435.6± 292.6	574.5± 417.0	0.002	-
Total EBL (mL)	882.2± 447.1	1132± 562.1	<0.001	-
Total Transfusion (mL)	155.9± 133.8	273.9± 274.9	<0.001	-
Patients Receiving Allogenic Blood	14	20	<0.001	4.2
Cell Saver Transfusion (mL)	135.6± 91.6	154.2± 113.1	0.15	-
Pre-operative Hemoglobin (g/dL)	14.0± 7.7	14.2± 2.0	0.80	-
Post-operative Hemoglobin (g/dL)	9.7± 5.9	10.3± 8.8	0.56	-

Table

49. PAIN MEDICATION USE TWO YEARS AFTER ADOLESCENT IDIOPATHIC SCOLIOSIS FUSION SURGERY

Tracey P. Bastrom, MA; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Peter O. Newton, MD; Harms Study Group

Hypothesis
The prevalence of opioid use at 2 years after surgical correction of adolescent idiopathic scoliosis (AIS) is low and is associated with lower pre-operative mental health scores.

Design
Observational case control

Introduction
Studies of heroin use have reported that up to 80% of users began their addiction with misuse of prescription opioids. Identifying opioid use and those at risk in the AIS population is critical for optimal outcomes.

Methods
A query of a multi-center prospective AIS surgical fusion registry was performed to identify patients of all Lenke types with responses to question 11 on the SRS-22 questionnaire at pre and 2 years post-operative, as well as pre-operative SRS-22 Mental Health (MH) domain scores. Question 11 asks about pain medication usage for the patients back

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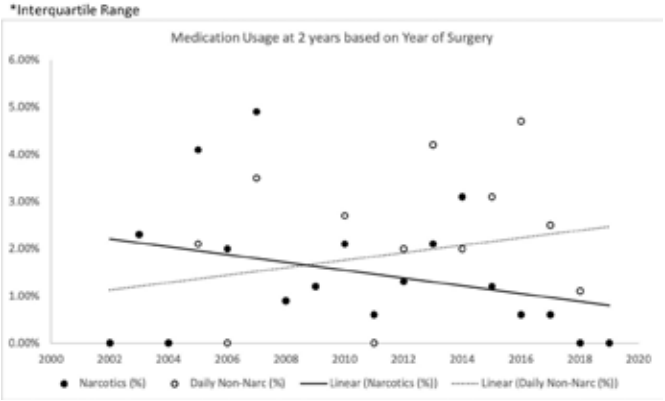
with 5 specific responses: narcotics daily, narcotics weekly or less, non-narcotics daily, non-narcotics weekly/less, or none. Descriptive analysis was performed and ordinal regression was used to evaluate the association between pre-operative MH score and 2-year medication.

Results
2220 patients who underwent surgery from 2002-2019 met inclusion. The average primary Cobb was 56±12°, average age 14.7±3 years, and 81.5% were female. 37 (1.7%) patients reported utilizing opioids 2 years after surgery and a significant difference in pre-operative MH scores was observed, with patients taking daily opioids demonstrating the lowest score (p<0.001, figure). The difference between the daily narcotic group and others exceeded the minimum detectable measurement difference (MDMD, 0.30) for MH. 3 patients reporting opioid use post-operatively reported pre-operative usage. Rate of revision surgery varied but was not significant (p=0.23). Rate of medication use based on year of surgery demonstrates a small linear decrease in opioid use over time, with a slight increase in non-opioid daily use (figure).

Conclusion
Less than 2% of patients reported taking opioids for back pain 2 years after surgical correction of AIS. Those taking opioids daily at 2 years demonstrated the lowest mental health score pre-operatively. An analysis of year of surgery suggests that changes in prescription practices over time may be occurring.

Two Year medication usage		Pre-operative Mental Health		Taking narcotics pre-op (n/%)	Rate of Revision Surgery
	n (%)	Median	IQR*		
Narcotics daily	18 (0.8%)	3.2	0.7	3 (17%)	0%
Narcotics weekly	19 (0.9%)	3.6	1.8	0 (0%)	10.50%
Non-Narc daily	48 (2.2%)	3.6	1.1	0 (0%)	4.20%
Non-Narc weekly	431 (19.4%)	3.8	1	11 (2.6%)	3.40%
None	1704 (76.8%)	4.2	1	23 (1.3%)	2.60%

*Interquartile Range



50. FACTORS ASSOCIATED WITH OPIOID USE DISORDER FOLLOWING SPINAL FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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Hypothesis
Variation in opioid prescribing following spinal fusion for AIS affects subsequent risk of development of opioid use disorder.

Design
Retrospective administrative database study

Introduction
Patients with OUD often trace their addiction to a legitimate medical prescription. Post-operative pain management following spinal fusion (SF) for Adolescent Idiopathic Scoliosis (AIS) typically involves opioids. Given that postoperative analgesia is often a child or adolescent's first opioid exposure, we sought to describe associations between OUD and analgesic prescribing practices following SF for AIS.

Methods
We identified patients ages 10-18 undergoing primary SF for AIS between 2007-2015 in the Truven Marketscan database, which is an administrative claims database containing data from inpatient and outpatient admission data across the United States. Demographic variables and prescription patterns (in morphine milligram equivalents [MMEs]) were analyzed to determine any potential association with OUD in the 1 year following SF.

Results
We identified 5,366 operative AIS cases(75.4% Female, 24.6% Male), of which 116 patients(2.2%) developed an OUD. AIS patients were prescribed on average 597.5(+/- 601.9) total MME and 62(+/- 47.1) MME/day post-operatively. Our multivariable model demonstrated no association of total MME, MMEs per day, or number of refills prescribed with the subsequent development of OUD within one year of SF. Presence and number of complex chronic conditions(CCC) diagnosed were significantly associated with development of an OUD(OR=1.76, p=0.021).Geographic Region was also associated with rates of development of OUD (p<0.001); operative AIS patients in the Northeast were more likely to be diagnosed with an OUD compared to North Central(p=0.005), South(p=0.002) and West(p=0.005) regions. No association was found between OUD and sex, age,reoperation rates, post-operative complications, or number of levels fused during surgery.

Conclusion
Here we use a large administrative database to demonstrate that large variations in opioid prescribing exist after SF for AIS. We used a multivariable model to demonstrate that variability in opioid prescribing is not associated with subsequent risk of development of OUD. This is the first report to describe such provider prescribing practices and identify such risk factors for development of OUD in operative AIS patients.

51. BACK PAIN AND QUALITY OF LIFE 10 YEARS AFTER SEGMENTAL PEDICLE SCREW INSTRUMENTATION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS): COMPARISON TO AGE AND GENDER MATCHED UNTREATED AIS PATIENTS AND HEALTHY CONTROLS

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Hypothesis
We hypothesized that posterior spinal fusion with pedicle screw instrumentation would result in improved pain and health-related quality of life (HRQoL) as compared with untreated AIS patients.

Design
Retrospective comparative study on prospectively collected data with 51 surgically treated AIS patients with minimum 10-year follow-up as compared with untreated AIS and healthy controls.

Introduction
Posterior spinal fusion with pedicle screws is the standard treatment for AIS, although it remains unclear whether this procedure results in improved long-term HRQoL compared with patients untreated for AIS. The aim of the present study was to evaluate pain and HRQoL in surgically managed patients with a minimum follow-up of 10 years compared with patients with untreated AIS and a healthy control group.

Methods
64 consecutive patients, minimum follow-up 10 years (mean 12.1), who underwent posterior pedicle screw instrumentation for AIS were prospectively enrolled. 51 (80%, 8 boys, mean age at FFU 27.0 [2.0] years) patients completed Scoliosis Research Society (SRS)-24 questionnaires, underwent clinical examination and standing spinal radiographs. Data on reoperations were collected. Pain and HRQoL were compared with those of 51 matched patients with untreated AIS (mean major curve 32° [13°] at skeletal maturity, mean age 26.4 [4.2] years at FFU) and 51 healthy controls (mean age at FFU 27.6 [6.1] years).

Results
Mean (SD) major curve was 57 (8.4) degrees preoperatively and 15 (6.3) degrees at FFU. Two (3.9%) re-operations were needed. The SRS-24 pain, self-image, function and activity remained at high level from preoperative to 10-year follow-up ($p>0.10$ for all changes). Pain, general activity and total scores were significantly better at 10-year follow-up in the surgically treated patients as compared to untreated patients ($p\leq0.05$ for all) (Table 1). In contrast untreated patients had better function scores ($p=0.024$). Healthy controls had significantly higher scores than surgically treated at FFU.

Conclusion
Patients undergoing segmental pedicle screw instrumentation for AIS maintain high level HRQoL during 10-year follow-up. Their HRQoL was significantly better than in untreated AIS, except for function domain.

SRS domain	Surgical treatment	Untreated	Healthy controls	p value*	p value**
Pain	4.01 (0.75)	3.70 (0.85)	4.65 (0.50)	0.052	<0.001
Self-image	4.06 (0.90)	3.70 (0.81)	4.38 (0.52)	0.11	0.025
Function	4.11 (0.47)	4.43 (0.89)	4.92 (0.22)	0.024	<0.001
Activity	4.47 (0.74)	3.87 (1.08)	4.65 (0.40)	0.0013	0.14
Total	4.09 (0.68)	3.79 (0.74)	4.54 (0.43)	0.033	<0.001

*p values represent comparison between surgical treatment and untreated.

**p values represent comparison between surgical treatment and healthy controls.

Table 1. SRS-24/22r outcomes at 10-year follow-up.

52. FROM PHQ-2 TO SRS-22: IMPACT OF DEPRESSION SCREENING TOOL ON SRS SCORES IN AIS PATIENTS

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Hypothesis
Patients screening positive for depression will have lower SRS scores, specifically within the Mental Health domain.

Design
Retrospective review

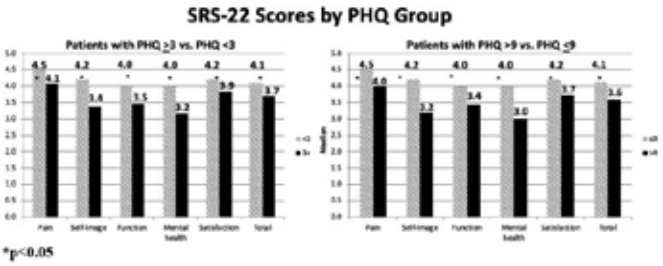
Introduction
As consideration of mental health in adolescents has become more of a focus during clinical assessments, we began administering the PHQ-2, a validated 2-question depression screen, to AIS patients. Our study sought to determine the relationship between depression scores obtained from this simple screening tool and SRS-22 scores.

Methods
AIS patients screened for depression with the PHQ-2 over a 2-year period were retrospectively reviewed. Patients received the PHQ-2, and if positive (>3), the more comprehensive PHQ-9 was administered. The median SRS-22 scores between positive and negative PHQ screens were compared. Nonparametric correlation between PHQ and SRS-22 Mental Health domain was performed. The ability of the MH domain to discriminate between patients with positive versus negative screens and patients with moderate-severe depression risk versus no/mild risk was evaluated with ROC analysis.

Results
521 patients were included, with those having +PHQ-2 screens having significantly lower total and individual domain SRS scores, especially within the MH domain (4.0 vs. 3.2, see Figure 1 for complete data). For those with moderate-severe depression (PHQ >9), total and individual domain scores were also significantly lower than those scoring ≤9, highlighted by the MH domain (4.0 vs. 3.0, $p<0.05$). Acceptable to excellent discriminant ability was observed for the SRS MH domain, the AUC was 0.76 for positive versus negative screens and the AUC was 0.85 for moderate or greater depression versus no to mild risk. A cutoff of ≥3.6 on the MH domain demonstrated sensitivity of 0.75 and specificity of 0.86 for identifying patients at no-mild risk for depression.

Conclusion
Recognizing mental health conditions is critical to successful AIS treatment as psychosocial conditions can negatively affect treatment outcomes as demonstrated by our cohort. Given the correlation between PHQ and SRS-22, AIS patients scoring <3.6 on the SRS-22 MH domain should be considered for depression screening due to an increased risk of moderate or severe depression.

PODIUM PRESENTATION ABSTRACTS



53. MACHINE-LEARNING FOR SURGEON PERFORMANCE BENCHMARKING IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) SURGERY

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Hypothesis
Machine-learning algorithms will provide improved targets for surgeon benchmarking

Design
Retrospective cohort

Introduction
Surgeon performance improves with benchmark feedback. Benchmarking without case adjustment may dissuade participation and hinder improvement. Machine-learning algorithms offer the opportunity for personalized surgical performance targets.

Methods
A surgical registry for AIS was queried. Data collected include demographic, radiographic, and surgical plan data. Linear regression, gradient boosting(GB), and extreme gradient boosting (xGB) models were created for length of stay (LOS), estimated blood loss (mL, EBL), SRS-22r Pain, and SRS-22r Self Image. For SRS-22r scores, patients were assumed to be recovered and 6m, 12m, or 24m data used as available. RMSE and R2 evaluated model fit. Model predictions required margins of acceptable predictions (LOS = 1 day, EBL = 250/500mL, SRS-22r 0.5pts). Percentages of correct predictions within these margins were calculated and compared. Variable importance was assessed with SHAP plots.

Results
6076 patients (81%F, median age 15yrs, 39% Lenke 1, 56°) were included in model generation. GB and xGB performed better than linear regression for all outcome measures (Table) where linear techniques performed poorly. LOS (mean 4.51) was correctly predicted 58-59%, EBL(mean 616mL) 70-73% within 250ml and 93-95% within 500mL. SRS-Pain 21-63%, -Self Image 40-59% were less precise predictions. Preoperative pain, surgical time, and preoperative FEV were most important for modeling LOS; surgery time and levels fused most important for EBL. Starting SRS scores were most important for patient-reported outcomes (PRO). SHAP plots suggest that models can be parsimonious.

Conclusion
Machine learning techniques (GB and xGB) performed better than linear regression for all outcome measures where linear regression performed poorly. Modeling PRO was less accurate than objective measures such as LOS and EBL reinforcing the complexity of predicting subjective outcomes. These data show proof of concept of personalized target outcomes in a surgeon benchmark platform. Variable importance data suggest few data points may be needed to minimize the response burden for participating surgeons.

	Length of Stay	Estimated Blood Loss	SRS-22r Pain	SRS-22r Self Image
Linear Regression	R2= -2.70E+21 RMSE = 1.08E+11 Correct: 0%	R2=-4.81E+21 RMSE = 2.30E+13 250mL = 0.21% 500mL = 0.43%	R2= -1.30E+21 RMSE = 1.75E+10 Correct: 0%	R2= -5.51E RMSE = 1.27E+11 Correct: 0%
Gradient Boosting	R2= -0.04 RMSE = 2.16 Correct: 59%	R2=0.18 RMSE = 301 250mL = 70% 500mL = 95%	R2= -0.33 RMSE = 0.56 Correct: 63%	R2= -0.2 RMSE = 0.6 Correct: 59%
Extreme Gradient Boosting	R2= -0.24 RMSE = 2.35 Correct: 58%	R2=0.11 RMSE = 314 250mL = 74% 500mL = 93%	R2= -3.06 RMSE = 1.06 Correct: 21%	R2= -0.8 RMSE = 0.73 Correct: 40%

Model Fit and Performance Characteristics

54. PREDICTIVE MODELS IDENTIFY PATIENT AND SURGICAL VARIABLES THAT SYNERGISTICALLY PRODUCE AN OPTIMAL OUTCOME FOLLOWING ADULT SPINE DEFORMITY (ASD) SURGERY

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Hypothesis
Identifiable patient and surgical variables work synergistically to predict an optimal ASD surgical outcome.

Design
Prospective, multi-center analysis.

Introduction
Identifying the components needed for an optimal ASD surgical outcome could help inform surgeons and improve ASD treatment. This study aimed to identify the components of ASD treatment that surgeons can employ to improve ASD surgery by creating a model that predicts a multi-perspective "optimal" surgical outcome

Methods
Surgically treated ASD patients prospectively enrolled into a multi-center study from 2009-2018 were assessed at minimum 2 year follow up for optimal outcome defined as

1) no major postoperative complication or complication requiring surgery, 2) patient reached MCID for ODI and SRS-22r subscore, and 3) patient satisfied and indicates would have the surgery again. Demographic, radiographic, PROM, and surgical variables were assessed for associations with optimal outcome. Multivariate regression models were built based upon level of upper instrumented vertebra (UIV) to identify variables that created a best fit predictive model for optimal outcome by R2 maximization and AIC/BIC minimization.

Results
788 of 1291 patients, mean 3.5 years follow up, were eligible for study and evaluated. Optimal outcome (OP; n=196) had less preoperative opioid use (47.5% vs. 56.8%) and fewer history of prior spine surgery (65.4% vs. 77.3%) than nonoptimal outcome (NO; n=592), respectively ($p<0.05$). All other preoperative demographic, spinal alignment, and PROM values were similar for OP vs. NO ($p>0.05$). Creation of the best fit predictive model for optimal outcome demonstrated synergy between several modifiable variables including preoperative BMI and opioid and tobacco use, final SVA and scoliosis, and use of supplemental rods and PJF prophylaxis. Refining the model for specific surgeries based upon UIV demonstrated increased synergistic impact of the modifiable variables and predictive accuracy (R2 = 0.41-0.77; Figure).

Conclusion
Predictive modeling identified preoperative BMI, opioid and tobacco use, final SVA and scoliosis, and use of supplemental rods and PJF prophylaxis as variables surgeons can optimize and/or employ that act synergistically to predict an optimal ASD surgical outcome.

55. ANGELMAN AND PRADER-WILLI SYNDROME: SISTER IMPRINTING DISORDERS AND HIGH COMPLICATION RATES FOLLOWING SPINAL DEFORMITY SURGERY

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Hypothesis
Surgical management of scoliosis in Angelman (AS) and Prader-Willi Syndrome (PWS) is associated with severe and high rates of complications.

Design
Retrospective Case Series

Introduction
Angelman Syndrome (AS) and Prader-Willi Syndrome (PWS) are complex disorders with unique genetic etiologies that have received a great deal of attention due to the novel imprinting mechanism that produces some forms of the syndromes. Both syndromes are highly associated with spinal deformity and previous reports have shown extremely high rates of postoperative complications. We sought to examine the modern surgical treatment of spinal deformity associated with these sister imprinting disorders, with emphasis on the specific complications encountered in these patient populations.

Methods
IRB-approved retrospective chart review of 15 patients with PWS and 5 patients with AS who underwent surgical intervention for spinal deformity between 2000 and 2018 were identified. Post-operative complications were classified using the modified Clavien-Dindo-Sink (CDS) system and further categorized into specific subtypes including excessive drainage, dehiscence, implant failure, infection, and delayed wound healing. Peri-operative and final follow-up radiographic data was analyzed.

Results
Mean age at surgery was 12.9 years (4-21) with mean follow-up of 46.1 months (1-145). There were postoperative complications in 17 patients (85%). There were a total of 10 major complications (CDS ≥ 3) occurring in nine patients (45%). These included 5 infections requiring reoperation, 1 seroma requiring drainage, 2 severe cervical-thoracic deformities requiring reoperation, 1 implant failure requiring reoperation, and 1 death secondary to fungal sepsis and thromboembolic disease. 8 additional patients (40%) had minor complications (CDS 1-2). There were 8 intraoperative complications occurring in five patients (25%), including loss of neuromonitoring signals and CSF leaks.

Conclusion
Surgical intervention for scoliosis in PWS and AS continues to have high complication rates secondary to medical and behavioral comorbidities found in these patient populations. The exact etiology of the high complication rates encountered cannot be definitively stated, but both syndromes frequently present with a number of unique features that may predispose patients to develop surgical complications.

PODIUM PRESENTATION ABSTRACTS

Table 3 Modified Clavien-Dindo-Sink for Post-Operative Complications

Overall Grade	Case	Syndrome	Sex	Post-Operative Complication	Age at Surgery	Surgery Type	Intra-Op Complication	Levels	Osteotomy
Grade 1: Wounds infections opened at the bedside and any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. [Allowed therapeutic regimens are: drugs as antiemetic, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy.]	1	AS	M	Suture abscess; wound dehiscence	14+10	PSF	No	T4-L4	No
	2	PWS	F	Chronic pain	14+3	PSF	No	T4-L4	No
	3	PWS	F	Excess drainage	12+8	PSF	No	T1-L1	No
	4	PWS	F	Post-Op Ileus	16+5	ASF/PSF	No	T1-L3	No
	5	PWS	M	Wound dehiscence; delayed wound healing	12+3	PSF	No	T2-L3	Yes
Grade 2: Requiring pharmacological treatment with drugs other than such allowed for grade 1 complications also includes blood transfusions and total parenteral nutrition	6	PWS	F	Excess drainage; wound dehiscence; delayed wound healing	11+7	PSF	No	T4-L4	No
	7	PWS	F	Excess drainage; wound dehiscence; superficial infection, mild PJK	13+10	PSF	No	T2-L4	No
	8	PWS	F	Wound dehiscence; excess drainage treated with prophylactic antibiotics	18+11	PSF	No	T1-L3	No
Grade 3: Requiring surgical, endoscopic or radiological intervention	9	AS	F	SWAP abscess; culture negative seroma	13+3	PSF	No	T2-L4	No
	10	AS	F	Deep infection	14+4	PSF	No	T3-Pelvis	No
	11	AS	M	Wound dehiscence; excess drainage; deep infection	21+1	PSF	No	T4-L4	No
	12	PWS	F	Primary Growth Sparing Procedure: implant failure; pseudarthrosis	4+4	GS	CSF Leak	T2-L3	No
				Definitive Procedure: No Post-Operative Complications	16+4	PSF	IONM alert	T2-L3	No
	13	PWS	F	Implant failure; PJK	12+8	PSF	IONM alert	C7-L4	Yes
	14	PWS	F	Primary Growth Sparing Procedure: wound dehiscence; implant failure; excess drainage; deep infection; delayed wound healing	7+7	GS	No	T9-T12	No
				Definitive Procedure: Implant failure; PJK	16+9	PSF	IONM alert	T1-L3	Yes
	15	PWS	M	Wound dehiscence; delayed wound healing; deep infection	11+9	ASF/PSF	No	T1-L3	Yes
	16	PWS	M	Excess drainage; deep infection	17+5	PSF	No	T4-L4	No
Grade 4: Life-threatening complications [including CNS complications] requiring IC/ICU management		No patient experienced a Grade 4 Post-Operative Complication							
Grade 5: Death of a patient	17	PWS	F	Wound dehiscence; excess drainage; deep infection; delayed wound healing; sepsis; death	13+10	PSF	IONM alert	T1-L4	Yes
Ungraded: No Post-Operative Complications	18	AS	F	-	13+10	PSF	No	T1-L4	No
	19	PWS	F	-	13+7	ASF/PSF	CSF Leak IONM alert	T2-L1	No
	20	PWS	F	-	7+8	GS	No	T1-L4	No

56. SURGICAL TREATMENT OF SCOLIOSIS IN PATIENTS DIAGNOSED WITH DOWN SYNDROME: A 15-YEAR EXPERIENCE

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Hypothesis

Patients with Down Syndrome (DS) who undergo surgical treatment of syndromic scoliosis experience elevated rates of post-operative complications.

Design

Retrospective Cohort

Introduction

DS is the most commonly diagnosed chromosomal abnormality and has been associated with multiple orthopedic concerns, including scoliosis. There is a paucity of literature on postoperative outcomes and the specific complications found in this population.

Methods

14 patients with DS who underwent surgical intervention for spinal deformity between 2000 and 2018 were identified. Postoperative complications were classified using the modified Clavien-Dindo-Sink (CDS) system and further categorized into specific subtypes including excess drainage, wound dehiscence, delayed wound healing, and infection. Perioperative and final follow-up radiographic data was analyzed.

Results

Mean age at surgery was 14.3 years (11-19) with mean follow-up of 36.3 months (0.75-74) at the time of data collection. 8 (57%) patients had postoperative complications. 3 patients (21%) had major complications (CDS grade ≥ 3). These included 1 infection requiring drainage, 1 hematoma requiring drainage, and 1 seroma requiring drainage. Five additional patients (36%) had minor complications (CDS grade 1 or 2). Of the 8 patients who experienced complications, 7 had complications related to wound healing. There were no intraoperative complications for any patients.

Conclusion

Surgical intervention for scoliosis in patients with DS continues to be associated with elevated complication rates comparable to previous studies. Rates of infection were comparable to previous studies. Complications in this cohort primarily involved wound healing while previous studies described high rates of post-operative implant failure, pseudoarthrosis, and significant curve progression, none of which were experienced by the patients in this study. This is likely due to the use of more modern implants (screws vs. hooks) allowing for improved fixation. Although the specific etiology of wound healing-related complications is unknown, awareness of this significant risk may help surgeons optimize surgical technique, post-operative monitoring, and appropriate counseling of families preoperatively.

Cohort Demographics and Modified Clavien-Dindo-Sink for Post-Operative Complications

Overall Cohort (Mean ± Standard Deviation)		Age at Treatment		BMI	Max Pre-Op Cobb	Final Follow-Up Cobb	Surgical Time (min)	EBL (mL)	Follow-Up (months)
		14.3 ± 2.5		22.1 ± 4.4	70 ± 15	33 ± 10	307 ± 70	595 ± 195	36.3 ± 26.6
Overall Grade	**Post-Operative Complication**	**Age at Treatment**	**Sex**	**BMI**	**Max Pre-Op Cobb**	**Final Follow-Up Cobb**	**Surgical Time (min)**	**EBL (mL)**	**Follow-Up (months)**
Grade 1	Wound dehiscence; bilateral popliteal fossa wounds	16+6	F	21.6	92	49	390	700	41
	Mid-cervical kyphosis	12+8	M	23.3	63	33	243	600	74
	Excess drainage	11+10	F	27.9	60	40	327	450	5
Grade 2	Pleural effusion, excess drainage, post-op fever treated with antibiotics	13+4	M	25.8	61	23	270	500	45
	Purulent drainage treated with antibiotics	16+4	F	21.0	57	26	225	100	12
Grade 3	Culture-negative hematoma undergoing I&D	12+1	F	21.4	64	32	435	850	64
	Deep SSI undergoing I&D x2 with fluid culture positive for Enterobacter	12+2	F	21.8	55	19	210	550	52
	Excess drainage undergoing I&D, cultures negative	12+6	M	16.9	76	40	255	785	28
Grade 4	No patient experienced a Grade 4 Post-Operative Complication								
Grade 5	No patient experienced a Grade 5 Post-Operative Complication								
Patients without complication	-	12+6	M	17.1	58	21	333	500	64
	-	13+4	M	18.1	66	20	312	1000	64
	-	18+10	F	21.1	73	45	300	350	6
	-	13+11	F	21.8	76	39	315	400	36
	-	15+6	F	18.7	109	40	420	650	7
	-	19+4	M	33.1	62	30	270	400	0.75

57. TREATMENT OF KYPHOSIS IN ANKYLOSING SPONDYLITIS BY OSTEOTOMY THROUGH THE GAP OF A PATHOLOGICAL FRACTURE: A RETROSPECTIVE STUDY

Hongqi Zhang, MD

Hypothesis

Is a safe and effective surgical procedure that Osteotomy through the pathological fracture gap?

Design

a retrospective study

Introduction

Surgical interventions are commonly advocated for correcting kyphotic deformities and relieving severe back pain in ankylosing spondylitis (AS) patients. The aim of this study was to evaluate the clinical outcome of osteotomy performed through the gap of a pathological fracture for the treatment of kyphosis in ankylosing spondylitis and to introduce the key points of this novel surgical approach.

Methods

From January 1, 2010, to December 31, 2014, 13 consecutive AS patients who were treated with osteotomy through the fracture gap were retrospectively reviewed.

Patients underwent the radiographic assessment of sagittal balance parameters. Visual analog scale (VAS) scores were used to assess improvement in back pain.

Results
The average follow-up time was 2 years and 1 month. The median operation time was 280 min (range, 220–460 min). The mean blood loss was 1100 mL (range, 820–1300 mL). No major acute complications such as death or complete paralysis occurred. There were no neurologic complications or cerebrospinal fluid leaks in any patient. One patient had postoperative wound infection, which subsided after a switch of antibiotics. The global kyphosis Cobb angle of patients decreased from the preoperative 55.8°±11.0° to 23.2°±6.7° (P<0.001) after surgery. The C7 plumb line was used to assess global balance; its relationship with the posterosuperior corner of the sacrum decreased from 166±37 mm to 111±20 mm (P<0.001). The thoracolumbar kyphosis Cobb angle decreased from 51.0°±9.9° to 21.6°±11.0° (P<0.001). VAS scores for back pain decreased from 7.2±1.2 to 2.1±1.1 (P<0.001). Lumbar lordosis increased from 5.7°±23.2° to 10.5°±29.2° (P=0.001).

Conclusion
Osteotomy through the pathological fracture gap is a safe and effective surgical procedure for kyphosis correction and improvement of back pain in AS patients with pathological fractures. A significant kyphosis correction and improvement of back pain can be achieved with this surgical procedure.

58. HOW TO RECTIFY THE CONVEX CORONAL IMBALANCE IN PATIENTS WITH UNSTABLE DYSTROPHIC SCOLIOSIS SECONDARY TO TYPE I NEUROFIBROMATOSIS: EXPERIENCE FROM A CASE SERIES

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Hypothesis
Convex coronal imbalance (CCI>3cm) in dystrophic scoliosis secondary to Type I neurofibromatosis (DS-NF1) can be well managed via the mutual adjustment on the corrections of upper and lower arc of the scoliosis.

Design
Retrospective study.

Introduction
There was a paucity of valid information on how to discriminate between different patterns of CCI in DS-NF1), while unanticipated aggravation of postoperative CCI occurred regularly resulting in poor patient satisfaction. We aimed to stratify different patterns of CCI in DS-NF1, and to optimize the coronal rebalancing strategies.

Methods
NF1-related scoliosis database was reviewed and different types of CCI were identified, and the outcomes of coronal rebalance were analyzed.

Results
CCI with dystrophic thoracolumbar/lumbar apex (7 CCI in 11 patients) was prone to remain uncorrected when compared to those with thoracic apex (0 CCI in 4 patients) (63.6% vs. 0.0%, p=0.077). Further comparison between those with and without post-op CCI showed a higher correction of main curve Cobb angle (65.9±9.1% vs. 51.5±37.3%, p=0.040), more tilted instrumentation (10.3±3.6° vs. 3.2±3.1°, p=0.001) and reversed tilting and translation of upper instrumented vertebra (UIV) to convex side (8.0±2.3° vs. -3.4±5.9°, p<0.001; 35.4±6.9 mm vs. 12.3±13.1 mm, p=0.001) in the uncorrected imbalanced group. Multiple linear regression analysis revealed that ΔUIV translation (pre- to post-operation) (β=0.832; p=0.030) was significantly correlated with the correction of CBD.

Conclusion
Thoracolumbar/lumbar CCI in dystrophic scoliosis was prone to suffer high risk of persistent post-op CCI. Satisfying coronal rebalance should avoid UIV tilting and translation to the convex side, which was mainly attributed to over correction maneuvers in the upper curve region.

59. CONTINUOUS-INCREMENTAL-HEAVY HALO-GRAVITY TRACTION COMBINED WITH POSTERIOR-ONLY APPROACH FOR CERVICAL KYPHOSIS CORRECTION IN PATIENTS WITH NEUROFIBROMATOSIS-1

Hongqi Zhang, MD

Hypothesis
To evaluate the safety and effectiveness of Continuous-Incremental-Heavy Halo gravity traction (CIH-HGT) combined with posterior-only approach in the treatment of cervical kyphosis in patients with neurofibromatosis-1(NF-1).

Design
a retrospective study

Introduction
Cervical kyphosis due to NF-1 is rare and surgical management of this deformity is challenging surgical problem. Few studies have recommended posterior-only approach for cervical kyphosis correction in patients with NF-1. The safety and effectiveness of HGT combined PO approach is not well defined.

Methods
19 patients with cervical kyphosis due to NF-1 were reviewed retrospectively between January 2010 and April 2017. All the cases underwent CIH-HGT combined with posterior instrumentation and fusion surgery. Correction result, neurologic status and complications were analyzed.

Results
In this study, 92% total correction was achieved via CIH-HGT combined with PO approach. Cobb angle decreased from initial 63.0 ± 21.0 degrees to postoperative 10.8 ± 4.0 degrees, P<0.01. Traction correction rate was 44% and surgical correction rate was 48%. JOA scores were improved from preoperative 13.6±1.6 to postoperative 16.0±1.0, P<0.01. Neurological status was also improved. There was no correction loss and the neurological status was stable in mean 3.7 years follow-up. The incidence of complications was 36.8%(7/19).

PODIUM PRESENTATION ABSTRACTS

6 patients underwent local complications and 1 patient underwent a second surgery.

Conclusion
CIH-HGT combined PO approach is safe and effective method for cervical kyphosis correction in patients with NF-1. A satisfied correction result, and successful bone fusion can be achieved via this procedure, even improvement of neurological deficits can also be obtained. Our study suggested that CIH-HGT combined PO approach is another consideration for cervical kyphosis correction in patients with NF-1.

60. ESTABLISHING EXPERT CONSENSUS: DETERMINANTS OF HIGH-RISK & PREVENTATIVE STRATEGIES FOR NEUROLOGICAL EVENTS IN COMPLEX SPINAL DEFORMITY SURGERY

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Hypothesis
Guidelines to define high-risk factors and strategies to avoid intraop neuromonitoring (IONM) events and neurological deficits during spinal reconstructive surgery can be generated through expert consensus.

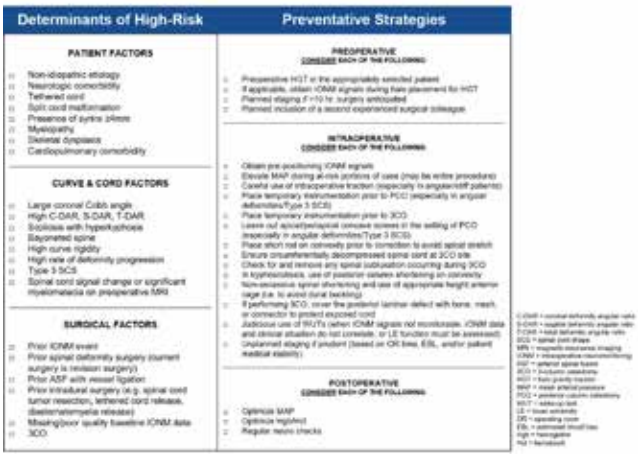
Design
Delphi study

Introduction
Although there is a sentinel consensus checklist for managing IONM events for more straight-forward spinal deformity surgery (Vitale et al. Spine Deformity 2014), there is a lack of published guidelines for assessing preop high-risk profiles along with specific intraop/postop neurological event strategies in more complex spinal deformity pts. and surgeries.

Methods
Through a series of surveys and virtual consensus meetings, the Delphi method was utilized to establish consensus among a group of expert spinal deformity surgeons regarding high-risk factors and preventative strategies for intraop/postop neurological events. The group consisted of 10 orthopedic surgeons and 5 neurosurgeons, with 4 having an isolated pediatric practice, 2 with a solely adult practice, and 9 with a mixed practice. The average number of years in practice was 19±8.1 (range 8-35). Consensus was defined as ≥80% agreement.

Results
Consensus was achieved regarding 22 high-risk factors (8 patient-related, 8 curve-/cord-related, and 6 surgical-related) and 21 preventative strategies (4 preop, 14 intraop, and 3 postop). Determinants of high-risk were subclassified into patient factors (e.g. congenital kyphosis), curve/cord factors (e.g. high deformity angular ratio, type 3 spinal cord shape at the apex), and surgical factors (e.g. poor baseline monitoring data, performance of a three-column osteotomy, previous anterior spinal fusion with vessel ligation). Several pre-, intra-, and post-operative strategies for neuroprotection were also agreed upon, such as the involvement of an experienced assistant, mean arterial pressure augmentation in certain stages of the procedure, use of appropriate temporary stabilization, and careful postop neurological monitoring.

Conclusion
A guiding resource highlighting multiple preop clinical and radiographic factors that characterize high-risk spinal deformity pts. and surgery, as well as strategies to prevent intraop/postop neurological events, was successfully created through expert consensus. This is intended to serve as a global reference for surgeons and clinicians involved in the care of complex spinal deformity pts.



61. MULTICENTER ANALYSIS OF INTRAOPERATIVE NEUROMONITORING ALERTS IN SPINAL SURGERY FOR IDIOPATHIC AND NON-IDIOPATHIC SCOLIOSIS

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Hypothesis
Analysis of IONM records in 930 consecutively patients during spinal deformity surgeries

Design
Multicenter IONM review and prospectively collected data

Introduction
IONM modalities, transcranial motor-evoked potentials (TcMEPs), and somatosensory-evoked potentials (SSEPs) are accepted methods to identify impending spinal cord injury during spinal deformity surgery.

Methods
A retrospective review of IONM (TceMEPs, SSEPs, including EMG and EEG) in 930 consecutive spinal deformity surgery from December 2010 to December 2019 in 2 istitutions using TIVA anesthesia. The mean age: 17y.(range: 6-71) female are 68%. Diagnoses include: idiopathic scoliosis (83%), EOS(3%)), neuromuscular scoliosis (10%), congenital scoliosis (2%), syndromic(2%).

The average kyphosis was 71°(20°-90°) and the average scoliosis was 68°(38°-128°). Alerts with TceMEPs amplitude decreasing wave more than 65% and SSEPs decreasing more than 50% from baseline and/or increase of the latency more than 15%, were positive changes. A complete pre-operative data, IONM report and post-operative neurological data were reviewed.

Results

There were 125 alerts in 112 patients (12%) of 930 underwent surgery for their spinal deformities and collected data from the 2 istitutions. The most common causes of alerts were hypotension (18), hypovolemia/drug induced (46), deformity correction (20), osteotomies (4), screw placement (11), electrodes disconnection (6) and patient positioning (20). Risk factors:preoperative neurological deficits, comorbidity, surgical procedure, curve types, and a presence of kyphosis were evaluated. In 5 cases in persistent alerts we perform Stagnara wake up test with 2 cases neurodeficit after awakening completely recovered after few weeks

Conclusion

TceMEPs are more sensitive then SSEPs. Late TceMEPs reduction folowed by SSEPs changes without surgical manovers often are correlate with anesthetic changes (>50%), patient with long or wrong positioning (16%) and may cause plexopathies or monolateral hyporeflexia wich recovered in few days. There are both reduction of signals in patients under intra-op traction or non-idiopathic scoliosis. In 2 cases the remained neurodeficit recovered in few weeks

62. THE ADJUNCT USE OF DESCENDING NEUROGENIC-EVOKED POTENTIALS WHEN TCEMEPS DEGRADE INTO WARNING CRITERIA: MINIMIZING FALSE-POSITIVE EVENTS

Scott J. Luhmann, MD; Barry L. Raynor, BS; Brian A. Kelly, MD

Hypothesis

The supplemental use of Descending Neurogenic-Evoked Potentials (DNEPs) can help identify false positive events when Transcranial Electrical Motor-Evoked Potentials (TCeMEPs) degrade into warning criteria during pediatric spinal deformity surgery.

Design

Retrospective case series

Introduction

Multimodal intraoperative spinal cord monitoring using TCeMEPs and SomatoSensory-Evoked Potentials (SSEPs) has become the standard for pediatric spinal deformity surgery. However, TCeMEPs are susceptible to false-positive warnings. At our institution, DNEP monitoring has been used when TCeMEPs degraded into warning criteria, as an adjunct method to evaluate spinal cord function.

Methods

An institutional database was queried to identify all primary and revision pediatric spinal deformity cases </= 21 years of age (1/2006 to 12/2021) in which TCeMEPs were the primary motor tract modality, and TCeMEP degraded into warning criteria with subsequent initiation of adjunct DNEPs. 14 surgical cases in 14 patients were identified which met inclusion criteria, out of 3351 total cases (0.42%).

Results

Mean age (8F:6M) at surgery was 13.2 years. See Table for data. At baseline, all patients had well-formed and repeatable TCeMEP data. After TCeMEPs degraded into warning criteria, DNEP epidural leads were placed with robust initial bilateral responses in all patients, and 13/14 had continued robust DNEP responses and 1 had degradation of DNEP response. Intraoperative Stagnara tests were not done in 12/14 cases. At the conclusion of surgery there were 2 neurologic deficits, with resolution of 1 at longer follow-up. Of the 5 TCeMEPs which remained absent through remainder of surgery, 4 (80%) had normal DNEP responses and were neurologically intact at the completion of surgery. Evaluating at final neurologic outcome, DNEP sensitivity was 100%, specificity 100%, PPV 100%, and NPV 100% when TCeMEPS degrade into warning criteria in this study.

Conclusion

In this small subset of spinal deformity patients who had degradation of TCeMEPs, the use of DNEPs provided highly-reliable information (NPV and PPV 100%) to the surgeon, which obviated the need for intraoperative Stagnara wake-up tests in 86% of patients. The use of DNEPs should be viewed as an adjunct spinal cord modality which may provide useful data to minimize the impact of TCeMEP false-positive warnings.

Diagnoses	Syndromic (7), Kyphosis (3), Idiopathic (2), Congenital (2)
Surgery Type	Primary (9), Revision (5)
3 Column Osteotomies/Vertebral Column Resections	8
Event at Data Loss	Screw placement (7), VCR performance/closure (4), Deformity correction (3)
Corrective Maneuvers (15 in 11 patients)	Raising mean arterial pressure (4), Decompression (3), Decreasing correction (3), Screw removal (2), Decreased traction (2)
TCeMEPs Outcome After Degradation into Warning Criteria	Returned to acceptable levels (4) Returned to baseline levels (3) Absent to conclusion of surgery (5) TCeMEPS discontinued by surgeon (2)
DNEPs During Remainder of Surgery	Continued robust responses to conclusion of surgery (13) Degradation into warning criteria (1)
Neurologic Deficits at Conclusion of Surgery	None (12) Lower extremity paraparesis (1) Weak unilateral foot dorsiflexion (1)
Neurologic Deficits at Longer Term Follow-up	None (13) Lower extremity paraparesis (1)

63. UTILITY OF INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING IN DETECTING MOTOR AND SENSORY NERVE INJURIES IN PEDIATRIC HIGH-GRADE SPONDYLOLISTHESIS

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Hypothesis

We hypothesize that multimodal intraoperative neurophysiological monitoring (IONM) is highly sensitive and specific in diagnosing nerve root injuries in pediatric patients with high-grade spondylolisthesis (HGS) undergoing posterior spinal fusion surgery (PSF) with or without anterior interbody fusion.

PODIUM PRESENTATION ABSTRACTS

Design
Retrospective study.

Introduction
IONM, including motor evoked potentials (MEP), somatosensory evoked potentials (SSEP), and electromyography (EMG), have been shown to be highly sensitive and specific in detecting spinal cord injuries during adult spine surgery. However, IONM sensitivity and specificity in HGS remains unknown. In the present study, we aim to assess the diagnostic accuracy of IONM in the surgical management of pediatric HGS.

Methods
Data on patient demographics, radiographic parameters, and the presence of pre-and post-operative neurological deficits were collected. In addition, MEP, EMG, and SSEP alerts were extracted. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for each modality. The 95% confidence intervals (CIs) were calculated using the exact (Clopper-Pearson) method.

Results
54 pediatric patients with HGS undergoing PSF between 2003 – 2021 in a tertiary care centre were reviewed and included in the analysis. 72% (39/54) of patients were female and the average age was 13.7±2.3 years. In 12 patients (22.2%) post-operative neurological deficit was diagnosed; all these patients were flagged during the procedure, thus having no false negatives. Six patients (11.1%) had an intra-operative alert which recovered following intra-operative intervention; these patients were asymptomatic post-operatively. The sensitivity of combined MEP and SSEP was 100% (95% CI [73.5 to 100]), MEP 92.3% (95% CI [64.0 to 99.8]), SSEP 77.8% (95% CI [40.0 to 97.2]) and EMG 69.2 (95% CI [38.6 to 90.9]). The specificity of combined MEP and SSEP was 82.9% (95% CI [67.9 to 92.9]), MEP 80.0% (95% CI [64.4 to 91.0]), SSEP 95.1% (95% CI [83.5 to 99.4]) and EMG 65.9 (95% CI [49.4 to 79.9]).

Conclusion
Based on our cohort, multimodal IONM, using both MEP and SSEP, were highly accurate in diagnosing motor and sensory nerve injuries in pediatric HGS. We recommend the utilization of multimodal IONM in all HGS PSF surgeries.

64. A NOVEL MRI-BASED SAGITTAL CLASSIFICATION OF SPINAL CORD IN PATIENTS WITH KYPHOSIS: ASSOCIATION WITH THE INTRAOPERATIVE NEUROMONITORING DATA LOSS

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Hypothesis
The occurrence of intraoperative neurophysiological monitoring (IONM) data loss was related to the shape of the cord in the spinal canal on the sagittal-T2 MRI at the apex of the curve in patients with kyphosis.

Design
Retrospective cohort.

Introduction
The IONM data loss is an undesirable event occurred during spinal deformity correction. Previous studies have shown that patient characteristics, surgical procedures and severity of deformity were risk factors for IONM data loss. Recently, a novel classification system which aims to identify patients with increased odds of IONM data loss during thoracic deformity correction was proposed, but this classification has not yet been extensively validated.

Methods
From January 2015 to December 2021, a consecutive cohort of 250 patients who underwent surgical correction of a spinal kyphosis were retrospectively reviewed, including 167 males and 83 females, aged 30.8±17.8 years (range,2-76 years). Spinal cords were classified into 3 types based on the shape of the cord and the presence of cerebrospinal fluid (CSF) on the sagittal-T2 MRI at the apex of the curve. Type A (188 cases) is defined as the spinal cord being attached to the anterior wall of the spinal canal with no visible CSF between the cord and the apical vertebral body. Type B (42 cases): the spinal cord is located in the middle of the spinal canal with visible CSF around the spinal cord. Type C (20 cases): the spinal cord that is attached to the posterior wall of the spinal canal with no CSF behind the cord. The occurrence of IONM data loss were recorded.

Results
250 patients were reviewed. Among all patients, 188(75.2%) were Type A; 42(16.8%) were Type B; and 20(8%) were Type C. The trans-cranial motor-evoked Potentials (MEPs) and/or somatosensory evoked potentials (SSEPs) data loss was identified intraoperatively in 14(5.6%) cases, with full recovery of signal in 13 of those cases. The incidence of IONM data loss was 4.3%(8/188) in Type A group, 2.4%(1/42) in Type B group and 20%(5/20) in Type C groups. The Fisher's exact test showed that patients with Type C spinal cord suffered from higher risk of IOMN data loss(P=0.004).

Conclusion
We validated a novel spinal cord classification to identify patients with increased odds of IONM data loss with spinal kyphosis correction. Patients with type C spinal cord shape are at significant risk for IOMN data loss.

65. CURVE PROGRESSION AND HEALTH RELATED QUALITY OF LIFE (HRQOL) IN IDIOPATHIC SCOLIOSIS: 40-YEAR FOLLOW-UP FROM DIAGNOSIS†

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Hypothesis
The purpose was to assess long-term curve progression and HRQoL in patients with IS and compare thoracolumbar/lumbar (TL/L) and thoracic curves.

Design
Single center long-term follow-up.

Introduction
Treatment of idiopathic scoliosis (IS) in childhood is mainly guided by curve size and location with the aim to prevent curve progression and long-term effects of larger deformities. It is generally accepted that curves >50° will progress throughout adulthood, but less well described what happens with mild to moderate curves and whether curve size and location affects long-term HRQoL.

Methods
We identified 177 patients diagnosed with a pediatric spinal deformity and treated at our institution from 1972 through 1983. 104 of all eligible patients completed follow-up (69%), 91 of these were diagnosed with juvenile (n=5) or adolescent IS (n=86). We excluded patients with infantile, neuromuscular, syndromic, and congenital scoliosis. Patient files from treatment/observation in childhood were reviewed including detailed descriptions of main curve, type and magnitude. At follow-up, we assessed long-standing full-spine radiographs and HRQoL with the SRS22r questionnaire.

Results
Mean follow-up was 40.8±2.6 years and 95% were female. Overall, SRS22r subscore was 3.8 (95%CI: 3.7-3.9) which is lower than an age-matched normal population. 18 patients underwent Harrington rod instrumentation in adolescence and additional 3 patients underwent surgery later in adulthood leaving 70 patients for analysis of curve progression, 43 (61%) had been treated with a Boston brace. For curves <30° at skeletal maturity (n=32), mean curve progression was 10±12° (range -5 to 44); for curves 30-50° (n=28) mean progression was 19±12° (range -3 to 49); and for curves >50° (n=7) mean progression was 17±6° (range 10-25). This corresponds to a curve progression of 0.3°/year, 0.5°/year and 0.4°/year, respectively. Main curve size at follow-up was larger for thoracic curves 53±18° than for TL/L curves 35±21° (p<0.001); however, we found no difference in SRS22r subscore between the two groups (3.8±0.7 and 4.0±0.7, respectively). For curves 30-50°, we found a greater curve progression for TL/L curves (mean 22°) than for thoracic curves (mean 17°), but this was not statistically significant [95%CI for mean diff: -1.7 to 2].

Conclusion
Long-term curve progression for curves 30-50° at skeletal maturity is substantial and comparable to curves >50° and curve progression tends to be larger for TL/L than for thoracic main curves, however with no difference in HRQoL.

66. MAJOR COMPLICATIONS FOLLOWING ANTERIOR VERTEBRAL BODY TETHERING SURGERY†

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Hypothesis
AVBT is likely associated with a significant rate of major complications requiring reoperation at ≥2yr f/u

Design
Retrospective multicenter review

Introduction
The aim of this study is to report on complications following anterior vertebral body tethering(AVBT) surgery for the treatment of adolescent idiopathic scoliosis(AIS)

Methods
A retrospective multicenter database identified consecutive patients with AIS who were treated with AVBT surgery from 2011-2019. Patients with ≥2yr f/u were included for analysis.All peri- and postoperative complication data following surgery were collected.Those requiring revision surgery or unplanned invasive interventions were considered major complications while all others were deemed as minor.

Results
In this series of 328 patients the major complication rate was found to be 22%,and minor complications were noted in 29%.58 patients had 67 various reoperations(26 posterior spinal fusion(PSF:7.9%);37 tether release/removal/replacement(11.3%);1 wound infection(0.3%);3 dural tear repair(0.9%)).5 patients had unplanned interventions for respiratory concerns (pneumo/hemothorax(0.6%);shortness of breath(0.9%)).Radiographic complications of overcorrection >10°(7.6%),new compensatory curve/adding-on(4%),loss of correction/progression of primary curve(5.5%),and other(4.6%) were seen in 61 patients.80% of overcorrected curves were either revised to PSF(0.6%) or had tether revision(5.5%). New compensatory curve/adding-on resulted in revision surgery in 12 patients(PSF:1.5%;tether extension:2.1%). Loss of correction/progression of primary curve without suspected tether breakage was noted in 4 patients who were all revised to PSF(1.2%).Suspected broken tether was the highest reported complication noted in 23% of patients;however only 7% had revision surgery(PSF:3.4%;tether replacement:3.7%).Pulmonary issues were reported in 21 patients:2 required chest tube re-insertion,1 re-intubation,and 2 admissions to ICU for bi-pap.Minor complications included 51 broken tethers without revision surgery(15.5%),1 transient u/e numbness(0.3%),8 postoperative pain complaints(received physio/NSAIDs(2.4%)),and 3 mild GI symptoms(0.9%).

Conclusion
Major complication rate following AVBT was noted to be 22% at ≥2yr f/u.Revision AVBT is more likely than conversion to PSF due to the high overcorrection rate. Understanding these complications may aid in better patient selection and advances in technology to improve outcomes following AVBT.

PODIUM PRESENTATION ABSTRACTS

Type and Rate of Complications

COMPLICATION TYPE	AVBT REVISION SURGERY; N (%)	CONVERSION TO PSF; N (%)	OTHER UNPLANNED INTERVENTION; N(%)
Overcorrection >10°	18(5.5%)	2(0.6%)	
Compensatory Curve Progression / Adding-On	7(2.1%)	5(1.5%)	
Loss of Correction/Progression of Primary Curve/Suspect Broken Tether	11(3.4%)	16(4.5%)	
Dural Tear			3(0.9%)
SSI			1(0.3%)
Other	1(0.3%)	3(0.9%)	
Pulmonary			5(1.5%)
TOTAL	37(11.3%)	26(7.9%)	9(2.7%)

Timeline of Major Complications

67. MATERNAL RISK FACTORS FOR CONGENITAL VERTEBRAL ANOMALIES: A POPULATION-BASED CASE-CONTROL STUDY*

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Hypothesis
We hypothesized that maternal smoking, chronic diseases, and medication used during the first trimester of pregnancy increases the risk of congenital vertebral malformations.

Design
A nationwide register-based case-control study.

Introduction
Maternal risk factors for congenital vertebral malformations remain mainly unclear. Hence, we aimed to assess and identify potential risk factors for these anomalies.

Methods
All cases with vertebral anomalies (including live births, stillbirths, and terminations due to fetal anomaly) were identified in the Finnish Register of Congenital Malformations from 1997 to 2016. Five age-matched controls from the same university hospital district were randomly selected for each case. Preliminary univariate regression analyses on maternal risk factors included BMI, parity, smoking, history of miscarriages, chronic diseases, and prescription drugs used during the first trimester of pregnancy.

Results
256 cases diagnosed with congenital vertebral anomalies were identified. After excluding 97 malformations associated with known syndromes, 159 children/fetuses (59 formation defects, 4 segmentation defects, and 96 with mixed anomalies) were included and compared with 795 matched controls. Maternal pregestational diabetes and exposure to insulin was associated with vertebral anomalies. Similarly, oral diabetes medication increased the risk of vertebral anomalies. Also, heparins and estrogens were associated with elevated the risk (Table). Maternal BMI, previous miscarriages, and parity were not associated with increased risk. Maternal smoking was associated with formation defects (OR 2.47, 95% CI 1.28 – 4.76).

Conclusion
Our preliminary results suggest that pregestational diabetes increases the risk of congenital vertebral anomalies. Maternal smoking increased the risk of formation defects. Metformin, heparin, and estrogens are often used with assisted reproductive technologies and were all associated with increased risk of vertebral anomalies.

	Number of Events		Odds ratio	95% CI
	Cases (n=159)	Controls (n=795)		
Pregestational diabetes	8 (5.0%)	6 (0.8%)	6.97	2.38 – 20.37
Insulin (ATC code A10A)	8 (5.0%)	6 (0.8%)	6.97	2.38 – 20.37
Biguanides (e.g. metformin, A10BA)	3 (1.9%)	1 (0.1%)	15.27	1.58 – 147.7
Heparins (B01AB)	3 (1.9%)	3 (0.4%)	5.08	1.02 – 25.39
Estrogens (G03CA)	5 (3.1%)	3 (0.4%)	8.57	2.03 – 36.24

Univariate analysis of maternal risk factors for congenital vertebral anomalies

68. VARIANTS IN COLLAGEN HOMEOSTASIS GENES ARE ASSOCIATED WITH ADOLESCENT IDIOPATHIC SCOLIOSIS*

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Hypothesis
Alterations in components of the extracellular matrix (ECM) contribute to AIS pathogenesis.

Design
Genetic association study of variants within ECM-encoding genes, meta-analysis including four independent cohorts, in vitro and in vivo candidate gene studies

Introduction
Despite its medical significance, the pathogenesis of AIS is poorly defined. Prior genetic studies in multiple ancestral groups have implicated genes involved in cartilage and connective tissue development. Additional studies in humans and vertebrate model systems have suggested that components of the extracellular matrix (ECM) contribute to AIS. To define the role of the ECM in AIS we first performed an ECM-focused genetic association study, and next investigated AIS-associated genes in vitro and in vivo.

Methods
1,358 cases and 12,507 controls were genotyped using the Illumina HumanCoreExome BeadChip, and 2,009

protein-altering variants within ECM genes were tested for association with AIS. Two significantly-associated variants were further tested in four independent cohorts from USA, Sweden-Denmark, Japan, and Hong Kong, and results were analyzed by meta-analysis using METAL (total N=10,519 AIS cases and 93,238 controls). Gene expression was tested by quantitative real-time PCR, and protein was studied in mouse spine using immunohistochemistry and immunofluorescence microscopy. MMP14 enzymatic activity was measured by an established collagen degradation assay.

Results

We detected significant associations with variants in COL11A1 (p.(P1335L), PMETAL=7.01E-11, OR=1.118 [1.081-1.156]) and MMP14 (p.(D273N), PMETAL=7.61E-9, OR=1.210 [1.134-1.291]). Collagen type XI alpha 1 chain, encoded by Col11a1, was detected at highest levels in the nucleus pulposus, cartilaginous endplates, and condensing bone. Further, we found that Col11a1 expression was dysregulated in cells from mice lacking either the Pax1 or Gpr126 gene, both previously linked to AIS. Mmp14 encodes matrix metalloproteinase 14 and was detected at highest levels in the periosteum and in condensing vertebral bone of mice. Further, the collagen degradation activity of the AIS-associated MMP14 protein variant was significantly reduced in vitro.

Conclusion

Our data define new human AIS disease genes. Studies of these and other AIS genes in animal models highlight collagen formation and/or maintenance in its pathogenesis, and suggest possible new therapeutic targets.

69. THE IMPACT OF GROWTH, CESSATION OF GROWTH AND BRACING ON CURVE PROGRESSION IN IDIOPATHIC SCOLIOSIS*

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Hypothesis

We hypothesized that increased rate of growth and decreased bracing compliance would result in increased risk of curve progression

Design

IRB approved Prospective Comparative Study

Introduction

Assessment of growth is critical for guiding the treatment of scoliosis. This is particularly true for cessation of bracing, as 1/4 of AIS patients that are Risser 4 (RS) at cessation of bracing will progress. When Sanders Stage 7 (SS) is used, up to 20% of patients have curve progression at cessation of bracing. Cheung et al questioned if growth mattered when they showed that up to 1/3 of patients will demonstrate progression if bracing is stopped at RS 4, with no growth in 6 months and 2 years postmenarche. We have previously established that Collagen X Biomarker (CXM) is a direct measure of enchondral ossification and longitudinal bone growth and that patients with CXM <5ng/dl had no remaining growth

Methods

Q6mo anthropometrics and spine PA biplanar slot scanner hand in images were assessed for major curve magnitude, RS, triradiate cartilage status (TRC), Greulich and Pyle bone age (BA), and SS. Serial Dried Blood Spots to obtain CXM levels were collected 3 consecutive days Q1-2months based on SS. Brace compliance was monitored with i-buttons

Results

171 patients (140 female/31 male) with idiopathic scoliosis (Cobb ≥20) were recruited between 2018-2021. Average age at enrollment 12.71 yrs (range 7-16.5). The average change in Cobb ranged from -1.0-0 based on SS with a large range from -12.0-28.0 degrees. CXM levels (ave 27.7 ng/dl, range 12.7-47.7) and height velocity ave 8.3 cm/yr (range 6.0-12.9) peaked at SS 2.For patients wearing a TLSO, there was a significant correlation (r=-.361, p=.03) between change in Cobb and average number of hours of brace wear, with a decrease in change in Cobb with increased wear time

Conclusion

CXM is the first biomarker specific to longitudinal bone growth. We previously established that it is a patient-specific, real time measure of growth velocity highly correlated to the anthropometric and radiographic measures of growth and that patients with CXM<5ng/ml had no remaining growth. In this study, we found rapid growth was not a risk factor for curve progression in braced patients. We further found that the combination of skeletally mature, CXM<5ng/dl, and demonstrated no growth for 6 months prior to cessation of bracing appears to be appropriate criteria for cessation of bracing

Rate of growth, CXM level and curve progression by Sanders Stage

Sanders Stage	Sanders 1	Sanders 2	Sanders 3	Sanders 4	Sanders 5	Sanders 6	Sanders 7	Sanders 8
N*	12	21	29	13	15	22	79	14
Height Velocity cm/yr	6.1 (3.2-10.9)	8.3 (6.0-12.9)	7.4 (3.1-11.9)	5.3 (1.9-9.3)	5.2 (1.2-9.9)	3.5 (0.2-7.6)	2.5 (0-9.2)	1.2 (1.5-2.6)
Mean CXM ng/dl	24.0 (15.9-26.7)	27.7 (12.7-47.7)	20.0 (9.1-33.3)	17.0 (7.0-29.4)	13.1 (6.6-34.6)	11.0 (4.8-27.0)	7.6 (2.5-18.7)	4.2 (1.9-7.2)
Ave Major Cobb**	37.2 (13.0-61.0)	27.4 (5.0-60.0)	27.0 (3.0-60.0)	23.9 (6.0-59.0)	28.0 (13.0-50.0)	29.4 (9.0-50.0)	29.9 (9.0-53.0)	25.9 (16.0-41.0)
Ave Curve progression degrees/6 months	-.4 (-6.0-6.0)	-.74 (-8.0-4.4)	.24 (-12-23)	-.8 (-13.0-9.0)	.34 (-6.0-8.0)	-.36 (-10.0-12.0)	-.15 (-28.0-19.0)	-.08 (-5.0-5.0)
Brace Wear Time by brace time and Sanders Stage								
Mean TLSO brace wear time	15.1 N=1	14.97 (11.9-18.1) N=6	11.53 (5.8-17.2) N=7	11.57 (9.3-14.7) N=3	13.8 (12.9-14.7) N=2	15.76 (11.5-21.5) N=5	15.10 (8.38-22.5) N=21	13.9 N=1
Mean Providence brace wear time		7.0 N=1	7.26 (6.2-8.6) N=5	7.20 (7.1-7.3) N=2	8.03 (7.4-8.6) N=3	7.67 (7.5-8.0) N=3	6.87 (3.8-12.5) N=11	7.2 (3.98-10.45) N=2

*N- patients were followed longitudinally over time and thus may be included in more than one sanders stage
** Postoperative patients were excluded as that may impact change in height

70. IN VIVO ANALYSIS OF RESPIRATORY DYSFUNCTION USING HYPERPOLARIZED XENON-129 MRI IN TIS RABBIT MODEL*

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PODIUM PRESENTATION ABSTRACTS

Hypothesis
Hyperpolarized xenon-129 MRI can measure respiratory pathophysiology in rabbit model of thoracic insufficiency syndrome (TIS).

Design
Basic Science

Introduction
TIS is caused by constrictive thoracic deformities that hinder pulmonary function and manifests as: 1) hypoventilation - the result of mechanically restricted chest wall and diaphragmatic motion; 2) impaired respiration - the result of impaired lung development with retardation of alveolarization, neovascularization, and increased septal wall thickness. This increases the alveolar-arterial (A-a) gradient and impedes oxygen exchange. Non-invasive, in vivo regional assessments of respiratory function during lung development are lacking. The purpose of this pilot study was to demonstrate that hyperpolarized xenon-129 (HXe) MRI can noninvasively measure respiratory dysfunction in-vivo using an established rabbit model of TIS.

Methods
Constriction of the right hemithorax was generated by tethering ribs 2-9 (Fig 1A) in 6-week female NZ white rabbits (n=4), compared to controls (n=2). Serial CT scans documented progressive thoracic deformity and corresponding lung hypoplasia (Fig 1B). At adulthood (30 weeks), MR imaging of the lungs (1.5T magnet with custom xenon-129 transmit/receive birdcage coil) was performed on intubated rabbits breathing 20% oxygen + 80% HXe administered for 15 breaths at 6mL/kg tidal volume in n=1 TIS rib-tether and n=1 control. A-a gradient functionally represented as equivalent A-a septal wall thickness was calculated from ratio of parenchyma to alveolar xenon gas concentration (Fig 1C, D).

Results
Rib tethering produced constriction of the right hemithorax, a corresponding scoliosis (Cobb 55.3°) and decreased lung volume. The ratio of parenchymal to alveolar xenon gas concentration was 20-80% higher in the TIS rabbit (Fig 1C). The equivalent A-a septal wall thickness was increased for both the ipsilateral constricted lung (18.0 ± 2.1μm) and contralateral lung (14.7 ± 1.0μm) in TIS animals compared to controls (12.5 μm).

Conclusion
Hyperpolarized xenon-129 MRI demonstrated decreased oxygen exchange as a consequence of diminished alveolar permeability provoked by thoracic constriction and restricted lung growth. This non-invasive, in vivo technique can be used clinically to enhance our understanding of TIS pathophysiology and evaluate effective treatment strategies to foster age appropriate alveolarization.

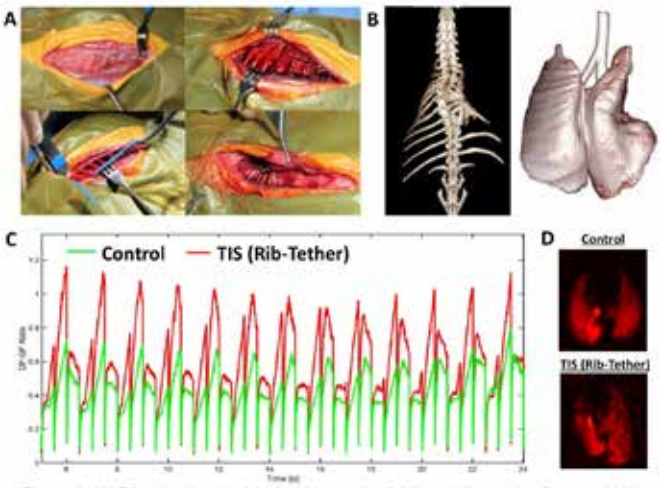

Figure 1. (A) Rib-tethering the right hemithorax ribs 2-9 in rapidly growing 6 week old New Zealand White rabbits and induced **(B)** expected thoracic and spinal deformity as well as changes in lung volume by computed tomography at 30 weeks of age (24 weeks post-op). **(C)** Hyperpolarized xenon-129 MRI imaging non-invasively revealed alterations in the dissolved phase to gas phase ratio indicating detection of impaired lung pathophysiology in TIS compared to control and illustrated by representative images of hyperpolarized xenon in the lung **(D)**.

71. LONG-TERM CLINICAL, RADIOGRAPHIC, AND COST ANALYSIS OF THE CORRECTIVE SPINE SURGERY FOR ADULT SYMPTOMATIC LUMBAR DEFORMITY AT MEAN 7.5-YEAR-FOLLOW-UP†

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Hypothesis
Long-term surgical outcome for adult symptomatic lumbar deformity (ASLD) will be favorable with relatively low late stage complication rate, and revision rate. The overall direct cost will be slightly increased due to the revision surgery at the final followup (f/u).

Design
Multicenter retrospective case series.

Introduction
The results of corrective spine surgery for ASLD are favorable despite the higher complication rate. However, long-term outcome has not fully described. This study sought to report the long-term clinical and radiographic outcomes in surgically treated ASLD patients.

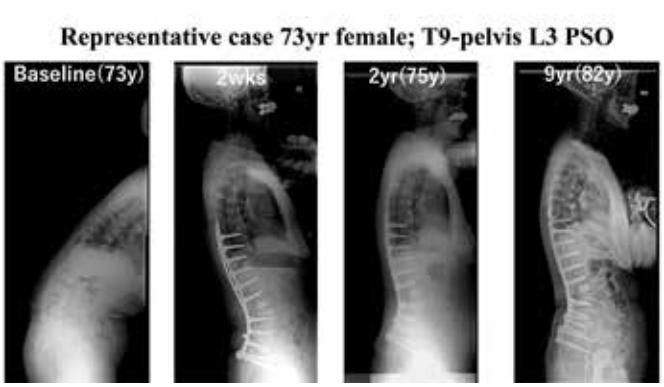
Methods
169 consecutive ASLD patients (>50y) who had corrective spine surgery at 3 different hospitals and reached 5 years f/u were included (mean f/u 7.5y, age 67±8 y, 96% female). The subjects were stratified by 3 age groups (50s, 60s, 70s) and compared. Further analyses were conducted for the risk of long-term progression of thoracic kyphosis (pTK>10°) by multivariable logistic regression analysis (MRLA). The initial and overall direct cost of the surgery was also analyzed.

Results
The SRS22 at final f/u was similar among the 3 groups (SRS22 subtotal; 50s:60s:70s; 4.0±0.5 vs 3.5±0.6 vs

3.8±0.5). The overall major complication rate was high (56%), while the late complication rate was low (12%). The overall revision rate was 20% and the late revision developed 4%. The most common reason for revision was rod fracture (7%). The 70s had significantly higher revision (30%) and 2y complication rate (62%) which lead to higher overall complication rate (65%). However, the late complication rate was not different among the 3 groups (9% vs 12% vs 13%). Sagittal alignment was improved at 2y and well maintained until to the final f/u while significant pTK was observed in all groups (pTK:9±7°). The MLRA indicated that baseline C7SVA: OR 1.9[1.0-3.1], DXA (T score<-1.5): OR3.2[1.1-8.9], and UIV (lower thoracic): OR5.4[1.1-27.4] were identified as the independent risk for pTK >10°. The direct cost of initial surgery was $45±8K and increased 13% ($50±11K) at the final f/u.

Conclusion

Long term surgical outcomes for ASLDs were favorable with relatively low late-stage complication rate, revision rate, and less increased direct cost. The patient with pre-existing low BMD, large SVA, and LIV(LT) were high risk for pTK while further study warrants the clinical significance of pTK.



Case example

72. BONE MORPHOGENETIC PROTEIN (BMP) USE IN ADULT SPINAL DEFORMITY SURGERY IS ASSOCIATED WITH REDUCED IMPLANT FAILURES AND LOWER COST/QALY AT MEAN 4 YEARS POSTOPERATIVE†

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Hypothesis

Cost, complications and postoperative outcomes, and cost/QALY will be similar for ASD patients treated with BMP vs. no BMP.

Design

Prospective, matched analysis.

Introduction

Despite studies reporting the efficacy of BMP to promote surgical spinal fusion, hospital systems and third-party payors continue to deny BMP use. Study purpose: perform a cost-effectiveness analysis of surgically treated ASD patients receiving BMP vs. no BMP.

Methods

Surgically treated ASD patients prospectively enrolled into a multi-center study from 2009-2018 were assessed for receiving BMP or NOBMP (iliac crest bone graft and allograft only) at the time of surgery. BMP and no BMP cohorts were propensity score matched (PSM) for age, BMI, frailty, total levels fused, fusion to the pelvis, osteotomies, interbody fusion, and supplemental rod use. Postoperative alignment, complications, rod fractures, patient reported outcomes (PROMs), cost of care (based upon DRG reimbursements adjusted to 2021 US dollars) were evaluated at minimum 3 year follow up, and cost/QALY calculated at last follow up.

Results

483 of 888 patients, mean 4.2 years follow up (range 2.9 to 8.8), were evaluated. Mean BMP dosage was 27.6 mg total (range 1-200), 2.2 mg/level posterior (range 0-25), and 1.7 mg/level interbody (range 1-18). BMP (n=407) had similar demographics, osteotomies, levels fused, preop PROMs, follow up duration, and pre and postoperative spinal alignment as NOBMP (n=76; p>0.05). BMP had less implant failures (0.17/patient vs. 0.33/patient; p<0.05), all other complications were similar BMP vs. NOBMP (p>0.05). BMP had lower mean total cost of care/patient ($78,679.61 vs. $103,388.78) and lower cost/QALY ($22,455.48 vs. $32,947.68) at last follow vs. NOBMP, respectively (p<0.05). Revision surgery rates were similar for BMP vs. NOBMP (0.32 vs. 0.42/patient, p=0.11), however, costs of revision surgery were less for BMP ($11,114.33) vs. NOBMP ($22,912.53, p<0.05).

Conclusion

Propensity score matched analysis demonstrated BMP use in ASD surgery at mean 4 year follow up was associated with decreased implant fracture rates, lower treatment costs, and better cost/QALY than NOBMP. Hospital systems, third party payors should consider the initial cost of BMP for ASD may be offset by decreased total cost of care and improved cost/QALY.

73. OPIOID SPARING ANESTHESIA FOR ADULT SPINAL DEFORMITY SURGERY REDUCES POSTOPERATIVE PAIN, LENGTH OF STAY, ICU STAY, OPIOID CONSUMPTION, AND OPIOID-RELATED COMPLICATIONS: A PROPENSITY MATCHED ANALYSIS†

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Hypothesis

Reducing intraoperative opioid consumption will improve postoperative recovery kinetics.

PODIUM PRESENTATION ABSTRACTS

Design
Retrospective, single center propensity-matched observational cohort.

Introduction
The US opioid crisis highlights the dire need to reduce opioid exposure with alternative approaches. Prior studies report that 25% of opioid naive patients are still on opioids two years after spinal fusion surgery. Currently, opioids are a primary component of anesthesia during spinal surgery. We developed an opioid sparing anesthesia (OSA) protocol for adult spinal deformity (ASD) surgery to mitigate opioid exposure.

Methods
Opioid naive patients undergoing > 5 level lumbar fusion for were identified. Patients receiving OSA were propensity-matched to non-OSA patients based on sex, smoking status, BMI, ASA grade, surgical invasiveness, number of levels fused, and revision vs primary procedure. The OSA protocol includes a combination of IV propofol, lidocaine, ketamine, magnesium, dexmedetomidine, and esmolol as needed. A standard opioid escalation protocol was used postoperatively.

Results
Of 45 OSA patients meeting inclusion criteria, 43 were successfully propensity matched to 43 non-OSA patients. There were no differences in baseline demographic or surgical parameters. Opioid consumption was reduced intraoperatively (3.6 vs 53.2MME, p=0.000), on POD 1 (67.4 vs 111.6MME, p=0.030), and each POD with decreased total consumption (241.3 vs 453.9MME, p=0.022). OSA patients had reduced opioid-related complications (1 vs 9, p=0.015) and less patients required blood transfusion (1 vs 28, p=0.000) despite similar EBL (570 vs 692cc, p=0.294). Emergence time (17.4 vs 14.3min, p=0.374) and PACU time (113.8 vs 142.6min, p=0.077) was similar between cohorts. There was a shorter LOS for OSA patients (4.3 vs 6.2 days, p=0.009) and less ICU admissions (4 vs 14, p=0.015). Pain score on transfer in (4.6 vs 7.6, p=0.000) and out (4.2 vs 6.2, p=0.002) of PACU was lower for OSA patients as well.

Conclusion
Our results show that OSA in ASD surgery improves immediate postoperative recovery kinetics by reducing the need for ICU, blood transfusion, pain scores, and LOS. Opioid-related complications and total opioid consumption were reduced as well. OSA appears to be an attractive alternative to opioid-dependent anesthesia protocols in ASD surgery.

74. COMPLICATION RATES FOLLOWING ADULT SPINAL DEFORMITY (ASD) SURGERY: THE CATEGORY OF COMPLICATION DICTATES TIMING†

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Hypothesis
Provide benchmarks for the rates of complications by type and timing

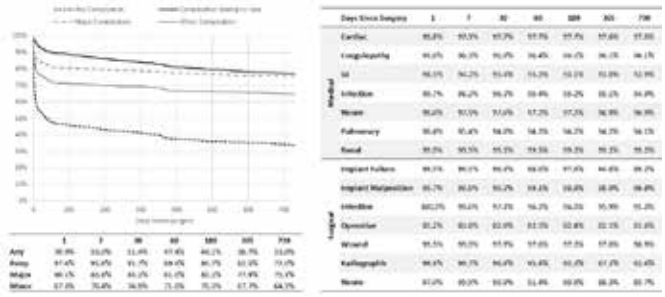
Design
Prospective multicenter database

Introduction
Although complication rates have been previously reported, the interplay between timing and type of complications has not been fully analyzed.

Methods
In the context of a prospective multicenter ASD database, standardized forms were used to collect data on surgery-related complications. On-site research coordinators and central auditing helped ensure data capture completeness. Inclusion criteria were age >18 years, ASD, and minimum 2-year follow-up. Date and type of complication were collected and classified into three severity groups (minor, major, major leading to a reop). Only complications occurring before the 2-year visit were retained for analysis.

Results
997 out of 1260 patients eligible for 2-year follow-up (79.1%) were captured. The mean age at the time of surgery was 60.4yo±14.3, 76.3% were female, and 50.5% had a history of previous spine surgery. Surgical data were typical of ASD surgery (98.9% posterior fusion, 57.9% decompression, 71.2% osteo, 18.1% 3CO, 64.0% IBF). The overall complication rate was 67.4% (N=672). 247 patients (24.8%) experienced at least one complication the day of surgery (including intra-op), 359 (36.0%) between POD1 and 6-weeks post-op, 271 (27.2%) between 6 weeks and 1-year post-op, and finally 162 (16.3%) between 1-year and 2-years post-op. Using Kaplan-Meier survival analysis, the rate of remaining complication-free was estimated at different time point for different severity (left graph / table) and type of complication (right table). Stratification by type of complication demonstrated that most of the medical complications occurred within the first 60 days. Surgical complications followed two types of behavior: operative, wound, and infection occurred early (within 60 days), while implant-related and radiographic complications happened at a constant rate over the 2-year period. Neurologic complications had a high occurrence with the first 60 days, followed by a continuous increase up to the 2-year visit.

Conclusion
Only one-third of ASD patients remained complication-free by 2 years, and two patients out of ten will have had a complication requiring a reoperation/revision. Estimation of timing and type of complication associated with surgical treatment is crucial when counseling patients and planning treatment cost-effectiveness.



75. CAN A THRESHOLD CURVE MAGNITUDE BE IDENTIFIED AS A SURGICAL INDICATION IN CEREBRAL PALSY SCOLIOSIS?

Jenny L. Zheng, BS; *Patrick J. Cahill, MD*; Jessica H. Heyer, MD; Paul D. Sponseller, MBA; Burt Yaszay, MD; Harms Study Group; Keith Baldwin, MD, MPH, MSPT

Hypothesis
Posterior Spinal Fusion (PSF) for neuromuscular scoliosis (NMS) in children with Cerebral Palsy (CP) is performed on a broad range of curve magnitudes that differs by institution.

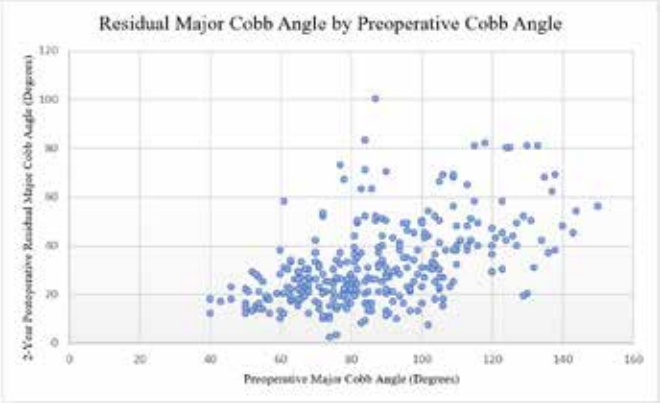
Design
Retrospective cohort study of prospectively collected database.

Introduction
A curve magnitude at which surgery is indicated for NMS in children with CP is ill-defined due to medical complexity of patients, patient/provider preferences, and limited benchmarking research. We sought to identify a curve magnitude at which fusion is undertaken for NMS and to evaluate the relationship between operative curve size and clinical outcomes.

Methods
A prospective multicenter pediatric spine database was queried for patients with a Gross Motor Function Classification Scale (GMFCS) IV or V who underwent PSF for CP scoliosis with at least 2 years of follow-up. We examined patient demographics, curve magnitude, post-operative radiographic outcomes, and CPCHILD scores.

Results
489 patients from 15 sites were included in our analysis. We evaluated 264 (54.0%) males and 226 (46.0%) females who were fused at a median age of 14.2 years (IQR 11.8-16.3 years). The median major Cobb angle at time of PSF was 87° (IQR 72-104°) and significantly varied by site ($p<0.001$). The median Cobb angle on bending or traction radiographs was 55° (IQR 40-72°) and median percent correction on flexibility studies was 63.7% (IQR 50.0-77.1%). Severity of the curve at surgery correlated significantly with lower preoperative overall quality of life ($\rho= -0.147$, $p=0.003$) and total CPCHILD score ($\rho= -0.120$, $p=0.018$). Age, sex, and GMFCS did not significantly influence curve magnitude at surgery ($p>0.05$). 2-year post-operatively, patients with larger operative curves were left with greater residual curves ($\rho=0.539$, $p<0.001$), although post-operative CPCHILD scores did not differ by curve size or flexibility at time of fusion, magnitude of correction, or size of residual curve ($p>0.05$).

Conclusion
Although clinical outcomes were not influenced by larger curve size at surgery, patients in higher quartiles of operative curve size were left with larger residual curves. While early fusion of NMS may improve radiographic outcomes, patients fused later may be assured beneficial effects of PSF are still available at a larger residual curve size.



Comparing residual curve size by operative curve size.

76. PREVALENCE AND RISK FACTORS OF PELVIC ROD/SCREW RADIOGRAPHIC LUCENCY AFTER SURGERY IN SPASTIC CEREBRAL PALSY SCOLIOSIS PATIENTS: A LONGITUDINAL STUDY

Armagan C. Ulusaloglu, MD; Ali Asma, MD; James R. Bowen, MD; Petya Yorgova; Jason J. Howard, MD; M. Wade Shrader, MD; Suken A. Shah, MD

Hypothesis
The hypothesis was that we might describe a type of radiographic lucency in the area of pelvic fixation that is benign, not associated with risk factors or complications; that is ubiquitous.

Design
We evaluated demographics, radiographs, and complications in 101 cases from a single center to determine prevalence, risk factors, complications associated with persistent radiographic lucency from one to more than five years following spinal fusion.

Introduction
The aim of the scoliosis surgery in cerebral palsy restore coronal and sagittal spinal alignment, to improve sitting ability and personal care. Correction of pelvic obliquity is achieved by instrumentation to the sacropelvic; and, while many techniques are available, no technique is superior. Implants used for pelvic fixation are frequently associated with deformation of a radiographic lucent zone about instrumentation in the pelvis, prompting concern, even in asymptomatic patients since the fate of significance of this lucent zone is unclear.

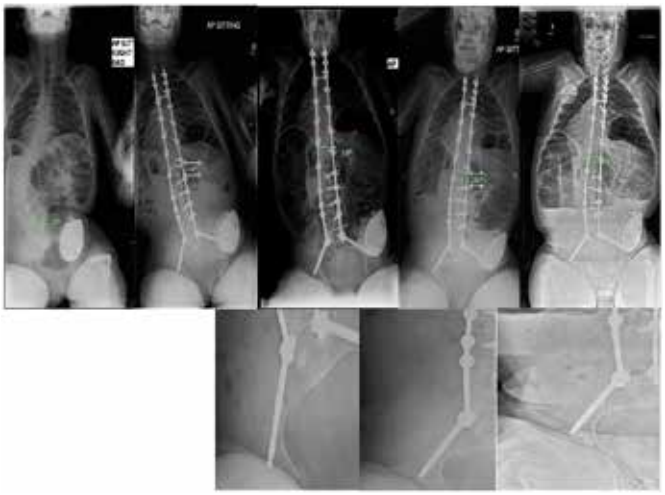
Methods
Inclusion criteria were diagnosis of non-ambulatory spastic cerebral palsy under 18 years of age, scoliosis with pelvic fixation (Galveston rod, iliac or sacroiliac screw),adequate radiographs (one/two/more than 5 year follow up). Demographics,radiographic parameters,comorbidities,type of pelvic screw/rod,use of off-set connector, screw

PODIUM PRESENTATION ABSTRACTS

width,associated with posterior column osteotomy and/or additional anterior spinal release concurrent with posterior spine fusion, and infection over the follow-up period.Logistic regression analysis was used to define risk factors(p=0.05).

Results
In 101 patients, mean interval of one-year, two year and more than five-year follow-up were 12.9±1.5, 25.8±2.5 and 81.5±23 months respectively. Prevalence of pelvic rod/screw radiographic lucency were unchanged at 33% ,35% and 24% in first year, second year and more than five year follow up respectively, and radiographic parameters did not change (p>0.05).No risk factor or complication were found to be associated with radiographic lucency around pelvic rods/screws(p>0.05).

Conclusion
Prevalence of pelvic rod/screw lucency is high.Persistent lucency greater than 2mm around pelvic implants does not appear to be clinically significant, warrant advanced imaging or indicate a complication if stable over time and wider distally rather than proximally



≥2mm lucency, stable curve

77. PROXIMAL JUNCTIONAL KYPHOSIS AFTER SPINAL DEFORMITY CORRECTION IN CEREBRAL PALSY: INCIDENCE AND PREDICTIVE ANALYTICS

Nicholas Gajewski, MD; Ali Asma, MD; Paul D. Sponseller, MD, MBA; Amit Jain, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Burt Yaszay, MD; *Suken A. Shah, MD*; Harms Study Group

Hypothesis
Development of proximal junctional kyphosis (PJK) is associated with increased thoracic kyphosis (TK) and decreased HRQoL in patients with cerebral palsy (CP).

Design
Retrospective review of prospective multicenter CP patient cohort who underwent posterior spinal fusion (PSF) with minimum 2 yr follow-up.

Introduction
PJK is a common and clinically significant complication after PSF, but little is known about the risk factors, reoperation rate, or the effect of PJK on HRQoL in patients with CP.

Methods
PJK was defined as a change in kyphosis greater than 10° above the UIV over 2 levels compared to first erect post-op X-ray. Logistic regression was used to evaluate risk factors for PJK. Receiver operating characteristic curve analysis determined a preop T2-T12 kyphosis threshold for development of PJK.

Results
319 patients were included with mean follow-up 3.9 yrs (SD 1.7 yrs). Average age at surgery was 13.9 yrs (SD 2.7 yrs). The incidence of PJK was 14% (45/319), with an average 14° (range: 10-30°) of kyphosis. In those who developed PJK, 16% (7/45) underwent revision for infection, instrumentation complications, or both. The incidence of PJK differed between construct types: proximal hook constructs had the lowest rate (9%), compared to unit rods (16%) and all screws (21%) (p=0.018). Preop TK (T2-T12) was 52° (SD 27°) in the PJK group compared to 40° (SD 23°) in the no-PJK group (p<0.05). Magnitude of TK correction was different between the PJK and no-PJK groups (p=0.07). CPCHILD health domain scores were significantly lower at 2-year follow-up in those that developed PJK (p=0.018). Patients classified as having no mental impairment had a 15.6% incidence of PJK compared to 7.7% in those with any level of mental impairment (p=0.08). Preop T2-T12 kyphosis greater than 72° had a 92% specificity and 27% sensitivity in predicting postoperative PJK (p=0.018). Patients with GMFCS level 5.3 had the highest incidence (66%) of PJK (p=0.06).

Conclusion
The incidence of PJK after PSF in patients with CP was 14% and 16% required reoperation. Patients who developed PJK had more TK preoperatively, lower HRQoL scores postoperatively, were more likely to have larger corrections and were more likely to be GMFCS level 5.3. Preoperative TK greater than 72° was found to have 92% specificity in predicting PJK. Proximal instrumentation with hooks had the lowest rate of PJK, but UIV level was not predictive.

78. POSTOPERATIVE URINARY RETENTION OCCURS IN 1 IN 5 PATIENTS AFTER POSTERIOR SPINAL FUSION FOR NEUROMUSCULAR SCOLIOSIS

Rachel Lai, BA; Kenneth D. Illingworth, MD; David L. Skaggs, MD, MMM; *Lindsay M. Andras, MD*

Hypothesis
Postoperative urinary retention (POUR) following posterior spinal fusion (PSF) for neuromuscular scoliosis (NMS) is very common.

Design
Retrospective Single Center

Introduction
Although POUR can occur after any surgical procedure, NMS patients may be at increased risk because of underlying neurologic involvement, as well as the type and duration of surgery. This may be particularly concerning for parents/providers trying to differentiate between typical POUR and a neurogenic bladder that could signify an intraoperative or postoperative neurologic injury. Our

objective was to quantify the incidence, duration and outcome of POUR in NMS.

Methods
Retrospective review of NMS patients undergoing PSF between January 2004 and May 2019 at a tertiary pediatric hospital with > 2 years follow up. Patients who were catheter dependent preoperatively were excluded. POUR was defined as needing catheterization or Foley reinsertion following initial Foley removal. Electronic medical records were reviewed.

Results
299 patients met the inclusion criteria. Mean follow-up was 55.6 ± 25.6 months (range: 24-181 months). 60 (20%) of 299 patients had POUR following spinal surgery and required a mean duration of intermittent catheterization of 3.6 days (range: 1-27 days). 10 of the 60 patients with POUR (16.7%) had Foley reinsertion. 3 patients (5%) were diagnosed with and treated for a postoperative urinary tract infection. In 92% (55/60), POUR resolved prior to discharge. 5 patients had continued symptoms of POUR at the first postoperative visit (2-4 weeks following the procedure), 4/5 resolved by the three month postoperative appointment. The other patient was noted by urology to have findings of severe hydronephrosis and urinary retention consistent with a neurologic bladder on their preoperative MRI.

Conclusion
POUR occured in 20% of NMS patients after PSF and resolved in 98% of cases.

79. PELVIC OBLIQUITY CORRECTION IN SCOLIOSIS SURGERY IN CEREBRAL PALSY: A RADIOGRAPHIC ANALYSIS OF 208 PATIENTS

Ib J. Green-Petersen, MD; Luigi Magnano, MD; Anastasios Charalampidis, MD; Paul Gerdhem, MD, PhD

Hypothesis
There is a difference in pelvic obliquity correction in patients with cerebral palsy and scoliosis operated with spinal fusion surgery to either L5 or the pelvis.

Design
Retrospective study

Introduction
Fusion surgery is the definitive treatment for individuals with cerebral palsy and scoliosis. There is no consensus whether the fusion should be extended to the pelvis or not. The aim of this study was to compare radiological outcome and complications in individuals fused to the fifth lumbar vertebra (L5) or below.

Methods
208 cerebral palsy patients aged 10 through 25 years at surgery were identified in the national quality registry Swespine. Complications and reoperations were collected from the registry. The Cobb and the Maloney methods were used for radiographic analyses. Statistical analysis was performed using the Welch-Satterthwaite t-test, the Mann-Whitney U-test, the Chi-square test and Fisher's exact test.

Results
58 individuals were fused to L5 and 150 to the pelvis. Mean follow-up time was 2.3 years. Preoperatively, the mean (SD) pelvic obliquity was 18° (12°) in the L5 group and 23° (14°) in the pelvic group (p=0.01). The immediate postoperative correction was 9° (10°) in the L5 group and 13° (12°) in the pelvic group (p=0.008) with no significant difference in correction rate (p=0.11). Mean loss of pelvic obliquity correction at last follow-up was -5° (7) and -4° (6), respectively (p=0.03). Operative time was 318 (98) mins in the L5 group and 365 (116) mins in the pelvic group (p=0.006). 8 (14%) and 22 (15%) individuals sustained at least one complication (p=0.87) and 5 (9%) and 14 (9%) required at least one reoperation (p=0.87), respectively. In a subgroup analysis of 58 cases in the L5 group and 58 cases in the pelvic group matched on preoperative pelvic obliquity, the pelvic obliquity correction was 9° (10°) and 8° (11°), respectively (p=0.10).

Conclusion
Both fusion to L5 and the pelvis results in pelvic obliquity correction with similar risk of complications, and a sustained correction of pelvic obliquity.

80. TEN-YEAR FOLLOW-UP OF SPINOPELVIC PARAMETERS IN CHILDREN WITH ACHONDROPLASIA

Luiz Silva, MD; Ali Asma, MD; Kenneth J. Rogers, PhD; Armagan C. Ulusaloglu, MD; James R. Bowen, MD; William G. Mackenzie, MD; *W.G. Stuart Mackenzie, MD*; Abdulhalim Akar, MD; Yoshinao Koike, MD; Helene Pillet, PhD

Hypothesis
Spontaneous resolution of thoracolumbar kyphosis in children with achondroplasia is correlated with their spinopelvic parameters.

Design
Single center retrospective cohort study

Introduction
Thoracolumbar kyphosis (TLK) deformities in children with achondroplasia resolve in 70% one year after independent walking and 90% by 10 years old. Our objective is to evaluate the relationship with spinopelvic parameters, beginning prior to walking, up to 10 years old. We believe that pelvic tilt will predict spinopelvic outcomes.

Methods
Patients with achondroplasia with clinical exam and lateral spine radiographs (pre-walking, 1 year after independent walking, 5 years old and 10 years old) were identified. Medical records were reviewed for demographic and clinical details, and radiographs analyzed for spinopelvic parameters. Chi-square and t-test were used for statistical analysis of the relationship between clinical data and sagittal balance over 10 years.

Results
Sixty-two children with achondroplasia (32 male, 30 female) had radiographs and clinical data from pre-walking and 1 year after walking. Mean age at first exam was 10±3 months. Forty (65%) children showed TLK resolution

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(<20°) at 1 year after walking, 42 (68%) by 5 years old and 17 (89%) at 10 years old. No child required spinal decompression and fusion for progressive deformity or symptomatic spinal stenosis. Twenty-four patients had follow-up at 10 years old and were divided into two groups: positive pelvic tilt (PT) (7) and negative pelvic tilt (17). (Table 1) At the initial radiograph, children with negative PT had higher sacral slope (SS) (p=0.006) and lumbar lordosis (LL) (p<0.001), and lower pelvic incidence (PI) (p<0.001). This significant relationship remained constant through age 10. (Figure 1 and 2) When comparing the two groups, there was no association with the persistence of TLK.

Conclusion

In this largest series to date, spontaneous resolution of TLK in children with achondroplasia was 65% 1 year after walking and 89% by 10 years old. With early identification and regular follow-up with patient education, no patient in this series required treatment or developed symptomatic spinal stenosis. While not predictive of resolution of TLK, dichotomous presentation of pelvic tilt in children with achondroplasia persists at 5 and 10 years of age and reliably predicts spinopelvic parameters.

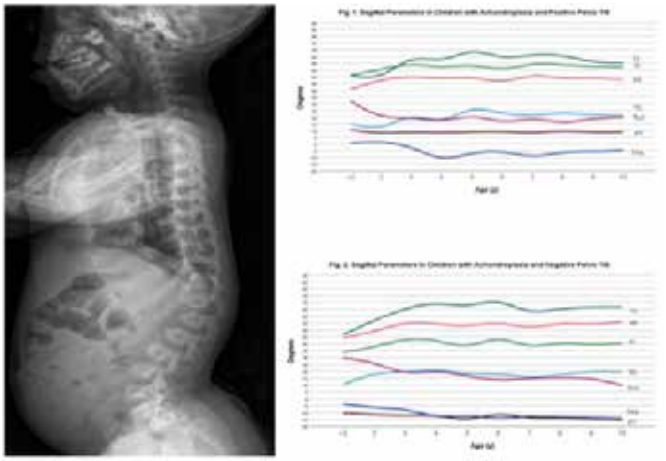


Table 1. Sagittal spinopelvic parameters of 24 children with achondroplasia divided into two groups by positive and negative pelvic tilt measured at 1 year after walking

Spinopelvic parameters of 24 children with Achondroplasia over 10 year followup

81. THE ONE-WAY SELF-EXPANDING ROD: RESULTS AND COMPLICATIONS IN A PROSPECTIVE SERIES OF 21 NEUROMUSCULAR SCOLIOSIS WITH MORE THAN 3-YEAR FOLLOW-UP

Lotfi Miladi, MD; Mathilde Gaume, MD; Nejib Khouri, MD

Hypothesis

The aim of this study was to report the preliminary results of a new self-growing rod in a series of 21 neuromuscular early onset scoliosis. We hypothesized that this device would maintain a stable correction of spinal deformity with a reduced rate of complications thanks to the avoidance of repetitive surgery while preserving spinal and chest growth.

Design

Monocentric prospective study.

Introduction

Fusionless techniques for treatment of early onset neuromuscular scoliosis are increasingly used to preserve spinal and thoracic growth, but surgical-related complications rate remains high. The self-expanding rod was designed to avoid repetitive surgery and to preserve spinal and thoracic growth thanks to its free sliding.

Methods

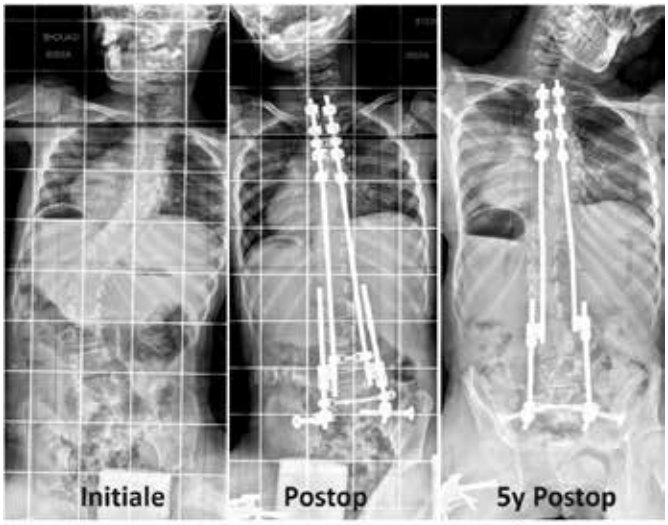
Patients with EONMS who underwent fixation with self-expanding rod were prospectively recorded with a minimal follow-up of 3years. The surgical technique relies on a minimally invasive bipolar fusionless fixation from T1 to the sacrum. The self-expanding device comprises a rod with a notched part that slides freely in one direction inside a domino. The rods expanded spontaneously in all cases. Changes in Cobb angle, pelvic obliquity, thoracic kyphosis, lumbar lordosis, T1 -S1 and T1-T12 length, space available for lung and chest width were assessed. All types of complications were reviewed.

Results

Mean age at surgery was 10.5years. Mean follow-up was 3.9years. Mean pelvic obliquity improved from 20° to 8° postoperatively, and 6° at last follow-up. Mean Cobb angle improved from 66° to 38° postoperatively, and 32° at last follow-up. Mean preoperative kyphosis was reduced from 41° to 26° at last follow-up (p=0.13). Mean preoperative lordosis was 34° and 38° at last follow-up (p=0.10). Mean growth per month of the T1-T12 segment was 0.8mm and 1.5mm for T1-S1. Global complication's rate was 38% (2 surgical site infections, 3 lacks of rod expansion due to a misplaced crosslink, 1 pyelonephritis and 2 central veinous catheter-related infection). At last follow up, the correction was maintained. No patient needed a conversion to an arthrodesis.

Conclusion

The self-growing rod associated with minimally invasive bipolar technique for EONMS provided satisfactory and stable correction of spinal and pelvic deformities after 3years follow-up with a reduced rate of complications. A longer follow-up is required.



82. GRADUAL CORRECTION OF SCHEUERMANN'S KYPHOSIS BY USING GROWTH MODULATION: PRELIMINARY RESULTS OF FLEXIBLE POSTERIOR VERTEBRAL TETHERING

Mehmet Aydogan, MD; Tuna Pehlivanoglu, MD; Yigit Erdag, MD; Umut D. Akturk, MD; Abdulhalim Akar, MD; Ozgur Basal, MD

Hypothesis
Posterior Vertebral Tethering (PVT) might induce a growth arrest on posterior portion of vertebral growth plates by compression, while accelerating growth on anterior portion of growth plates by distraction, resulting in gradual correction of the kyphotic deformity.

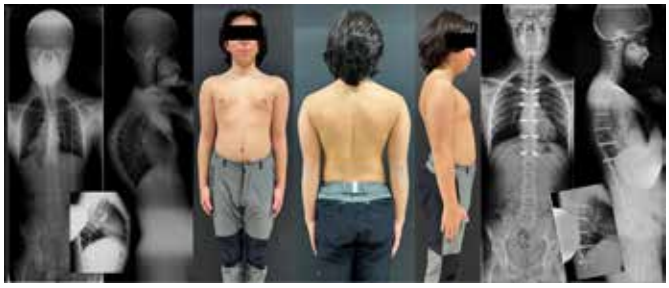
Design
Prospective Case series

Introduction
Vertebral body tethering as a growth modulating, motion preserving surgical option is gaining popularity to correct scoliosis in skeletally immature patients. We aimed to question the safety and efficacy of PVT as a fusionless, growth modulatory approach used for the first time in the literature in 10 skeletally immature patients with Scheuermann's kyphosis (SK) by describing the surgical technique.

Methods
10 patients (mean follow-up:41 months,36-48) with a diagnosis of SK had a mean age of 13.2 years (13-15) with thoracic Cobb angles of 81 (79-83) and mean flexibility of 39% (35-43). Persistant back pain with unacceptable cosmetic results as a result of failed conservative treatment of at least a year was noted. It was discussed with the patients and their families, that this was an off-label use of the device and may yield to additional future surgeries.

Results
Wiltse approach was utilized and by using Zimmer Dynesis system. Pedicle screws of a diameter of 6.5mm were placed on either side at levels of T4-T6-T8-T10-T12. Tethering cord was then applied to screws. After sufficient tethering and achievement of correction, set screws were placed and secured on the tether at each level. A mean correction of 42 of kyphosis was detected immediately after surgery (mean pre-operative: 81, Post-operative: 39, $p<0.001$). At 1st,2nd and 3rd year follow-up, mean sagittal Cobb angles were measured as 42, 37, and 32 ($p<0.001$) indicating gradual correction. 3rd year post-op lumbar lordosis improved from 44.6° to 33.7°, sagittal vertical axis improved from -19mm to -3.8mm, vertebral wedge angle from 14.1 to 6.2, total SRS-22 score from 3.6 to 4.8. At the end of 3rd year spinal segments were shown to be mobile by using fulcrum X-rays.

Conclusion
The present case series demonstrated promising radiographic and functional results regarding the gradual correction of SK as a result growth modulation applied by applying flexible posterior vertebral tethering (PVT) which might be an alternative to fusion in adolescent patients with SK.



Pre-op X-rays, Post-op 3rd year Clinical pics + X-rays

83. SURGICAL OUTCOMES FOR SPINAL DEFORMITY IN OSTEOGENESIS IMPERFECTA

Susan Sienko, PhD; Carol A. Tucker, PhD; *Michelle C. Welborn, MD*

Hypothesis
Pts with Osteogenesis imperfecta (OI) are at high risk of developing scoliosis, we hypothesized that severity of bone disease would correlate with progression of scoliosis

Design
IRB approved retrospective review of the the SHOnet (Shriners Health Outcomes Network), electronic health record database from 1/1/11 to 12/31/17

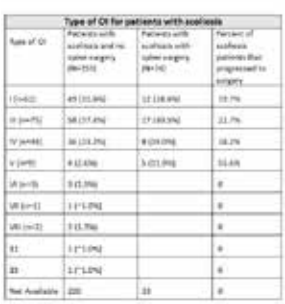
Introduction
OI is the most prevalent pediatric genetic bone disorder of bone, with an incidence of 1/15,000-20,000. Scoliosis has been reported in 39-100% of OI patients and may progress in adulthood. The purpose of this study is to examine the prevalence of scoliosis in OI. The rate at which these pts progress to surgery, the perioperative complication rate, if there is an association between complications and age at surgical intervention, pre-operative Cobb angle, number of fractures, ambulatory status and type of OI

Methods
Inclusion criteria included International Classification of Diseases (ICD) code for OI and scoliosis. The database was queried for age, gender, presence of vertebral body fractures, proximal junctional kyphosis, basilar invagination, bisphosphonate use, and perioperative complications including post-op infection

PODIUM PRESENTATION ABSTRACTS

Results
There were 2,372 OI pts, 18.1% also had scoliosis, while 81.9% did not. Only 74 pts with scoliosis underwent spine surgery with an average preop thoracic Cobb 58.18 (range 7-115), and thoracolumbar Cobb 59.83 (range 5-145). Twelve had staged surgery, 5 required revision spine surgery. Average time to revision was 3.88 years (6.9mo-69mo). Bisphosphonate use was present in 35.5% of patients that did not require surgery and in 40.5% that did

Conclusion
With over 2,300 patients this is the largest study to date on scoliosis in patients with OI. We found that contrary to prior studies which had indicated rates of scoliosis from 39-100% that it was only present in 18% of our patients. Furthermore, only 17% of those patients in our study with scoliosis eventually underwent surgery. This indicates that the rate of scoliosis in OI is potentially lower than previously reported, many may never require surgical intervention and those that do require surgical intervention have an 8% reoperation rate at an average of 3.3 years postop. Patients with Type III and Type V were most likely to progress to surgery. Lastly, bisphosphonate does not appear to impact the likelihood of progression to surgery in this group of patients, though this may be due to later initiation of the bisphosphonate use



84. UNPLANNED RETURN TO THE OPERATING ROOM (UPROR) OCCURS IN HALF OF MCGR PATIENTS AT 2.4 YEARS AFTER INITIAL IMPLANTATION

Amy L. McIntosh, MD; Anna McClung, BSN; John T. Smith, MD; Paul D. Sponseller, MBA; Matthew E. Oetgen, MD; Pediatric Spine Study Group

Hypothesis
A majority of MCGR implants would survive to achieving maximal lengthening without UPROR.

Design
Multiple institution, retrospective review of prospective data. (PSSG Study Group)

Introduction
At the onset of the Magnetic Controlled Growing Rod (MCGR) era, a number of studies were published assessing potential cost-effectiveness of MCGR compared to Traditional Growing Rods (TGR). MCGR was found to be cost effective compared to TGR but these studies were limited by estimates being drawn from small cohort studies/ expert opinion. The goal of this study was to determine an accurate accounting of the rates of UPROR in patients that underwent MCGR implantation from a large multi-center prospective database.

Methods
EOS patients that underwent MCGR implantation were reviewed. If the patient did not experience an UPROR, then they had to have undergone at least 3 lengthenings during the follow up period. Age at placement, preop cobb, immediate post-implantation cobb, diagnosis, lengthening duration, and cause of UPROR were analyzed.

Results
376 EOS patients were included. No patients had surgery prior to initial MCGR implantation at a mean age of 7.7 yrs. The mean pre-op cobb was 76.7°, and immediate postop correction was 41%. We found that 45% (168/376) of MCGR patients experienced an UPROR prior to maximal actuator length being achieved. UPROR occurred at an average of 2.42 years after initial implantation. The most common reason for UPROR was MCGR implant (44/376: 11.7%) or anchor related complications (70/376: 18.6%). Wound related: 32/276 (8.51%), Neuro related: 6/376 (1.59%), and Other: 16/376 (4.25%) accounted for the remaining UPROR occurrences. Patients that experienced an UPROR were younger at MCGR insertion (6.98 vs. 8.07 yrs.) p= 0.00001, and stiffer, with less initial correction (38.6° vs. 42.7°) p = 0.0441. There were no differences when in preop cobb (76.6° vs 76.8°, p=.9), or BMI (16.5 vs. 16.3, p = .9). Having an underlying neuromuscular diagnosis was associated with wound related UPROR. (p=0.001)

Conclusion
MCGR UPROR rate was 168/376 (45%) after an average of 2.42 years post implantation. The "true" survival rate of the MCGR is lower than the initial estimates, and this may impact the time required to achieve cost neutrality of this implant.

85. COMPLICATIONS ASSOCIATED WITH USE OF MCGRS AND TGRS IN THE MANAGEMENT OF EOS: A MULTICENTER DATABASE STUDY OF 800 PATIENTS

Smitha E. Mathew, MBBS; David L. Skaggs, MD, MMM; *Craig M. Birch, MD*; Matthew E. Oetgen, MD; Pediatric Spine Study Group

Hypothesis
In early onset scoliosis (EOS) patients, complications and unplanned surgical procedures will be higher with traditional growing rods(TGRs) as compared to magnetically controlled growing rods(MCGRs).

Design
Retrospective review

Introduction
TGRs, though commonly used for the management of EOS, require multiple surgical procedures and are associated with high complication rates. With the introduction of

MCGRs, there was reduction in the number of surgical lengthening procedures.

Methods

Children with EOS with a minimum of 2-year follow up were identified from the Pediatric Spine Study Group database. Patients were categorized as those treated with TGRs and those with MCGR placement. Patient demographics, radiographic parameters and complications were reviewed.

Results

803 EOS patients treated between 2006 and 2021, including 372 with TGRs and 431 with MCGRs, met the inclusion criteria. Mean age at index surgery was 7.5years(range,2.1 to 11);mean duration of follow-up was 48.7(SD 25.7)months(Table 1).271 TGR patients had a minimum of one complication in comparison to 206 MCGR patients(p<0.001).Complications rate in TGRs was 24% and 50% in MCGRs(Table 3).Unplanned return to OR was significantly higher among TGRs(255 versus 120;p<0.001), with implant related complications being the most common cause. This included implant breakage(30.6% versus 7.9%;p<0.001) followed by prominent implants(10.5% versus 5%;p<0.001). 86 TGRs developed wound complications in comparison to 50 MCGRs(p<0.001).Pain and neurological injury was more common in the TGR group(p<0.001 and p=0.007 respectively)(Tables 1 and 2). Odds of incurring a minimum of one complication was around three times higher with TGRs as compared to MCGRs(p<0.001)(Table 4).Within individual cohorts, odds of incurring at least one postoperative complication was over 3 times higher with every additional surgery in the MCGR group while in the TGR group it was 1.2 times higher(p<0.001)(Table 5).

Conclusion

TGR patients had more total complications, implant related complications(breakage and prominence), wound complications, pain, neurological injury and unplanned surgical procedures than MCGRs. Older age at implantation and limiting additional surgical procedures may help reduce risk of complications. Our overall reported complication risk with TGRs was similar to previous report by Bess and colleagues. MCGR is an effective option for the management of EOS.

Table 1: DEMOGRAPHICS

Demographic and baseline characteristics	Overall (N= 803)	TGR (N= 372)	MCGR (N= 431)	P value
	Mean (SD) or n (%)			
Mean age at index sx in years, mean [range]	7.5 [2.1-11.0]	7.2 [2.5-11.0]	7.7 [2.1-10.9]	**0.001**
Mean age at final definitive sx in years, mean [range]	12.6 [5.2-18.5]	12.7 [7.0-16.0]	12.2 [5.2-18.5]	**0.025**
Female, n (%)	476 (59.3)	220 (59.1)	256 (59.4)	0.941
Etiology, n (%)				
Congenital	96 (12.0)	57 (15.3)	39 (9.0)	
Idiopathic	193 (24.0)	81 (21.8)	112 (26.0)	
Neuromuscular	295 (36.7)	119 (32.0)	176 (40.8)	**0.003**
Other	5 (0.6)	2 (0.5)	3 (0.7)	
Syndromic	214 (26.7)	113 (30.4)	101 (23.4)	
Major Cobb magnitude (degree)				
Initial	75.3 (21.5)	76.2 (21.4)	74.5 (21.6)	0.272
Latest follow up	46.6 (18.8)	49.0 (19.7)	44.5 (17.6)	**0.001**
Change in major Cobb angle	28.5 (20.2)	26.8 (21.2)	29.8 (19.2)	**0.045**
Kyphosis magnitude (degree)				
Initial	54.9 (25.2)	54.6 (26.6)	55.2 (24.0)	0.77
Latest follow up	50.5 (22.0)	53.4 (23.4)	47.8 (20.3)	**<0.001**
Change in kyphosis	4.6 (25.5)	1.6 (25.9)	7.5 (24.8)	**0.004**
Duration of follow up (months)	48.7 (25.7)	60.3 (29.8)	38.6 (15.5)	**<0.001**
Surgical procedures per pt [mean (SD)]	5.0 (4.7)	8.7 (4.6)	1.8 (1.3)	**<0.001**
Lengthening procedures per pt [mean (SD)]	7.7 (6.4)	4.3 (2.8)	10.7 (7.1)	**<0.001**
Duration between lengthening procedures (months) [mean (SD)]	8.3 (7.5)	13.1 (8.7)	4.2 (2.0)	**<0.001**
Planned surgical procedures [no.] [mean (SD)]	3643 4.5 (4.2)	2970 8.0 (4.0)	673 1.6 (0.8)	**<0.001**
Unplanned surgical procedures [no.] [mean (SD)]	375 0.5 (1.1)	255 0.7 (1.3)	120 0.3 (0.7)	**<0.001**
Ratio of planned sx to unplanned sx	9.7:1	11.6:1	5.6:1	NA

Table 2: COMPLICATIONS TGR vs MAGEC (N=Number of patients)

	Overall (N= 803)	TGR (N= 372)	MCGR (N= 431)	P value
No. of patients with a minimum of 1 complication, n (%)	477 (59.4)	271 (72.8)	206 (47.8)	**<0.001**
Mean age at onset of complication in years [range]	8.6 [0.9-19.1]	9.0 [1.6-19.1]	8.0 [0.9-14.3]	**<0.001**
Wound complications, n (%)	136 (16.9)	86 (23.1)	50 (11.6)	**<0.001**
- Superficial	41 (5.1)	25 (6.7)	16 (3.7)	**0.053**
- Deep	65 (8.1)	48 (12.9)	17 (3.9)	**<0.001**
- Other wound problems	90 (11.2)	56 (15.1)	34 (7.9)	**0.001**
- UPROR due to wound problems	84 (10.5)	53 (14.2)	31 (7.2)	**0.001**
Implant complications, n (%)	295 (36.7)	191 (51.3)	104 (24.1)	**<0.001**
- Migration	27 (3.4)	11 (3.0)	16 (3.7)	0.554
- Implant break	148 (18.4)	114 (30.6)	34 (7.9)	**<0.001**
- Prominent implants	61 (7.6)	39 (10.5)	22 (5.1)	**0.004**
- Malfunction	4 (0.5)	0 (0.0)	4 (0.9)	0.063
- Failure to lengthen	15 (1.9)	0 (0.0)	15 (3.5)	**<0.001**
- UPROR due to implant complications	138 (17.2)	86 (23.1)	52 (12.1)	**<0.001**
Other complications, n (%)				
- Pain	102 (12.7)	76 (20.4)	26 (6.0)	**<0.001**
- Pseudoarthrosis	8 (1.0)	7 (1.9)	1 (0.2)	**0.019**
- Excessive blood loss	4 (0.5)	0 (0.0)	4 (0.9)	0.063
- Neuromonitoring change	12 (1.5)	6 (1.6)	6 (1.4)	0.797
- Neurological injury	42 (5.2)	28 (7.5)	14 (3.2)	**0.007**
* Sensory	15 (1.9)	8 (2.2)	7 (1.6)	0.583
* Motor	17 (2.1)	9 (2.4)	8 (1.9)	0.580
- Pulmonary (Pneumonia, Atelectasis, Respiratory Failure, Pulmonary effusion)	44 (5.5)	24 (6.5)	20 (4.6)	0.261

Table 4: ODDS RATIOS FOR RISK OF INCURRING A MINIMUM OF ONE PERIOPERATIVE COMPLICATION

	Odds Ratio	95% Confidence Interval	P value
Additional surgery beyond initial growing-rod implantation	1.27	1.22-1.34	**<0.001**
No. of lengthening	0.98	0.96-1.00	0.074
Age at initial growing-rod implantation	0.90	0.84-0.96	**0.003**
Type of implant (TGR vs MAGEC)	2.93	2.18-3.95	**<0.001**

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Table 5: ODDS RATIOS FOR RISK OF INCURRING A MINIMUM OF ONE PERIOPERATIVE COMPLICATION (MCGR versus TGR)

Variables	MCGR		TGR	
	Odds Ratio (95% CI)	P value	Odds Ratio (95% CI)	P value
Additional surgery beyond initial growing-rod implantation	3.48 (2.63, 4.74)	<0.001	1.24 (1.15, 1.35)	<0.001
No. of lengthening	1.03 (1.00, 1.06)	0.041	1.02 (0.94, 1.11)	0.721
Age at initial growing-rod implantation	0.91 (0.82, 1.00)	0.05	0.93 (0.83, 1.03)	0.182

86. INCIDENCE AND CHARACTERISTICS OF INSTRUMENTATION FAILURE IN GROWTH-SPARING SURGERY FOR PEDIATRIC SPINE DEFORMITIES: A RETROSPECTIVE REVIEW OF 1139 SURGERIES

Noriaki Yokogawa, MD; Satoru Demura, MD, PhD; Toru Yamaguchi, MD; Satoshi Suzuki, MD, PhD; Teppei Suzuki, MD, PhD; Kei Watanabe, MD, PhD; Keita Nakayama, MD; Yuki Taniguchi, MD, PhD; Hideki Murakami, MD, PhD; Takuya Yamamoto, MD; Ryo Sugawara, MD, PhD; Tesuya Ohara, MD; Noriaki Kawakami, DMSc

Hypothesis
The characteristics of IF in growth-sparing surgery for pediatric spine deformities could vary depending on the type of surgery and the number of lengthening procedures.

Design
A retrospective multi-center study.

Introduction
The complication rate for growth-sparing surgery is very high, and the risk of complications increases with the number of lengthening procedures. Instrumentation failure (IF) is a major complication of growth-sparing surgery, but there is no large-scale survey focusing on IF. In this study, we investigated the incidence and characteristics of IF in detail using a multi-center research database in Japan.

Methods
We reviewed 1139 growth-sparing surgeries for pediatric spine deformities performed between 2015 and 2017. Basic demographic information, radiographic measures, and the incidence per surgery and characteristics of IF were examined in two groups of surgeries using growing implants: growing rods (GRs) and vertical expandable titanium rib prostheses (VEPTRs).

Results
The incidence of IF per surgery was 4.3% (25/576 surgeries) and 4.1% (22/531 surgeries) in the GR and VEPTR groups, respectively, with no significant difference. The main complications were anchor loosening/dislocation (60%) and rod fracture (32%) in the GR group and anchor loosening/dislocation (50%) in the VEPTR group. In both groups, IF occurred even with a small number of lengthening procedures; the rod fracture occurred significantly later than the anchor dislocation in the VEPTR group, while there was no significant difference in the timing of these events in the GR group. The incidence of IF per surgery did not increase with the number of lengthening procedures. Almost all cases of IF required some kind of instrument correction, and about half of them required an unplanned return to the operating room.

Conclusion
The incidence of IF was 4.3% and 4.1% of surgeries using GRs and VEPTRs, respectively. It is important to note that IF occurred even with a small number of lengthening procedures, and an increase in the number of lengthening procedures did not increase the incidence of IF per surgery.

87. HOW DEEP IS TOO DEEP: THE ROLE OF TISSUE DEPTH IN MAGNETICALLY CONTROLLED GROWING ROD (MCGR) FORCE

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Hypothesis
Magnetically controlled growing rod distraction force will significantly decrease with increased distance from the external remote controller.

Design
Basic Science

Introduction
Magnetically controlled growing rods (MCGR) represent a significant advance in growth friendly EOS instrumentation, as they can be remotely lengthened without the need for repeated surgery. However, they rely on magnetic fields to lengthen, which decrease in strength as a function of distance. Thus, when magnetically controlled growing rods are implanted at relatively high tissue depths (e.g. obese patients), the distraction force may be reduced and compromise the implants ability to effectively lengthen. Therefore, the purpose of this study was to determine the relationship between MCGR distraction force as a function of distance from the external remote controller (ERC) to help guide clinical decision making for implant tissue depth placement.

Methods
Magnetically controlled growing rods (n=3) were tested with an external remote controller on a servohydraulic mechanical testing machine. Custom 3D printed nylon spacers were used to define a range of rod to ERC distances and verified with calipers. At each distance, the maximum force that the magnetically controlled growing rods could lengthen the full target distance was identified.

Results
Over a clinically relevant range (5-37mm), significant decreases ($p<0.05$) in MCGR distraction force were observed with increasing distance from the ERC (Figure 1). At a 5mm "tissue depth" distance from the ERC, rods could lengthen the full target distance against a 242N load, on average. However, at an 18mm distance from the ERC, this was reduced to 92N; and at a 24mm distance, this was further reduced to 50N. At a distance of 37mm from the ERC, 2/3 rods could not lengthen against a 10N force.

Conclusion
Magnetically controlled rod distraction force significantly decreased as a function of distance from the ERC. This

information may inform clinical decision making with respect to MCGR implant tissue depth, particularly for obese patients.

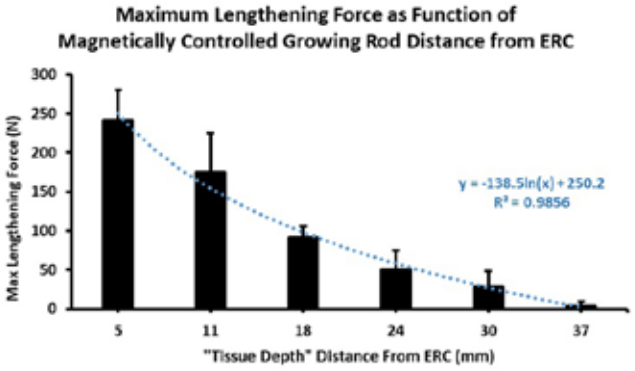

Figure 1: The maximum magnetically controlled growing rod distraction force significantly declines ($p<0.05$) with increasing distance from the external remote controller (ERC). Data are mean ± stdev from n=3 MCGRs.

88. PROXIMAL LEVEL SELECTION IN MAGNETICALLY CONTROLLED GROWING RODS: T2 OR T3 MAY BE PROTECTIVE AGAINST UPROR

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Hypothesis
UIV at T2 may be protective against an unplanned return to the OR in patients with WOS treated with dual MCGR

Design
Retrospective cohort study

Introduction
In comparison to traditional growing rods (TGRs), magnetically controlled growing rods (MCGRs) intend to reduce planned surgeries for lengthenings in the early onset scoliosis (EOS) population. Despite this, implant related complications and unplanned return to OR (UPROR) remains high. Clinical equipoise still exists surrounding the selection of upper instrumented vertebra (UIV) and its impact on UPROR.

Methods
Patients were identified from an international multicenter EOS database. Inclusion criteria were patients with EOS treated with dual MCGR, age ≤9 , availability of complete radiographs, and minimum of two year follow up. 507 patients were identified. Immediate postop and final follow-up x-rays were individually analyzed by two senior EOS specialists and two spine fellows. 185 patients were reviewed. UIV, number, type and anatomic location of proximal and distal anchors and rod orientation were documented in a digital spine template

Results
26.5% patients experienced UPROR for implant-related reasons (35.4% males vs 19.4% females, p=0.015). No significant differences were noted with respect to etiology of the scoliosis. A smaller change in spine height on initial postoperative imaging was associated with an increased risk for UPROR (p=0.049). A larger postoperative immediate curve (41.2° vs. 36.2°) was also associated with IRC, although not with UPROR. There were no differences noted with respect to the proximal fixation site (rib vs spine vs hybrid, p=0.497), or orientation of the rod. 164 (88.6%) patients had a UIV at T2 or T3, and 21 (11.4%) at other levels. UIV of T2 or T3 had a significantly lower UPROR rate (23.8% vs 47.6%) compared to other levels (p=0.02). Logistic regression analysis showed that a UIV at T2 or T3 are 66% less likely to have an UPROR compared to other levels (p=0.024)

Conclusion
Proximal UIV at T2 or T3 is protective against implant related UPROR in EOS patients treated with dual MCGR. A larger postoperative coronal curve angle and a smaller change in spine height postoperatively were associated with IRC, and implant related UPROR respectively. There were no significant differences with respect to rod orientation, or when comparing rib-based vs. spine-based constructs

89. THE LOWER INSTRUMENTED VERTEBRA DILEMMA IN GROWING ROD SURGERY

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Hypothesis
Saving distal segments in growing rods (GR) index surgery leads to a higher rate of adding-on

Design
Retrospective analysis of prospectively collected data

Introduction
Despite a wide experience with GR, there are still no established criteria on how to select the LIV at index surgery. Selecting too short an LIV may benefit growth sparing and mobility, but induce adding-on during follow-up

Methods
From a multicenter database, we selected ambulatory patients, suffering from EOS with an idiopathic curve pattern, treated at index surgery with GR (TGR/MAGEC), and followed by a minimum 2 years after graduation. Demographic, and radiographic (coronal and sagittal) data were studied. The LIV was analyzed regarding its relation to the stable vertebra (SV), the substantially touched -by the central sacral vertical line- vertebra (STV), and the not substantially touched vertebra (NSTV). Failure in LIV selection was considered when distal extension was needed due to adding-on (ΔLIV-tilt>10°, ΔLIV-disctilt>5°, ΔTSVL>10mm).

Results
125 patients were included (66% female). Mean age

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at index surgery was 8.1 years, with mean 7.2 years of follow-up. The mean Cobb was 74.4°. Most frequent LIV was L3. In 65 cases the STV was chosen as LIV, in 39 it was the NSTV, and in 21 the SV. Mean distal foundation anchors were 1.9 levels. During follow-up, 70 patients (56%) developed adding-on: 0% of SV, 60% of STV, 40% of NSTV. With no differences between magnetic vs TGR. However, only 23 (32.8%) of the patients with adding-on (18.4% of the whole sample) needed distal extension: 43.4% (10) of the STV, and 56.5% (13) of the NSTV. In general terms, the rate of extension if the LIV was set at the SV was 0%, at the STV 15%, and at the NSTV 33%. Risk factors for distal extension were: excessive immediate postop LIV-tilt (11.2°) and LIV-disctilt (5.8°). The selection of the LIV depended mainly on coronal radiographs, as sagittal images had little impact on the decision, they were less reliable. In 80% of the patients who underwent distal extension (mean 1.8 levels) this was performed during the last surgery, prolonged to SV or STV. It went down to the pelvis in only 2 occasions.

Conclusion

The higher the selection of the LIV above the SV at index surgery, the higher the risk for adding-on and distal extension during follow-up. Risk factors were excessive immediate postoperative (LIV and LIVdisc) tilt.

Table comparing different variables between group 1 (Adding-on with distal extension); group 2 (Adding-on without distal extension) and group 3 (No distal extension)

	Group 1	Group 2	Group 3	P1 G1 vs G2	P2 G1 vs G3
Number	23	47	102		
Gender	10 MALE 13 FEMALE	17 MALE 30 FEMALE	34 MALE 68 FEMALE		
Index Age (yrs)	8.1	8.1	8.1	0.20	0.15
Index Cobb	74.2°	74.5°	74.5°	0.73	0.21
Index sagittal SV	4% T9 12.5%T11 37.5% T12 12.5% L1 21% L2 12.5% L3	4.5% T7 4.5% T8 4.5% T9 2% T10 7% T11 18% T12 25% L1 29.5% L2 4.5% L3	1%T6 2% T7 5.5%T8 5.5%T9 2% T10 11% T11 17.5% T12 26% L1 19% L2 10% L3		
Index coronal					
SV	0	0	20.5%		
STV	43.4%	79.4%	53.9%		
NSTV	56.5%	20.5%	25.4%	P=0.008*	P=0.0009*
Index mean LIV	L1	L3	L3		
Postop LIV-tilt	11.2°	7.8°	6.6°	0.03*	0.002*
Postop LIVdisctilt	5.8°	3.5°	2.8°	0.006*	0.0002*
Postop CSVLT	16.2 mm	12.6 mm	8.26 mm	0.21	0.005*

SV: stable vertebra; STV: substantially touched vertebra; NSTV: not substantially touched vertebra; LIV: lower instrumented vertebra; CSVLT: central sacral vertical line traslation

90. THE PRICE OF ANOTHER CENTIMETER: REIMPLANTATION WITH A SECOND SET OF MAGNETIC GROWING RODS YIELDS DIMINISHING RETURNS

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Hypothesis

Reimplantation of a second set of magnetically controlled growing rods (MCGR) will yield less rod length and T1-T12 height gain compared to initial rod implantation

Design

Single center retrospective cohort study

Introduction

Many EOS patients receive multiple growth friendly implants before definitive fusion. Our study aims to compare the results in rod length and T1-T12 spinal height gain between a primary and second MCGR.

Methods

Patients with MCGR and minimum two years follow-up were identified. Patients with previous growth-friendly surgery were excluded. Pre-implantation, post-implantation, and last follow up post-lengthening radiographs were measured for rod length, T1-T12 height.

Results

We identified 77 patients who received MCGR; 56 met inclusion criteria. 9 had idiopathic EOS, 14 were neuromuscular, 28 were syndromic and 5 were congenital. 23 patients received a second set of rods with at least 2 years follow up. There was no statistically significant difference in age at time of index surgery between patients who received a second set of rods and those who did not (7.5 years vs 8.3, p= 0.2). Initial rods gained an avg of 2.09 cm and second rods gained an avg of 1.46 cm (p=0.02). Second rods achieved less gain per lengthening episode than initial rods (1.24 vs 2.8 mm p=0.02). T1-T12 height gained for initial rods was 4.16 cm, 2.19 cm after implantation and 1.97 cm post-lengthening. Second rods increased T1-T12 height 1.46 cm after lengthening, less than initial rods (p<0.001). On average initial rods were in place for 31.7 mos, but second rods for only 23 mos (p=0.04). In patients who received second rods, those with T1-T12 height >20 cm before second rods (9 patients) gained less than those with T1-T12 height ≤20 cm (14 patients) (1.13 cm vs 1.76 cm p= 0.16). Implant related revision rates were high: 28 patients were revised for failure to lengthen, 5 for rod breakage, 3 for screw pull out, and 1 for end cap failure.

Conclusion

Initial rods led to a total T1-T12 height gain of 4.16 with 50% from initial implantation and the remainder coming from subsequent lengthening. Second rods added an additional 1.46 cm of T1-T12 height gain and only 1.1 cm if T1-T12 was already more than 20 cm before second rod implantation. This study calls into question the value of revision to a second set of MCGR since the spinal length gains, patient benefit and cost effectiveness diminish with time.

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91. PREDICTING PULMONARY FUNCTION FROM THORACIC DEFORMITY PARAMETERS IN PRE-OPERATIVE EOS PATIENTS

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Hypothesis
Radiographic thoracic deformity parameters will correlate with % predicted preoperative pulmonary function test (PFT) measures in early onset scoliosis (EOS) patients.

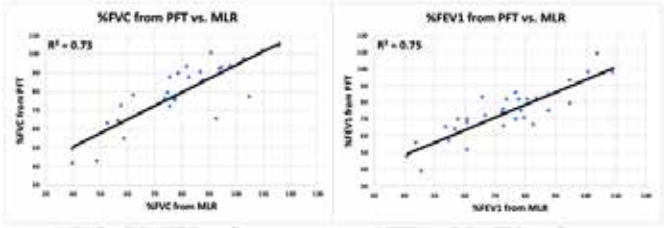
Design
Retrospective.

Introduction
Thoracospinal deformities in EOS often lead to thoracic insufficiency syndrome where lung growth and function are impaired. PFTs, used to assess lung function, are challenging to obtain in young EOS patients. Estimating PFT measures directly from radiographic thoracic deformity parameters would help to provide longitudinal outcome metrics following surgery to aid in clinical decision making.

Methods
Pre-operative PA and lateral radiographs and corresponding PFT (%FVC and %FEV1) measurements from 31 EOS subjects (11M/20F; mean age: 9.53 ± 3.14 years; 22 Idiopathic, 3 congenital, and 6 syndromic) were obtained from a large early onset scoliosis registry. A total of 18 radiographic literature-based thoracic deformity parameters were measured using a custom graphical user interface code (MATLAB R2018b, The MathWorks Inc.). Using SPSS v16.0 (IBM Corp.), after accounting for covariates, backwards elimination method was used to develop multiple linear regression (MLR) models to predict thoracic deformity measures. p value < .05 was considered statistically significant, and R^2 > 0.5 was considered clinically relevant.

Results
The MLR models and their respective coefficients (B) predicted %FVC and %FEV1 with high precision (R^2 ≥ 0.73, p < .001). Both models used the following thoracic deformity parameters: Rib Vertebral Angle Difference (RVAD), T6-Level Hemithorax Asymmetry, Thoracic Spine Height, Rib Hump Depth Index, and Spinal Intrusion Ratio. The %FEV1 model used an additional two parameters: number of involved vertebrae (within the main thoracic curve) and space available for the lung. The contribution of each predictor can be ascertained from the absolute value of Beta (Figure 1).

Conclusion
The MLR models provide clinically useful, precise predictions of %FVC (R^2 = 0.73) and %FEV1 (R^2 = 0.75) based on key radiographic thoracic deformity parameters. Sensitivity analyses using such models can help provide a surrogate measure to follow pulmonary function over time.



$\%FVC = \Sigma(B_i * TDP_i) + Constant$

FVC (% Predicted) Model Summary ($R^2 = 0.73$, $p < .001$)

i	Thoracic Deformity Parameter (TDP)	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	p
	(Constant)	100.99	8.78		<.001
1	T6-Level Hemithorax Asymmetry	-18.64	3.74	-0.76	<.001
2	Spinal Intrusion Ratio	-36.41	8.34	-0.75	<.001
3	Rib Hump Depth Index	158.78	46.15	0.65	0.002
4	Rib Vertebral Angle Difference (RVAD) (°)	-0.32	0.08	-0.54	<.001
5	Thoracic Spine Height (cm)	0.57	0.12	0.93	<.001

$\%FEV1 = \Sigma(B_i * TDP_i) + Constant$

FEV1 (% Predicted) Model Summary ($R^2 = 0.75$, $p < .001$)

i	Thoracic Deformity Parameter (TDP)	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	p
	(Constant)	161.37	31.01		<.001
1	T6 Level Hemithorax Asymmetry	-19.43	4.12	-0.88	<.001
2	Spinal Intrusion Ratio	-26.97	7.51	-0.62	0.002
3	Rib Vertebral Angle Difference (RVAD) (°)	-0.32	0.07	-0.59	<.001
4	Thoracic Spine Height (cm)	0.56	0.11	0.57	<.001
5	Rib Hump Depth Index	123.60	42.24	0.56	0.008
6	Space Available for the Lung (%)	-0.68	0.25	-0.44	0.013
7	Involved Vertebrae (# of Levels)	-3.36	1.55	-0.25	0.041

Figure 1: Multiple linear regression models to predict %FVC and %FEV1 using thoracic deformity parameters.

92. QUANTIFICATION OF DIAPHRAGM MOTION VIA FREE-BREATHING DYNAMIC MAGNETIC RESONANCE IMAGING

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Hypothesis
Quantification of regional motion of the hemi-diaphragms by free-breathing dynamic MRI (dMRI) is feasible.

Design
Retrospective cohort study

Introduction
The diaphragm is a critical structure in respiratory function yet quantitative description of its motion in the literature is limited. In the setting of spinal deformity, distortion of the insertion/origin of the diaphragm changes the surface topography of the muscle & likely alters function. We propose a novel 4D methodology for describing regional hemi-diaphragmatic motion via free-breathing dMRI.

Methods
After 4D image construction of the 3D chest from free-breathing dMRI acquired from a cohort of 51 normal children, we manually segmented the hemi-diaphragms at end-inspiration & end-expiration. We selected 25 points uniformly and homologously located on each hemi-diaphragm surface. Based on the caudo-cranial motion of these 25 points from end-inspiration to end-expiration, we computed their displacements & velocities. We estimated mean velocities for each of the 13 regions for each hemi-diaphragm over the subject cohort, where each region was composed of several points on the hemi-diaphragm surface.

Results
The mean and standard deviation of velocities for the 13 regions in the two hemi-diaphragms are listed in Table 1. The posterior-central regions of the hemi-diaphragms, where

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the area of apposition is, exhibited highest velocities, while anterior-medial regions had the lowest velocities. Most regions of the right hemi-diaphragm had statistically significantly greater velocities than homologous regions of the left hemi-diaphragm. The 13 velocities of the right hemi-diaphragm taken together were statistically significantly greater than those of the left hemi-diaphragm (p<<0.0001).

Conclusion

Regional diaphragm motion analysis is feasible using dMRI technology. The velocities of the right hemi-diaphragm are generally statistically significantly greater than those of the left hemi-diaphragm in normal children. Future larger scale prospective studies may be conducted using this method to confirm our findings in normal subjects and to quantitatively assess regional diaphragmatic dysfunction in the setting of spinal deformity or neuromuscular disease.

Table 1: Mean and standard deviation (SD) of velocities (mm/s) estimated in 13 regions of the right and left hemi-diaphragms in a cohort of 51 normal children along with P-values of left-to-right paired t-test comparisons.

Right hemi-diaphragm	Velocity (mean, SD) in mm/s		Left hemi-diaphragm	Velocity (mean, SD) in mm/s		P value
Anterior	5.06	2.04	Anterior	3.73	1.75	<0.0001
Posterior	8.74	3.69	Posterior	7.32	3.09	0.0070
Lateral	7.33	3.52	Lateral	5.99	3.68	0.0106
Medial	5.80	3.04	Medial	4.52	2.54	0.0135
Central	7.72	2.89	Central	5.96	2.85	0.0018
Anterior-Lateral	5.62	3.19	Anterior-Lateral	4.39	3.21	0.0106
Anterior-Medial	4.28	2.27	Anterior-Medial	2.86	1.94	0.0002
Anterior-Central	5.30	2.08	Anterior-Central	3.64	1.87	<0.0001
Posterior-Lateral	8.87	4.10	Posterior-Lateral	7.36	4.36	0.0094
Posterior-Medial	7.40	4.27	Posterior-Medial	6.38	3.82	0.1790
Posterior-Central	9.83	4.38	Posterior-Central	8.18	4.28	0.0571
Central-Lateral	7.60	3.59	Central-Lateral	6.31	3.84	0.0219
Central-Medial	5.71	2.98	Central-Medial	4.45	2.39	0.0053

93. INDEX DEFINITIVE FUSION PRODUCES OUTCOMES EQUIVALENT TO GROWTH-SPARING METHODS IN PATIENTS > AGE 6 YEARS

Charles E. Johnston, MD; David C. Thornberg, BS; Robert Palmer, MD

Hypothesis

There are no differences in outcomes between definitive correction/fusion (DF) as index procedure and growth-sparing (GS) techniques in patients age 6-10 years

Design

prospective data single institution, retrospective review

Introduction

Patients <10 years old by definition have early-onset scoliosis (EOS) implying that GS techniques are indicated to attain greater spine length and avoid early fusion with presumed pulmonary morbidity. With outcome reports of not infrequent revisions, UPRORs and complications, benefits of the GS method are not always intuitive especially if single DF procedures give equivalent xray parameter and PFT results.

Methods

We compared outcomes at 2yr minimum f/u from initial surgery by DF or GS procedures for patients >6 yr. N-m cases were excluded. Deformity correction, T1-12 and T1-S1 height, PFTs and EOSQ scores and complications were assessed.

Results

26 patients (8 congenital,7 idiopathic,11 syndromic) were identified. 13 were treated by definitive correction/fusion as index procedure (6 ASF/PSF,7 PSF only), while 13 had GS procedures (6 MCGR,6 TGR,1 VBT). Age at index procedure (DF 8.9yr,GS 7.2 p<.01) and clinical height (DF 122cm,GS 112 p<.05) were the only differences preop between groups. At f/u averaging 4.5 yr post index, DF had improved Cobb angle (DF 31.5deg,GS 47.7 p<.04) and % correction (DF 58%, GS 41), while GS had more absolute gain in T1-12(p=.04) and T1-S1(p=.015) length, although actual T1-12 (DF-19.2 vs GS-20.4cm) and T1-S1 (33.0 vs 34.4cm) heights and PFT values (FVC: DF 51.6%,GS 59.2; FEV1: DF 50.5%,GS 48.3) were no different. EOSQ pulmonary function domain (DF 77,GS 70) was no different, as were all other domains (Gen Health,Pain etc) with Satisfaction being lowest - DF 64,GS 63. TGR patients underwent mean 7.5 procedures, MCGR 2.5 while having 9 outpatient lengthenings, and DF had 1.4 surgeries. GS patients had 8 complications, 5 resulting in conversion to DF, while DF had 4, 2 requiring revision.

Conclusion

Except for better final curve magnitude and %correction in DF patients, and greater actual length gain in GS, there were no differences in xray or PFT results to suggest GS technique improved these outcomes. EOSQ scores were no different despite variation in number of procedures between DF vs GS cohorts. The necessity of utilizing GS methods for patients ages 6-10yr should be reassessed.

94. MORTALITY RATE IN PATIENTS TREATED FOR EARLY ONSET IDIOPATHIC SCOLIOSIS BEFORE MATURITY

Aina J. Danielsson, MD, PhD; Kerstin Lofdahl Hallerman, MD, PhD

Hypothesis

Treatment with brace or surgery completed before maturity in individuals with onset of idiopathic scoliosis before the age of 10 years will reduce the mortality rate to normal.

Design

176 consecutive patients with idiopathic scoliosis, diagnosed before the age of 10 years and treated before maturity, have been followed since start of treatment, with the last clinical follow-up at mean age 40 years. Information regarding mortality was collected from national registries.

Introduction

Mortality in individuals with onset of idiopathic scoliosis before the age of 10 years is increased from age 40 years if no treatment is given. We aimed to evaluate if treatment before maturity alters this outcome.

Methods

Information regarding mortality and cause of death was collected from national registries. For comparison, a control group was collected from the national population registry. Each patient received ten controls matched according to gender, age and living in the same area at the time of diagnosis of each individual patient.

Results

Follow-up after completed treatment was performed after

a mean of 38.1 years (range 22-53). The mean age was 53 (range 36-67) years at the time for collection of registry information. None of the 11 individuals with infantile onset (before age 4) were deceased. Out of 165 individuals with juvenile onset eight were deceased (4.8%) compared to 3.3% mortality in the control group (mean difference 1.6%, 95% CI 5.3; -2.1). Age at death was at a mean of 43 years (95% CI 33; 51), similar as for controls. Four of the deceased individuals were previously braced and four operated. They did not differ from those still alive in terms of curve size before (33° vs. 36°) or after treatment (20° vs. 27°), age at start of treatment or pulmonary function (forced vital capacity % of predicted) before treatment. Causes of death were in two cases neoplasms, in two circulatory disorders, in one multiple endocrine/inflammatory disorders and in three other causes.

Conclusion
Individuals with idiopathic scoliosis with onset before the age of 10 and treated before maturity show similar mortality compared to a control group at age of 50 years. This might indicate that treatment aimed to halt progression reduces the mortality, especially when compared to historical data showing increased mortality in similar but untreated patient groups.

95. CURVE CHARACTERISTICS AND SURGICAL OUTCOMES IN SCOLIOSIS ASSOCIATED WITH CHILDHOOD STERNOTOMY OR THORACOTOMY: A MULTICENTER STUDY OVER 19 YEARS

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Hypothesis
Use a multicenter approach to describe curve characteristics and surgical outcomes after spinal fusion for Post-Chest Incision scoliosis.

Design
Multi-center retrospective cohort study

Introduction
Thoracotomy and sternotomy in children are known thoracogenic scoliosis risk factors. This study describes curve characteristics and postoperative outcomes in patients with Post-Chest Incision scoliosis (PCIS) treated with spinal fusion.

Methods
A retrospective review of electronic medical records of all patients with PCIS treated with primary definitive fusion was performed at 2 tertiary care pediatric institutions over a 19-year period. Patients with neuromuscular and syndromic scoliosis were excluded. Pre and post-operative curve characteristics, operative and hospitalization parameters, rates of neuromonitoring alerts, and other complications were recorded.

Results
39 patients (61.5% female) were identified. 19 had a sternotomy alone; 13 had a thoracotomy alone; 7 patients underwent both approaches. Mean age at time of chest surgery was 2.5 years(range: 1.0 days-14.2 years). Leading cause of chest surgery was cardiac malformation(74.4%). 84.6% of patients had a main thoracic curve (mean cobb angle 71.6°, range: 40.0°-116.0°), commonly apex right (71.8%). Mean thoracic kyphosis was 39.9°(range: 3.7°-84.0°). 19.0% of patients with prior thoracotomy had rib fusions. Mean age at time of spinal fusion was 14.0 years (range: 8.2-19.9 years). 36 patients had posterior fusions; 3 patients had combined anterior/posterior arthrodesis. Mean of 10.7 levels were fused (range: 7-14). Mean coronal curve correction measured at first postoperative encounter was 53.4%(range: 8.5%-78.0%). There were 5(12.8%) neuromonitoring alerts and 2(5.1%) patients with transient postoperative deficits. Mean length of hospital stay was 9.0 ± 13.3 days. At an average follow-up time of 3.1 ± 2.4 years, 17 complications(13 Medical, 4 surgical) were noted in 10 patients for a 25.6% overall complication rate. There were no spinal reoperations in the cohort. 6/17 complications were (35%)Clavien-Dindo Sink class III and 3/17(17.6%) were class IV.

Conclusion
Right-sided kyphotic thoracic curves predominate in patients with PCIS undergoing PSF. Though good coronal and sagittal plane deformity can be expected following a fusion procedure, post-operative complications are not uncommon.

96. PREDICTION OF FUTURE CURVE SEVERITY IN IDIOPATHIC SCOLIOSIS BETWEEN AGE 6 AND SKELETAL MATURITY WITHOUT TREATMENT: A VALIDATED NATURAL HISTORY MODEL

Eric C. Parent, PhD; Sabrina Donzelli, MD; Maryna Yaskina, PhD; Alberto Negrini; Giulia A. Rebagliati, MD; Claudio Cordani, PT; Stefano Negrini, MD

Hypothesis
Future curve severity can be predicted from coronal x-rays taken prior and at the first specialist consult before starting treatment.

Design
Analysis of prospectively collected (n=22387) natural history data in a national clinical database since 2003.

Introduction
Our understanding of the natural history is limited because most models predicting curve severity have not been validated, did not include all growth or included treated patients. The objective was to predict future curve severity at a future timepoint specified by clinicians using x-ray data from prior to and at the first consult before starting any treatment.

Methods
We included patients with idiopathic scoliosis under age 26 previously untreated with an x-ray taken at their first specialist visit and with at least one prior spine x-rays. We excluded those with prior scoliosis-specific exercise, brace or surgery treatment. We extracted clinical variables for each x-ray: sex, age, triradiate, Risser, diagnosis (AIS or

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JIS), curve type, and max Cobb angle. Radiographs were re-measured blindly to ensure quality. Linear mixed-effect models with random effects and a variance components structure were used.

Results
We included 2317 patients (83% were females) with 3255 total prior x-rays where 71% had 1, 21.1% had 2, 5.6% had 3, and 1.9% had 4 or more (Max 8). Mean age was 13.9±2.2yrs (6-25) and 81% had AIS. Curve type was: 50% Double, 26% TL-L, 16% Th, and 8% other. Cobb angle at first x-ray was 20±10 (0-80) degrees vs 29±13 (6-122) at the specialist visit. Time between first x-ray and the clinic visit was 28±22mths. The best model to predict future Cobb angle was 4.41 + 1.12 Prior Cobb + 2.64 Time (in half-year) – 0.12Time^2 + 0.002 Time^3 -1.04 Risser -0.3 age@consult -0.29 time*Risser@prior visit-0.18 time*Sex. (coefficients p<0.008). Cross-validation found a median error of 4.38 (interquartile range 2.1-7.6) degrees (63.2% within prediction interval).

Conclusion
This is the first internally validated model to predict future Cobb angle in non-treated subjects. Our model can help clinicians predict how much curves would progress if offered no treatment at future timepoints of their choice using prior Cobb angle, Risser, sex, time to the prediction target and age at the target prediction time. This may help inform treatment prescription or reassure families not offered treatment.

97. NATURAL HISTORY OF IDIOPATHIC SCOLIOSIS: VALIDATED MODELS OF CURVE PROGRESSION FOR THREE GROUP AGES (PRE, AT AND POST GROWTH SPURT)

Stefano Negrini, MD; Maryna Yaskina, PhD; Sabrina Donzelli, MD; Giulia A. Rebagliati, MD; Alberto Negrini; Claudio Cordani, PT; Eric C. Parent, PhD

Hypothesis
The progression of idiopathic scoliosis (IS) can be predicted from x-rays obtained at the initial specialist consult.

Design
Secondary analysis of natural history data prospectively collected (n=22387) in a national clinical database since 2003.

Introduction
Knowledge of the natural history of IS during growth has limits (models not validated; only one age or treated patients included). We validated a model with fair precision (<63%) from age 6 to bone maturity to predict progression from the first x-ray. Duval-Beaupère described three progression risk periods: before, at, and after the growth spurt. We aimed to verify if three models specific to these growth periods provided better prediction than one encompassing all growth.

Methods
Inclusion: IS, age <26, no prior treatment, first consult and at least one previous spine x-ray. We identified three groups: before (GA), at (GB) and after (GC) growth spurt. Since growth spurt age is individual, for validation purposes, we chose the upper age limit for GA so to minimize Risser 1 patients (growth spurt ongoing) and have a sample size of GA good enough for validation. We developed linear mixed-effects models with random effects and a variance components structure to predict future Cobb angles. We evaluated models by the smallest Akaike (AIC) and Bayesian (BIC) Information Criterion. Due to the low number of males and the growth spurt differences between sexes, we developed a model for females and checked if valid for males in GB. We used two methods to evaluate the accuracy of the models: the standard prediction interval that comes with the model (standard) and the interval formed using 95% CI from coefficients' estimates (new).

Results
At ages 9, 10 and 11 we had 77, 246 and 548 patients with 1.3%, 3.2% and 10.2% Risser 1, respectively. Consequently, we included ages 10 in GA and 11 in GB. We included 275 participants (allowing three cross-validations) in GA, 782 (5) females and 190 (3) males in GB, and 316 (3) in GC. The selected predictors were similar in all the models, with sex influencing only model GC. Of note, curve severity over the clinically significant threshold of 30° improved all models. The prediction accuracy ranged 15-85% (standard), and 62-99% (new).

Conclusion
The accuracy of IS progression models increased when tailored by growth spurt periods.

PREDICTIVE LINEAR MIXED-EFFECTS MODELS

INTERCEPT	COBB	TIME	TIME²	(COBB-30) * TIME	(COBB-30) * TIME²	CURVE TYPE: DO	CURVE TYPE: TH	CURVE TYPE: L/TL	CURVE TYPE: OT	EU RISSER: 1	EU RISSER: 2	EU RISSER: 3	EU RISSER: 4	SEX
GROUP A (AGE 6-10)														
-0.51	+1.02	+2.80	/	+0.35	/	+2.40	+3.40	1	+1.40			/		/
GROUP B (AGE 11 – EU RISSER 3)														
-1.54	+1.09	+4.57	/	+0.02	/	-1.24	1	-2.08	-1.80	1	-1.58	-2.12	/	/
GROUP C (EU RISSER 3 – 5)														
-4.19	+0.99	+1.56	-0.13	/	+0.03	-1.32	1	-2.37	-2.44	/	1	-2.00	-1.20	

FUTURE COBB ANGLE PREDICTION ACCURACY

	STANDARD METHOD: WITHIN PREDICTION INTERVAL	STANDARD METHOD: WITHIN PREDICTION ± 5°	STANDARD METHOD: WITHIN PREDICTION INTERVAL ± 5°	NEW METHOD*: WITHIN PREDICTION INTERVAL	NEW METHOD*: WITHIN PREDICTION ± 5°	NEW METHOD*: WITHIN PREDICTION INTERVAL ± 5°
GROUP A	32.3%	59.9%	77.3%	62.0%	85.7%	96.6%
GROUP B						
Females	19.1%	58.2%	69.4%	63.7%	57.9%	91.0%
Males	14.8%	63.2%	69.5%	TBD	TBD	TBD
GROUP C	27.3%	72.3%	84.6%	94.2%	72.3%	99.2%

DO: double; TH: thoracic; L/TL: lumbar & thoracolumbar; OT: double thoracic, upper thoracic, triple, quadruple. TBD: to be determined. Time: years between observation and prediction. * The new method consists of making a prediction interval for each patient using the lower limit estimates for the coefficients 95%CI and then using the upper limit value of this interval for the coefficients in the model.

Predictive models and prediction accuracy

98. EARLY BRACE TREATMENT FOR IDIOPATHIC SCOLIOSIS MAY CHANGE THE PARADIGM TO IMPROVE CURVES PERMANENTLY

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Hypothesis
Bracing scoliotic curves <25° decreases the incidence of curve progression and surgery.

Design
Retrospective chart review

Introduction
The standard for brace prescription in skeletally immature curves is ≥25°, but this institution commonly braces curves <25°. Karol et al (2016) reported 33% of curves 25-29°, Risser 0, and open TRC progress to surgery despite full-time brace wear. We evaluated whether early brace treatment in

curves <25° decreases the incidence of curve progression and surgery, especially in patients in full-time braces with open TRC.

Methods
The charts of 2173 patients prescribed scoliosis braces from 1/2015-12/2019 were reviewed for the following: JIS/AIS diagnosis, braced <25°, no previous brace, and final visit of brace discontinuation, skeletal maturity, or surgery. Skeletally immature patients with thoracolumbar/lumbar curves were prescribed night-time braces (NTB) and thoracic curves had full-time braces (FTB). Comparisons were made for: 1) NTB vs FTB and 2) sub-analysis of FTB patients according to TRC status (open TRC vs. closed TRC) at brace prescription.

Results
297 patients (260 AIS, 37 JIS; 233 F, 64 M) Risser 0.5 ± 0.9 (74% premenarchal for F; 58% open TRC) with curves 21.8±2.4° were prescribed a brace, averaging 2.4 ± 10.8° curve progression during bracing. 22% (n=66) of curves improved ≥6°, 49% (n=145) remained stable, 25% (n=73) progressed ≥6° but did not require surgery, and 4% (n=13) progressed to surgery. Outcomes in these four categories did not differ by brace type or TRC status for the FTB patients. NTB patients (n=204) had significantly smaller initial curves (21.5° vs. 22.3°, p<0.01), were significantly older (12.3 yr vs. 12.1 yr, p=0.02), and had similar skeletal immaturity (Risser, TRC), but were braced significantly longer (2.3 yr vs. 2.0 yr, p=0.01) than FTB patients (n=93). FTB patients with open TRC (n=50) were significantly younger at brace prescription (11.6 yr vs. 12.6 yr, p<0.01), grew taller during bracing (11.9 cm vs. 6.0 cm, p<0.001), and had lower Risser grades at final visit (3.2 vs 4.0, p=0.03) than FTB patients with closed TRC. Only 8% (n=4) of FTB patients with open TRC progressed to surgery.

Conclusion
Early brace treatment reduces curve progression and the need for surgical treatment. Patients who begin brace treatment early may end brace treatment earlier and permanent curve improvement may result.

	Night-time brace	Full-time brace	p-value
Diagnosis			
AIS	79% (n=182)	84% (n=78)	0.27
JIS	21% (n=22)	16% (n=15)	
Gender			
Female	79% (n=161)	77% (n=72)	0.89
Male	21% (n=43)	23% (n=21)	
Initial age (yrs)	12.3±1.7 (n=204)	12.1±1.5 (n=93)	0.02*
Initial primary curve			
Proximal thoracic	1% (n=1)	1% (n=1)	<0.001*
Main thoracic	25% (n=50)	89% (n=83)	
Thoracolumbar	40% (n=81)	3% (n=3)	
Lumbar	35% (n=72)	6% (n=6)	
Initial Risser grade	0.5±1.0 (n=204)	0.4±0.7 (n=92)	0.25
Initial triradiate cartilage			
Open	59% (n=121)	54% (n=50)	0.44
Closed	41% (n=83)	46% (n=43)	
Initial menarchal status			
Pre	58% (n=119)	58% (n=54)	0.94
Post	21% (n=42)	19% (n=18)	
N/A	21% (n=43)	23% (n=21)	
Initial BMI	18.1±2.6 (n=197)	18.7±2.8 (n=92)	0.06
Initial maximum Cobb (°)	21.5±2.2 (n=204)	22.3±1.9 (n=93)	<0.01*
Years braced	2.3±1.0 (n=201)	2.0±0.9 (n=91)	0.01*
Total brace wear (hr/day), according to sensor data	7.3±3.2 (n=94)	11.9±6.0 (n=55)	<0.001*
Final age (yrs)	15.0±1.6 (n=204)	14.5±1.8 (n=93)	0.02*
Final Risser grade	3.8±1.1 (n=200)	3.5±1.3 (n=93)	0.08
Growth (cm)	10.5±7.1 (n=197)	9.1±5.7 (n=88)	0.08
Final maximum Cobb (°)	23.5±11.0 (n=204)	25.8±11.0 (n=93)	0.09
Total curve Progression (°)	2.0±10.7 (n=204)	3.5±11.2 (n=93)	0.28
Curve improvement ≥6°			
No	75% (n=153)	84% (n=78)	0.12
Yes	22% (n=51)	16% (n=15)	
Curve progression ≥6°			
No	72% (n=146)	70% (n=65)	0.87
Yes	28% (n=58)	30% (n=28)	
Progression to surgery			
No	96% (n=196)	95% (n=88)	0.79
Yes	4% (n=8)	5% (n=5)	

*p<0.05. Initial=time of brace prescription; Final=brace discontinuation, skeletal maturity, or progression to surgery

99. QUANTIFYING THE CONTRIBUTION OF LOWER LIMB COMPENSATION TO UPRIGHT POSTURE: WHAT HAPPENS IF ASD PATIENTS DO NOT COMPENSATE?

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Hypothesis
Elimination of lower limb compensation will increase spine deformity magnitude.

Design
Multicenter, prospective cohort

Introduction
ASD patients maintain upright posture by compensating through their spine, pelvis and lower extremities. Little data exist quantifying the contribution of lower extremity compensation through the hips, knees, and ankles to maintain upright posture.

Methods
Surgical ASD patients were enrolled into a prospective study based on three criteria: deformity severity, procedure complexity, and/or geriatric surgery. Preop full-body images were evaluated and age and PI-adjusted normative values were used to model spine alignment based upon 3 configurations: COMP (all lower extremity compensatory

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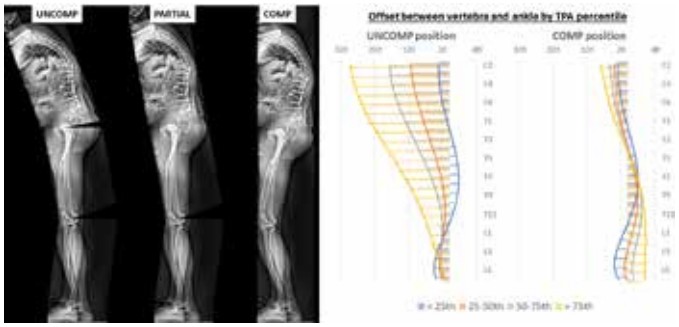
mechanisms maintained), PARTIAL (removal of ankle dorsiflexion and knee flexion, maintained hip extension), UNCOMP (ankle, knee, and hip compensation eliminated by reset to the age and PI norms).

Results
288 patients met inclusion criteria (60±15yo, 70.5% female, 27.4±5.9 BMI). COMP spine deformity magnitude included PI-LL:15±24, TPA:24±14, and SVA: 65±69mm. As the model transitioned from COMP to UNCOMP alignment, the initial posterior translation of the pelvis decreased significantly to an anterior translation vs. the ankle (P.Shift: 30 to -7.6mm). This was associated with a decrease in pelvic retroversion (PT: 24.1 to 16.1), hip extension (SFA: 203 to 200), Knee Flexion (KA: 5.5 to -0.4), and ankle dorsiflexion (AA: 5.3 to 3.7). As a result, the anterior malalignment of the trunk significantly increased: SVA (65 to 120mm) and G-SVA (C7-Ankle from 36 to 127mm), leading to a 3-fold increase in bending moments sustained by the ankle joint. The stratification of the COMP position by TPA percentiles revealed that as the deformity increases, the vertebrae above T8 translate anteriorly, those below T10 move posteriorly, with the T8-T10 segment remaining ~3cm posterior to the ankle joint independently of the deformity severity (Figure).

Conclusion
Removal of lower limbs compensation revealed an unsustainable truncal malalignment with a 3-fold increase of bending moments at the ankle joints. Combined, lower limb compensations permit "reducing" the SVA by two-fold and the C7-ankle SVA by 3-fold. From a mechanical point of view, this compensation permits maintaining the trunk center of mass (T9) at a fixed offset of ~3cm from the ankle joint.



100. A COMPLEMENT TYPE TO SRS-SCHWAB ADULT SPINAL DEFORMITY CLASSIFICATION: THE FAILURE OF PELVIC COMPENSATION

Ho-Joong Kim, MD; Ohsang Kwon, MD; Dae-Woong Ham, MD; *Sanghoon Lee, MD*

Hypothesis
We aimed to compare the characteristics, surgical outcomes, and surgical strategy between patients with successful and failed pelvic compensation. We hypothesized that there would be between-group differences in the clinical course after ASD surgery.

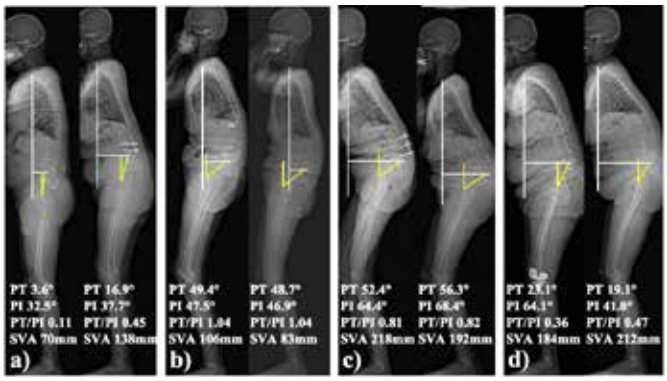
Design
This is a retrospective review study.

Introduction
Some patients with adult spinal deformity (ASD) show failed pelvic compensation despite significant sagittal imbalance. These patients reportedly present distinct clinical outcomes. However, to our knowledge, no study has clearly defined or characterized this subgroup of patients with ASD.

Methods
We examined 126 patients who underwent reconstructive spinal surgery for ASD between September 2016 and September 2020. Radiographic spinopelvic parameters were assessed. The patients were divided into four quadrant groups based on the two axes of pelvic tilt/pelvic incidence (PT/PI) and the sagittal vertical axis (SVA) with reference to the population median values (0.68 and 147.5 mm, respectively). Patients with low PT/PI and high SVA were considered to have failed pelvic compensation, and they were compared with other patient groups.

Results
Patients with failed pelvic compensation (low PT/PI and high SVA) had worse clinical outcomes than those with successful pelvic compensation (high PT/PI and high SVA) at one year after surgery. Regarding radiographic outcomes, patients with failed pelvic compensation showed a significantly larger postoperative SVA even after correcting the PI–LL mismatch was corrected to a comparable range with the group of successful pelvic compensation. Notably, patients with failed pelvic compensation showed larger cross-sectional areas of the psoas and back extensor muscles than those with successful pelvic compensation. This suggests that failure of pelvic compensation did not occur because of back muscle weakness, which implies another underlying pathophysiology, including neurological origin.

Conclusion
Compared with patients with successful pelvic compensation, those with failed pelvic compensation showed lower postoperative improvements in clinical and radiographic outcomes. Therefore, it is important to consider pelvic compensation when planning surgical correction of deformities. Distinct surgical approaches, including overcorrection of the PI–LL mismatch or global sagittal alignment, should be attempted to ensure postoperative symptom improvement.



Characteristic EOS images

101. HEIGHT GAIN FOLLOWING CORRECTION OF ADULT SPINAL DEFORMITY: MAGNITUDE, ANATOMIC DISTRIBUTION, AND ASSOCIATION WITH PATIENT SATISFACTION

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Hypothesis
Height gain following deformity correction is predictable and correlates with improved patient satisfaction

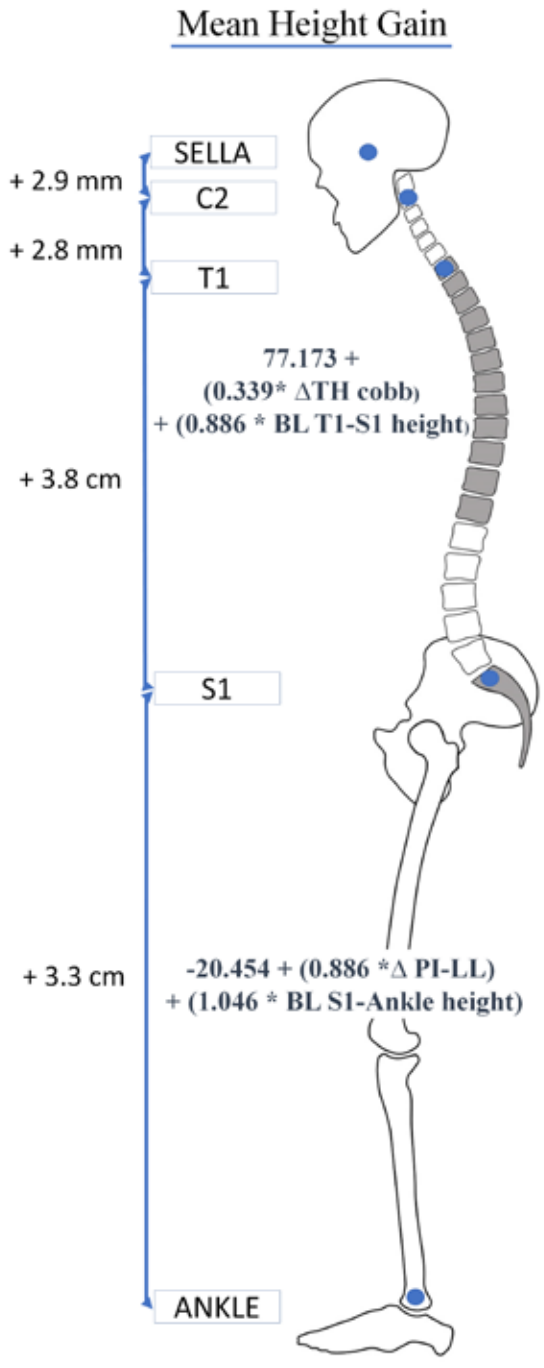
Design
Retrospective review of prospectively collected database

Introduction
Height gain following surgery for ASD patients has not been previously reported. It is unknown if height gain is predictable and correlates with improvements in outcomes

Methods
ASD patients with baseline and 6wk postop full body radiographic and PROM data were included. Outcomes were compared from baseline to 6wk postop for those who gained height. Correlation analysis assessed for relationships between vertical height differences and PROMs. Regression analysis was utilized to predict height change of T1-S1 and S1-ankle.

Results
198 patients were included: 147 patients (74%) gained height (mean age 57yrs; 69% female). At 6wks, sagittal and coronal alignment for patients improved significantly (PT: 25 to 21°; PI-LL: 14 to 3°, SVA: 60 to 17mm, all p<0.001). Full body mean height gain was 7.5cm, distributed as: Sella Turcica- C2(2.9mm); C2-T1(2.8mm); T1-S1(3.8cm trunk gain); S1-ankle (3.3cm lower extremity gain) (all p<0.001 except C2-T1). Height gain from S1-ankle correlated with correction in PT, PI-LL, SVA (p<0.001). Height gain from T1-ankle correlated with PT correction (p<0.001) and SVA (p=0.026). Height gain from T1-S1 correlated with thoracic Cobb correction and max Cobb correction (p<0.001). Regression analysis predicted T1-S1 height change utilizing baseline T1-S1 height and thoracic Cobb correction (r2= 0.64). Prediction of S1-ankle height gain was achieved utilizing baseline S1-ankle length and PI-LL correction (r2=0.713). Trunk height gain correlated with improved SRS-appearance scores (r=0.196, p=0.017). PROMIS-depression scores correlated with S1-ankle gain (r= - 0.185, p=0.027) and C2-T1 height gain (r= - 0.176, p=0.038).

Conclusion
Patients undergoing surgery for correction of adult spinal deformity who gain height experience a mean full-body gain of 7.5cm. Correction of coronal alignment increased trunk height, while correction of sagittal malalignment increased lower extremity height from relaxation of compensatory mechanism. Height gain is correlated with improvements in SRS-appearance and PROMIS-scores and can be predicted with novel formulas.



Mean height gain distribution

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102. PRE-CONTOURED RODS IN ACHIEVING PLANNED REGIONAL AND GLOBAL ALIGNMENT: A LOT OF PLANNING BUT DOES IT MATTER IN ADULT SPINAL DEFORMITY? A MULTICENTERED STUDY

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Hypothesis
Pre-contoured rod instrumentation for adult spinal deformity (ASD) can accurately achieve planned alignment parameters in the sagittal and coronal planes.

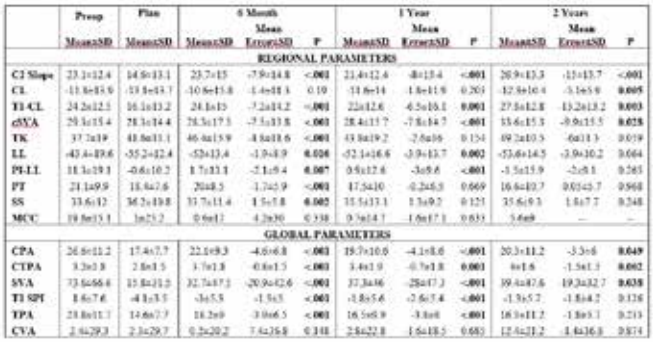
Design
Multicentered cohort.

Introduction
This is the first multicentered study with 2yr follow up that seeks to characterize the utility of patient-specific instrumentation in achieving planned regional and global alignment in the sagittal and coronal planes in patients undergoing fusion for ASD.

Methods
A multicenter cohort of adult patients (age ≥ 18) undergoing instrumentation with pre-contoured rods was reviewed from 2018-2021. Sagittal parameters included C2 slope, cervical lordosis (CL), C2 pelvic angle (CPA), cervicothoracic pelvic angle (CTPA), lumbar lordosis (LL), pelvic incidence (PI), PI-LL, pelvic tilt (PT), sacral slope (SS), sagittal vertical axis (SVA), T1 spinopelvic inclination (T1SPI), T1 slope, T1 slope-CL (T1 slope-CL), thoracic kyphosis (TK), T1 pelvic angle (TPA), C2-C7 SVA (cSVA). Coronal parameters included major coronal curve (MCC) and coronal balance (CVA). We utilized preop planning software to determine expected postop alignment. Differences in planned vs. postop measurements were determined at preop, 6mo, 1yr, and 2yrs.

Results
289 patients were included in the study (mean age: 61.3±13.5yrs, 156 (54%) female, mean total instrumented levels: 8.2±5.0). At 6mo follow up, the preoperative plan accurately predicted CL, MCC, and CVA with 71(62.8%), 33(68.6%), and 37(69.8%) patients meeting acceptable criteria (i.e. difference of ≤5° or ≤10mm), respectively. However, by 2yrs, accuracy in predicting regional parameters improved including LL (Mean Error: -3.9±10.2°; P=0.064), PI-LL (-2±9.1°; P=0.265), PT (0.05±5.7°; P=0.968), TK (-6.0±11.3°; 0.059). Similarly, mean errors for global parameters including T1SPI (-1.8±4.2°; 0.126), TPA (-1.8±5.7°, 0.233) and CVA(-1.4±16.8mm, 0.874) were low and statistically insignificant. Although mean differences between plan and 2yr postop for CPA, CTPA, SVA, and cSVA were statistically significant, the mean error was <5° and <20mm, respectively proving a small clinical difference.

Conclusion
In the first and largest, multicenter study with 2 year follow up evaluating use of pre-contoured rods, we found high accuracy for both coronal and sagittal correction (regionally and globally) in predicting postoperative alignment parameters.



	Preop	Plan	6 Month			1 Year			2 Years		
	Mean±SD	Mean±SD	Mean±SD	Mean Error±SD	P	Mean±SD	Mean Error±SD	P	Mean±SD	Mean Error±SD	P
REGIONAL PARAMETERS											
C2 Slope	23.1±12.4	14.9±13.1	23.7±15	-7.9±14.8	<.001	21.4±12.4	-8±13.4	<.001	20.9±13.3	-12±13.7	<.001
CL	-11.8±15.6	-13.8±13.7	-10.8±15.8	-1.4±18.1	0.19	-11.8±14	1.8±11.9	0.203	-12.8±10.4	-1.1±5.9	0.005
T1-CL	24.2±12.5	16.1±13.2	24.8±15	-7.2±14.2	<.001	22±12.6	-6.5±16.1	0.001	27.8±12.8	13.2±13.2	0.003
cSVA	29.3±15.4	28.3±14.4	28.5±17.5	-7.5±13.8	<.001	28.4±15.7	-7.8±14.7	<.001	33.6±15.3	-9.9±15.5	0.028
TK	37.7±19	41.8±11.1	46.4±15.9	4.8±18.6	<.001	43.8±19.2	2.6±16	0.154	49.2±10.5	6±11.3	0.059
LL	-43.4±49.6	-55.2±42.4	-52±13.4	-3.9±8.9	0.036	-52.1±16.6	-3.9±13.7	0.002	-53.6±14.5	-3.9±10.2	0.064
PI-LL	18.3±19.1	-0.6±10.2	8.7±13.1	-7.1±9.4	0.007	0.9±12.6	-3±9.6	<.001	-1.5±15.9	-2±8.1	0.265
PT	21.3±9.9	18.4±7.6	20±8.5	-1.7±5.9	<.001	17.5±10	-0.2±6.5	0.669	16.6±10.7	0.03±5.7	0.968
SS	33.6±12	36.2±10.8	33.7±11.4	1.5±7.8	0.005	35.5±13.1	1.3±9.2	0.121	35.6±9.3	1.8±7.7	0.248
MCC	19.8±15.1	1±25.2	0.6±11	-4.2±30	0.338	0.7±14.7	1.6±17.1	0.633	3.4±6	--	--
GLOBAL PARAMETERS											
CPA	26.8±11.2	17.4±7.7	22.1±9.3	-4.6±6.8	<.001	19.7±10.6	-4.1±8.6	<.001	20.3±11.2	-3.3±6	0.049
CTPA	9.3±3.8	2.8±3.5	3.7±3.8	-0.8±3.5	<.001	3.4±3.9	-0.7±3.8	0.001	4±3.6	-1.5±3.3	0.002
SVA	73.6±66.6	35.8±33.5	32.7±87.1	-20.9±42.6	<.001	37.3±46	-25±47.2	<.001	39.4±47.6	19.3±32.7	0.038
T1 SPI	8.6±7.6	-4.8±3.5	-3±5.5	-1.3±3	<.001	-1.8±5.6	-2.6±7.4	<.001	-1.3±5.7	-1.8±4.2	0.126
TPA	23.8±11.7	14.6±7.7	18.2±9	-3.6±6.5	<.001	16.5±9.9	-3.8±8	<.001	16.3±11.2	-1.8±5.7	0.233
CVA	2.6±29.3	2.3±29.7	0.2±20.2	7.4±26.8	0.318	2.8±22.8	1.6±18.5	0.683	12.5±21.2	-1.4±16.8	0.874

103. ASSESSING THE INTERNATIONAL SPINE STUDY GROUP AND EUROPEAN SPINE STUDY GROUP SAGITTAL ALIGNMENT GOALS IN AN ASYMPTOMATIC ADULT COHORT

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Hypothesis
In a cohort of asymptomatic adults, sagittal parameters predicted by ISSG methods will correlate with measured parameters and most patients will be classified as "proportioned" or "moderately disproportioned" based on GAP score.

Design
Retrospective review

Introduction
The International Spine Study Group (ISSG) formulae for age-specific realignment thresholds and the European Spine Study Group (ESSG) Global Alignment and Proportion (GAP) Score are validated models for surgical adult spinal deformity patients. The purpose of this study was to assess the correlation of calculated ISSG thresholds and distribution of GAP score in an asymptomatic population.

Methods
Standing thirty-six-inch scoliosis radiographs obtained prospectively from a cohort of 149 asymptomatic volunteers were reviewed retrospectively. Spinopelvic parameters were measured for each patient (pelvic incidence/PI, L1-S1 lumbar lordosis/LL, L4-S1 lumbar lordosis, sacral slope, pelvic tilt/PT, global tilt, T4-T12 thoracic kyphosis/TK, sagittal vertical axis/SVA, T1 pelvic angle/TPA) and compared with values predicted by ISSG formulae. Patients were also categorized as proportioned, moderately disproportioned, or severely disproportioned based on GAP score.

Results
The strength of correlation between measured and predicted spinopelvic parameters based on ISSG formulae was poor: PI-LL (r=0.24, P=0.032); PT (r=0.11, P=0.18); LL-TK (r=-0.36, P=<0.0001); SVA (r=0.20, P=0.01); TPA (r=0.15, P=0.06). Based on GAP score, most patients were moderately (43.0%) or severely (28.9%) disproportioned (Table 1). As patient age increased from

60 to 80 years, there was a significant decrease in the percentage of proportioned patients (33.3% vs. 11.9%, respectively) and a significant increase in the percentage of severely disproportioned patients (2.3% vs. 30.2%, respectively) (P=0.02).

Conclusion
In a cohort of asymptomatic adults, sagittal parameters predicted by ISSG methods correlated poorly with measured parameters. The GAP score demonstrated that most patients were either moderately or severely disproportioned. Interestingly, as patient age increased, the percentage of patients classified as "proportioned" decreased and the percentage of patients classified as "severely disproportioned" increased.

Patient Age	Number Proportioned (%)	Number Moderately Disproportioned (%)	Number Severely Disproportioned (%)	χ^2 *P*-Value
60 years	14 (33.3)	14 (21.9)	1 (2.3)	
65 years	9 (21.4)	14 (21.9)	6 (14.0)	
70 years	7 (16.7)	11 (17.2)	12 (27.9)	0.02*
75 years	7 (16.7)	12 (18.8)	11 (25.6)	
80 years	5 (11.9)	13 (20.3)	13 (30.2)	

Table 1: Summary of GAP scores organized in 5-year increments of age. *Denotes significance, *P*<0.05.

of GAP scores organized in 5-year increments of age. *Denotes significance, P<0.05.

104. IMPORTANCE OF MODIFIABLE NON-RADIOGRAPHIC PARAMETERS FOR ADULT SPINAL DEFORMITY

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Hypothesis
The purpose of this study was to clarify modifiable non-radiographic factors of adult spinal deformity (ASD).

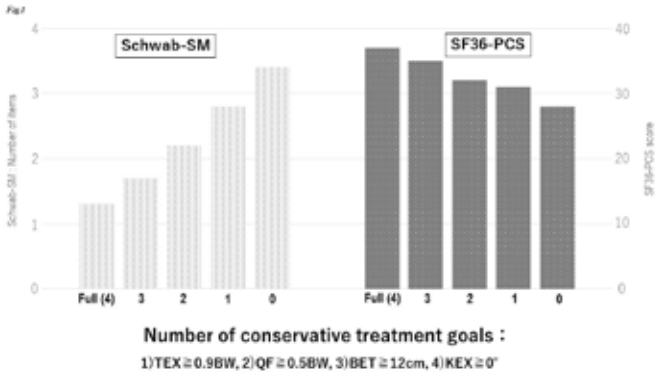
Design
A community-based cohort study.

Introduction
Recent multicenter studies of ASD indicated unsuccessful conservative treatments, however, study protocols could not provide detailed goals of conservative treatment.

Methods
Community-dwelling female volunteers were recruited and subjected to upright entire spine radiographs and clinical evaluations. Radiographic measurements included thoracic kyphosis (TK), lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence (PI), sagittal vertical axis (SVA), and the number of sagittal modifiers of SRS-Schwab ASD classification (Schwab-SM). Clinical evaluations included isometric muscle strength of trunk flexor (TFL), trunk extensor (TEX), quadriceps femoris (QF), gluteus maximus (GM), and iliopsoas (IP); ROM of hip extension, internal/external rotation, knee flexion/extension (KEX), ankle dorsiflexion, and active lumbar extension (BET); SF36 physical component score (PCS), VAS for back and knee pain, and the degree of ambulatory kyphosis (dTIA).

Results
Radiographic and clinical results of 409 female volunteers (67.0 years, BH151.6cm, BW56.0kg) were as follows; TK 29.8°, LL 38.8°, PI 53.2°, PT 24.6°, SVA 2.3cm, Schwab-SM 2.1, TFL 0.48BWkgf, TEX 0.90BWkgf, QF 0.45BWkgf, GM 0.38BWkgf, IP 0.17BWkgf, BET 11.6cm, dTIA 4.5°, and PCS 33.5. According to our previous study, subjects with dTIA≥7.4° and PCS≤27 were defined as clinically-significant dynamic deformity (n=19). Statistical analyses showed significant differences in TEX, QF, BET, and KEX between subjects with and without dynamic deformity, and the mean values in healthy subjects (TEX≥0.9BW, QF≥0.5BW, BET≥12cm and KEX≥0°) were used as 'conservative treatment goals' of ASD. Subjects with fully achieving these goals showed significantly better radiographic and clinical outcomes than those with unmet goals (fig. 1).

Conclusion
Our results showed that subjects with back extensor strength of above 90% of BW, quadriceps strength of above 50% of BW, active back extension reaching 12cm and without knee flexion contractures were associated with better radiographic and clinical outcomes. Upon prescribing conservative or physical therapies, modifiable clinical goals should be clarified, and our results suggested improving back/thigh muscles and lumbar/knee ROMs should be important clinical markers for successful management of ASD.



105. FACTORS EFFECTING OPIOID USE OF EUROPEAN ADULT SPINAL DEFORMITY PATIENTS: MINIMUM 5-YEAR FOLLOW-UP STUDY

Kadir Abul, MD; Arin Alanay; Caglar Yilgor, MD; Altug Yucekul, MD; Yasemin Yavuz, PhD; Tais Zulemyan, MSc; Louis Boissiere, MD; Anouar Bourghli, MD; Ibrahim Obeid, MD; Javier Pizones, MD, PhD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; *Ahmet Alanay, MD*; European Spine Study Group

Hypothesis
Several pre- and postoperative risk factors affecting opioid use can be identified

Design
Retrospective analysis of prospectively collected data

Introduction
Although appropriate pain control is a critical aspect of patient management, past few decades have been associated with major increases in opioid-related overdoses and addiction treatment. Current literature focuses on chronic back pain and degenerative conditions and information regarding long-term opioid use following adult spinal deformity surgery is limited.

PODIUM PRESENTATION ABSTRACTS

Methods
Patients with ≥4-levels fusion and ≥5y follow-up were included. Analgesic use was divided into 4 groups: No Analgesics; Non-Opioid Analgesics; Weak Opioids and Strong Opioids. Clinically-relevant 6 scenarios were investigated: Pre-op use; 6 weeks use; Continued use at 6 months and beyond; Opioid cessation; Restart on opioids and Persistent use at 5 years and beyond. Demographic, surgical, radiographic data and PROMs were analysed in a univariate-multivariate setup to determine risk factors for pre-op, 6-months and ≥5-years post-op usage.

Results
265 patients (215F, 50M, 52±19 yrs) with a mean follow-up of 67 (60-102) months were included. 202 (76%) patients were opioid naive while 63 reported preop opioid use. In the multivariate analysis, SRS-22 pain score and study-group site were the only important parameters. At 6 weeks, 23% of opioid naive patients were using opioids, which dropped to 13% at 6 months. Patients with reported preop use had usage rates of 67% and 43% at 6 weeks and at 6 months, respectively. Opioid use at 6 months was affected by ASA score, pre-op and 6-weeks opioid use and post-op sagittal plane deformity. At the final follow-up 15% of opioid naive patients were still using opioids. In the opioid group, there was a 44% of final follow-up use where more than half of the patients were using stronger opioids. Persistent opioid use at and beyond 5 years were only affected by pre-op, 6-weeks and 6-months postoperative use, and not by any demographic, surgical and/or radiographic parameters.

Conclusion
Approximately 15% of patients who received no preop opioids ended up receiving long-term (5+ years) postop opioids. Of the preop opioid users, only 56% could quit. Among identified risk factors, sagittal plane correction seems to be the only parameter that is directly at the surgeon's discretion. Observed differences among sites can point towards a room for improvement.

106. SPINAL CORD STIMULATORS ADVERSELY AFFECT OUTCOMES IN DEFORMITY SURGERY

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Hypothesis
Spinal cord stimulator placement predicts worse clinical outcomes and complication rates after adult spinal deformity (ASD) surgery.

Design
Retrospective cohort study of a prospectively collected single-center database of ASD patients.

Introduction
Spinal cord stimulation (SCS) is increasingly advocated for back pain. Since ASD patients often suffer from back pain, the frequency of ASD patients presenting with SCS is rising. However, the impact of SCS on surgical outcomes in ASD is underexamined.

Methods
33 patients with SCS undergoing ASD surgery with minimum 2-year follow-up were compared with a matched cohort of 61 ASD patients without SCS. Outcomes included visual-analog pain scale (VAS) and Oswestry Disability Index (ODI) at pre-op, 6 months, 1 year, and 2 years. Radiographic outcomes and complications were also tracked.

Results
Despite similar baseline ODI (56 vs. 50, p=0.11) and back VAS (6.8 vs. 6.6, p=0.52), SCS patients did worse at all post-op time intervals. At 6 months, the SCS cohort had higher ODI (48 vs. 31, p<0.001) and VAS (4.8 vs. 3.5, p=0.01). This difference persisted at 1 year for ODI (46 vs 30, p<0.001) but not for VAS (4.7 vs. 4.0, p=0.19). At 2 years, ODI remained significantly worse in the SCS cohort (49 vs 38, p=0.004) and a small difference was present in VAS (5.2 vs 4.2, p=0.05). Both cohorts had significant improvement at 2 years compared to baseline (SCS: -1.6 VAS, p<0.001, -7 ODI, p=0.03; Control: -2.5 VAS, p<0.001, -13 ODI, p<0.001). The proportion of patients achieving MCID was worse in the SCS cohort at 6 months (39% vs 62%, p=0.03), but by 2 years the difference was not significant (36% vs 52%, p=0.13). VAS leg scores were similar at all time intervals and showed significant improvement post-op for both cohorts. Radiographic parameters such as curve magnitude, curve correction, and balance were similar between the 2 groups. Complications and reoperation rates (excluding SCS removal) were also similar. Narcotic use significantly decreased post-op for the control, but not the SCS group.

Conclusion
Despite having substantial improvement after ASD surgery, patients with previous SCS placement did significantly worse in both back VAS and ODI post-op compared with controls. They also did not experience a decrease in narcotic use at 2 years despite having similar overall radiographic results and complication rates.

107. EVALUATING THE IMPACT OF MULTIPLE SCLEROSIS ON 2-YEAR POSTOPERATIVE OUTCOMES FOLLOWING LONG FUSION FOR ADULT SPINAL DEFORMITY: A PROPENSITY SCORE-MATCHED ANALYSIS

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Hypothesis
Long spinal fusion can be performed safely for patients with multiple sclerosis and adult spinal deformity.

Design
Retrospective Cohort

Introduction
The impact of neuromuscular disorders such as multiple sclerosis (MS) on outcomes following long segment

(≥4-level) fusion is underreported. We sought to identify the impact of MS on two-year (2Y) postoperative complications and revisions following ≥4-level fusion for ASD.

Methods
Patients undergoing ≥4-level fusion for ASD were identified from the New York Statewide Planning and Research Cooperative System. Patients with a baseline diagnosis of MS were also identified. Patients with infectious/traumatic/neoplastic indications were excluded. Subjects were 1:1 propensity score-matched (MS to no-MS) by age, sex and race and compared for rates of 2Y postoperative complications and reoperations. Logistic regression models were utilized to determine risk factors for adverse outcomes at 2Y.

Results
86 patients were included overall (n=43 per group). Age (50.1 vs. 50.1 years, p=0.225), sex, and race was comparable between groups. MS pts incurred higher charges for their surgical visit ($125,906 vs. $84,006, p=0.007) with similar LOS (8.1 vs. 5.3 days, p>0.05). MS patients experienced comparable rates of overall medical complications (30.1% vs. 25.6%) and surgical complications (34.9% vs. 30.2%) all p>0.05. MS pts had similar rates of 2Y revisions (16.3% vs. 9.3%, p=0.333). MS was not associated with medical, surgical, or overall complications or revisions at minimum 2Y follow-up.

Conclusion
Patients with MS experienced similar postoperative course compared to those without MS following ≥4-level fusion for ASD. This data supports the findings of multiple previously published case series' that long segment fusions for ASD can be performed relatively safely in patients with MS.

108. DETERMINING A CUT-OFF VALUE FOR HAND GRIP STRENGTH TO PREDICT FAVORABLE OUTCOMES OF ADULT SPINAL DEFORMITY SURGERY

Ho-Joong Kim, MD; Ohsang Kwon, MD; Dae-Woong Ham, MD

Hypothesis
To define a cut-off value for hand grip strength and predict favorable outcomes of adult spinal deformity surgery.

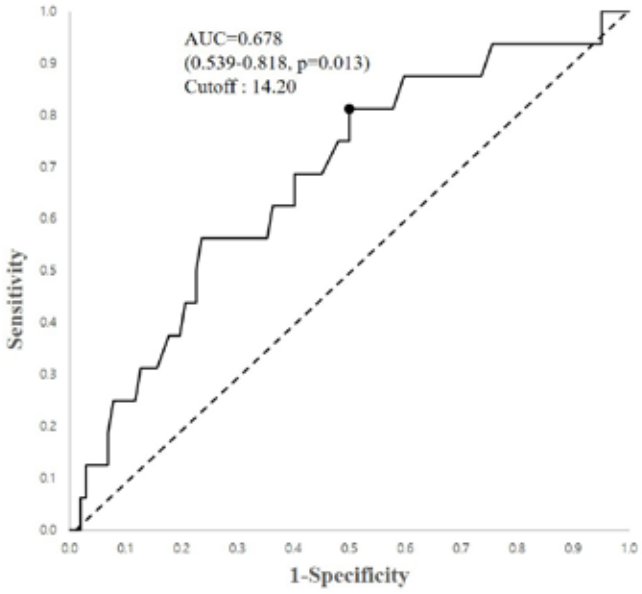
Design
Retrospective review

Introduction
Hand grip strength has been suggested as a predictive factor of surgical outcomes in various fields, including adult spinal deformity (ASD). However, to the best of our knowledge, no study has defined a cut-off value for hand grip strength in patients with ASD.

Methods
This study included 115 female patients who underwent reconstructive spinal surgery for ASD between September 2016 and September 2020. Hand grip strength was measured preoperatively. Oswestry disability index (ODI), EuroQOL-5 dimension (EQ-5D) score, and visual analog scale (VAS) score for back pain were recorded pre- and postoperatively. Patients were dichotomized into either favorable or unfavorable outcome groups using an ODI cut-off of 22 at 1 year after surgery. Multivariate logistic regression analysis was done to find out significant factors leading to favorable outcome. A receiver operating characteristic curve was drawn to define the cut-off value for hand grip strength for favorable outcomes.

Results
Multivariate logistic regression analysis showed that hand grip strength is significantly associated with favorable surgical outcomes in ASD (p=0.031). The receiver operating characteristic curve suggested a cut-off value of 14.20 kg for hand grip strength (area under the curve=0.678, p=0.013) to predict favorable surgical outcomes in ASD. The surgical complications were not significantly affected by hand grip strength.

Conclusion
Hand grip strength of patients with ASD can be interpreted with a cut-off value of 14.20 kg. Patients with hand grip strength above this cut-off value showed superior surgical outcomes at 1 year after surgery over patients with hand grip strength below this cut-off value.



Receiver operating characteristics (ROC) curve of hand grip strength to predict favorable surgical outcomes of patients with adult spinal deformity.

109. CIRCUMFERENTIAL MINIMALLY-INVASIVE ADULT SPINAL DEFORMITY SURGERY PROVIDES INCREMENTAL BENEFIT FOR INCREASINGLY FRAIL PATIENTS

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PODIUM PRESENTATION ABSTRACTS

Christopher I. Shaffrey, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Frank J. Schwab, MD; Shay Bess, MD; Praveen V. Mummaneni, MD; International Spine Study Group

Hypothesis
Circumferential minimally-invasive surgery (cMIS) may provide incremental benefit for patients with increasing frailty status by decreasing peri- and post-op complications versus open technique.

Design
Retrospective cohort study

Introduction
Circumferential minimally-invasive surgery techniques in ASD surgery provides greater incrementally benefit to patients with increasing frailty states, though may be limited with increasing deformity status.

Methods
Operative ASD patients ≥18yrs with pre-(BL) and 2-year(2Y) postop data were assessed. Propensity score matching (PSM) aligned cMIS vs Open groups by BL BMI, C7-S1 SVA, PI-LL, and S1PT. Frailty categorization was calculated per Passias et al. modified ASD frailty index and stratified as Not Frail (NF), Frail (F), and Severely Frail (SF). BL and post-operative factors were assessed using two-way ANCOVA and MANCOVA analysis while controlling for BL age, CCI, and levels fused.

Results
174 ASD patients (62.85±13.93 years, 75.7% female, 29.23±6.64 kg/m2) were included after PSM, split evenly between cMIS and Open. At BL, two-way analysis demonstrated that increasingly frail MIS patients were older, more likely to be female, and have higher CCI than Open patients (all p<.005). Surgically, Open patients had greater posterior levels fused (p=.021) and were more likely to undergo 3CO (p>.05). Peri-operatively, cMIS patients had lower EBL and use of cell saver across frailty groups when adjusting for BL age, CCI, and levels fused, less peri-operative complications (p<.001). Adjusted analysis also revealed that increasingly frail MIS patients were also more likely to demonstrate larger improvement in 1Y and 2Y ODI, SRS-36 Total, EQ5D, SF-36 metrics compared to Open patients (all p<.05). By post-operative complications, increasingly frail cMIS patients were noted to experience significantly less complications overall (p=.037), less major intra-operative complications (p= .039), and were less likely to need reoperation than their Open counterparts (p=.043).

Conclusion
Circumferential minimally invasive technique may offer acceptable outcomes with diminishment of peri-operative complications and mitigation of catastrophic outcomes in increasingly frail patients who may not be candidates for traditional open techniques. However, further study should investigate the long-term impact of less optimal alignment in this population.

110. RELATIONSHIP BETWEEN ADULT SPINAL DEFORMITY SURGERY AND EMPLOYMENT, SICK LEAVES, RETURN TO WORK AND EARLY RETIREMENT: MINIMUM 5-YEAR FOLLOW-UP STUDY

Caglar Yilgor, MD; Altug Yucekul, MD; Tais Zulemyan, MSc; Yasemin Yavuz, PhD; Javier Pizones, MD, PhD; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; European Spine Study Group

Hypothesis
Early retirement is common following adult spinal deformity surgeries.

Design
Retrospective analysis of prospectively collected data

Introduction
Adult spinal deformity (ASD) is a common cause of disability and sick leave. Although this presents an economic burden to the individual and the society, predictors of permanent disability and early retirement among individuals with operations for spinal deformity are not well established. The aim of the study was to evaluate preoperative and long-term postoperative work status in patients undergoing ASD surgery.

Methods
Patients with ≥4-levels fusion and ≥5 years follow-up were included. Work status was divided into 4 groups: 1) Employed 2) Employed but on sick leave (groups 1 and 2 together referred to as active work life) 3) Unemployed 4) Retired due to back pain (groups 3 and 4 together referred to as inactive work life). Clinically-relevant 6 scenarios were investigated: 1) Preoperative work status 2) Time it took active ones to return to work 3) Active ones that kept being on sick leave or had to quit their jobs 4) Active ones that had an early retirement 5) Inactive ones that could make it back to work or became employed and 6) Inactive ones that couldn't make it back to work.

Results
120 patients (92F, 28M, 44.6±14.1 years) with a mean follow-up of 68 (60-102) months were included. 74 (62%) patients were active while 46 reported being unemployed or retired early. Of the 46 that were employed, 39 (85%) returned to work within 6 months. At the final follow-up 7% became unemployed and 26% had an early retirement (mean age at surgery 49.5). Of the 28 that were on sick leave preoperatively, 17 (61%) never made it back to work; and it took longer for the ones that did. 39% had an early retirement (mean age at surgery 53.2). Of the 17 (mean age 42.5) that were unemployed and 29 (mean age 50.5) that were retired due to back pain, respectively, 29% and 24% made it back to work.

Conclusion
Approximately 30% of patients that were involved in active work life ended up having an early retirement due to back pain within 5 years after surgery. Another 15% had long-lasting sick leaves or became unemployed. Only 25% of patients who were not involved in active work life were able to make it back to work. Patients should be well

informed to have realistic expectations regarding future work life when considering ASD surgery.

111. THE EQUILIBRATION OF SAGITTAL ALIGNMENT OVER TIME IN THE ADULT SPINAL DEFORMITY PATIENT – IS THE IMMEDIATE POSTOPERATIVE RADIOGRAPH MISLEADING IN ULTIMATE SAGITTAL ALIGNMENT?

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Hypothesis
Sagittal alignment measured on immediate postoperative radiographs are not an accurate representation of long-term sagittal alignment over time.

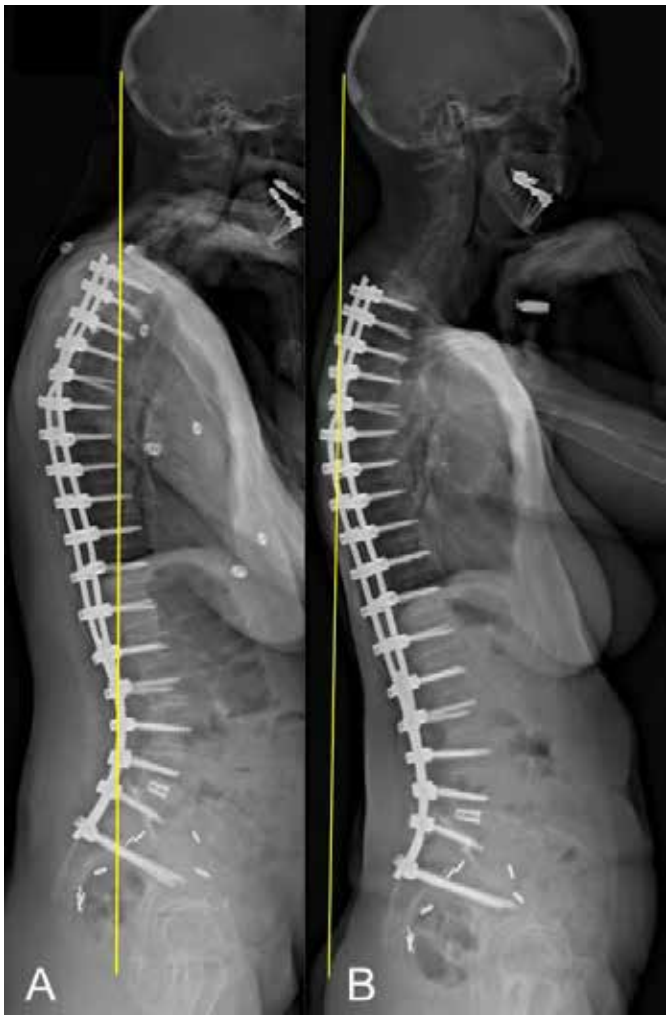
Design
Single center retrospective analysis

Introduction
Sagittal alignment in adult spinal deformity (ASD) is associated with improved pt reported outcomes. However, in the immediate postop period, pts are often in pain and still adjusting to their new alignment, and as such have difficulty standing upright for X-rays (XR). Understanding this change in sagittal alignment from immediate postop in-hospital XR long-term follow-up XR will help with interpretation of sagittal alignment prior to patient discharge.

Methods
Full-length radiographs of ASD patients were retrospectively reviewed with minimum 6 levels fused and minimum 2 year FU. The posterior cranial vertical line (PCVL) was used to assess sagittal alignment. Only patients with a PCVL falling anterior to the upper instrumented vertebra (UIV) implants on immediate postoperative XR were included. Sagittal and lumbopelvic radiographic parameters were measured for these patients preoperatively, immediately postoperatively and at final follow-up (FU).

Results
Of the 162 pts evaluated, 59 pts had a PCVL anterior to the UIV implants on immediate postop XR. Of these pts, 20 (34%) converted from having a PCVL anterior to cephalad-most instrumentation to posterior to final FU XR. Of pts that underwent a fusion to an upper thoracic (UT) UIV, 11/18 (61%) had an improvement of PCVL from anterior to posterior to the UIV implant, while 9/40 (23%) pts with a lower thoracic (LT) UIV became posterior to cephalad instrumentation by final FU (p=0.0042). Similarly, pts with greater total instrumented levels had a higher rate of conversion from anterior to posterior PCVL position to the UIV implants by final FU (11.4 vs 9.1 levels, p=0.0079).

Conclusion
The immediate postop radiograph following adult spinal deformity surgery can be misleading while assessing global sagittal alignment. We found that in 59 pts with a PCVL anterior to the UIV implants on the immediate postop radiograph, 20 pts (34%) improved to have a PCVL posterior to the UIV implants by final FU at min. 2 yr postop. Those with an UT UIV had a significantly higher rate of equilibrating to improved sagittal alignment vs. a LT UIV.



PCVL on (A) immediate postop XR and (B) 2yr follow-up XR.

112. LONG-TERM LOSS OF ALIGNMENT FOLLOWING ASD IN THE ABSENCE OF MECHANICAL COMPLICATIONS: AGING SPINE?

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Hypothesis
Postoperative Adult Spinal Deformity (ASD) alignment deteriorates during follow-up even in the absence of complications.

Design
Prospective observational cohort study.

Introduction
"Aging is kyphosing". ASD patients with significant sagittal deformity and/or functional impairment are frequently treated with posterior instrumented fusion (PSFI). Optimal Postoperative spinal alignment has been associated to better surgical outcomes. No previous study has analyzed

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the spontaneous long-term postoperative alignment changes occurring at the non-instrumented spine, its risk factors or impact on surgical outcomes.

Methods
We identified all patients operated before 2015 from a prospective multicentric international ASD database. Patients with long fusion to pelvis and no alignment changes in the instrumented area (including PJK) during follow-up were retained. We analyzed baseline characteristics, surgical treatment, postoperative alignment and the 5YFU surgical outcomes: alignment (coronal and sagittal), adverse events and Quality of Life (QoL; ODI, SRS22, SF36). Alignment changes at the non-instrumented levels and its impact on 5YFU QoL were analyzed using t-tests. Risk factors associated to alignment changes were identified using longitudinal mixed-effects models adjusted for confounding variables.

Results
79 patients met inclusion criteria: 83.5% women; age 61.9y (SD 10.5), 10.7 fused levels (range 5-18, SD 3.7), 29.1% 3CO, 88.6% posterior-only approach (Table). Despite having 65% of the sample well aligned at 6 weeks, a progressive worsening of global sagittal alignment (Global Tilt/RSA), thoracic kyphosis (T2-T12 and T5-T12), associated to increased pelvic compensation (PT and SS/RPV) was observed between 6 weeks and 5YFU ($p<0.05$). These changes however were not associated with worsening QoL outcomes ($p>0.05$) at any postoperative time point. Trends towards greater T2-T12 kyphosis progression linked to age, and an increased SVA and RPV linked to the presence of osteoporosis were observed. Optimal immediate postoperative sagittal alignment didn't seem to protect against this "aging effect".

Conclusion
Neither ASD surgery nor optimal postoperative alignment prevents ongoing "aging" of the non-instrumented spine. Thoracic and global sagittal alignments continue to worsen over time. While no functional deterioration has been documented, the implication of these changes on surgical planning is still to be determined.

113. LOSS OF SAGITTAL CORRECTION >3 YEARS AFTER ADULT SPINAL DEFORMITY SURGERY

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Hypothesis
Compared to those who maintain correction, patients who lose a portion of the original correction after surgery exhibit different surgical and radiographic characteristics.

Design
Retrospective analysis of a multi-institutional ASD database

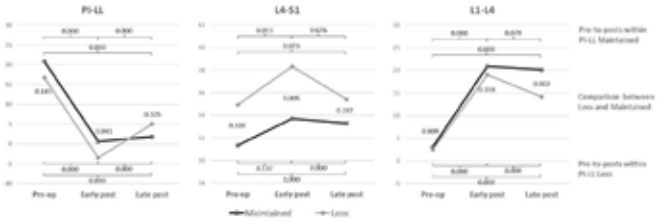
Introduction
The sustainability of adult deformity (ASD) surgery remains a health care challenge.

Methods
369 patients who underwent fusion of the lumbar spine (≥5 levels, LIV pelvis) with a revision-free follow-up ≥3 years were identified. Patients were stratified by change in PI-LL from 6wks to 3yrs postop as Maintained vs. Loss >5°. Those with a loss due to instrumentation failure (broken rod, screw pullout, etc.) were excluded before comparisons. Demographics, surgical data, and radiographic alignment were compared. Repeated measure ANOVA with factor comparison was performed to evaluate the maintenance of the correction for L1-L4 and L4-S1. Multivariate logistic regression was conducted to identify independent surgical predictors of correction loss.

Results
Mean age 64yrs, BMI 28kg/m2, 81% female. The baseline malalignment (PI-LL=21±19°, T1PA 26±12°) was corrected to PI-LL=3±13°, and T1PA=18±10° at 3

yrs (mean 3Y FU: 45m±11). 82 patients (25.5%) lost >5° of PI-LL correction (mean loss 10±5°). After exclusion of patients with instrumentation failure, 52 patients (Loss) were compared to 222 control with maintained LL. Demographics, osteotomies, 3CO, IBF, use of BMP, rod material, rod diameter, and fusion length were not significantly different, but Loss had less supplemental rods (5.8% vs 23.4% p=0.004). Loss of correction occurred in both the L4-S1 and L1-L4 segments (Figure 1). Multivariate logistic regression showed that lack of a supplemental rod (OR 4.0, p=0.005) and fusion length (OR 2.2, p=0.004) were associated with loss of correction. In the Loss cohort, the average loss of L1-S1 screw orientation angle was 1.3±4.1 from early postop to 3 years (p=0.031), but not appreciably different at L4-S1 (-0.1±2.9 p=0.97).

Conclusion
Approximately a quarter of patients lose an average of 10° of their 6-week correction by 3 years. Lordosis is lost proximally through the instrumentation (i.e. tulip/shank angle shifts and/or rod bending), but lost distally through bone "settling" through the instrumentation itself. The use of supplemental rods and avoiding sagittal overcorrection may help mitigate this loss.



114. CURVE OVERCORRECTION PREDICTS CORONAL IMBALANCE IN SELECTIVE THORACIC FUSION IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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Hypothesis
Pre- and postoperative parameters can be utilized to predict coronal imbalance

Design
Retrospective analysis on prospectively collected data

Introduction
Selective fusion in adolescent idiopathic scoliosis (AIS) with Lenke type 1 curves is associated with a risk of coronal imbalance. Coronal imbalance can either be expressed as a deviation of the C7 plumbline from the central sacral vertical line (list) or as truncal shift. We aimed to explore preoperative and immediate postoperative risk factors for coronal imbalance.

Methods
We included AIS patients with a Lenke type 1 curve with A, B and C lumbar modifiers. All patients were surgically treated with selective fusion defined as a lowest instrumented vertebra at L2 or cranial and had two-year follow-up. We assessed a series of radiographic parameters and calculated the curve flexibility (based on fulcrum bending radiographs) and the fulcrum bending flexibility index (FBCI). We defined patients as having coronal imbalance in cases of 1) More than 2 cm of truncal shift at two-year follow-up or 2) More than 2 cm list at two-year follow-up

Results
A total of 301 patients were included in the study. Coronal imbalance at two-year follow-up was found in 38 patients (13%). At the preoperative stage, we found a significant difference in main curve flexibility with 66±15% in the balanced group (at two-year follow-up) and 60±15% in the imbalanced group (p=0.032). At the immediate postoperative stage, mean curve correction was 71±13% vs. 70±13% and mean FBCI was 112±29% vs. 122±29% in the balance and unbalanced group, respectively (p = 0.031) A postoperative FBCI of more than 125% (third quartile) resulted in an odds ratio of 2.1(95%CI:1.1-4.3) for coronal imbalance at two years (p=0.031) Looking at the whole cohort from postoperative to two-year follow-up, we saw no significant changes in fusion mass or LIV tilt. Radiographic shoulder height changed from 16 mm in both groups at the postoperative stage to 11±7 vs 7±6 mm in the balanced and imbalanced group at the two-year follow-up (p=0.002).

Conclusion
A decreased preoperative flexibility and a higher FBCI was significantly associated with coronal imbalance. A high FBCI is an indication of a curve correction that exceeds the inherent flexibility of the spine, and our results add to a growing body of evidence that "overcorrection" of the main curve can lead to coronal imbalance.

115. SIMULTANEOUS OVERCORRECTION OF LOWEST INSTRUMENTED VERTEBRAL TILT AND MAIN THORACIC CURVE IS RELATED TO PROGRESSION OF UNFUSED RESIDUAL LUMBAR CURVE AFTER POSTERIOR FUSION IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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Hypothesis
Over-correction leads to rebound phenomenon

Design
Retrospective observational analysis

Introduction
To disclose radiographic parameters, including lowest instrumented vertebral (LIV) tilt, related to the postoperative magnitude and progression of residual lumbar curves (LCs) in adolescent idiopathic scoliosis (AIS) patients who underwent posterior spinal fusion (PSF) with LIV at or above L1.

Methods
Patients with Lenke type 1-4 curves who underwent PSF with LIV at or above L1 with a minimum follow-up of 2 years were evaluated. Multivariate linear regression analysis using selected radiographic parameters helped develop a

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prediction model for postoperative residual LCs. Subgroup analyses, comparing patients with or without postoperative progression of residual LCs, followed by sensitivity tests, were then performed for variables best predicting the progression of residual LCs.

Results

Overall, 130 patients were included. Multivariate linear regression analysis showed that immediate postoperative LIV-tilt angle was associated with the prediction model for immediate and final postoperative residual LCs, with high accuracy (R=0.93 and 0.77, respectively). Sensitivity tests revealed immediate postoperative LIV-tilt angle < 10° and correction rate of main thoracic curves (MTCs) > 53% as predictors for progression of residual LCs, and they reached moderate discrimination when combined together as one criterion (OR=16.3, 95%CI=5.3-50.1; sensitivity=89%, specificity=67%, PPV=51%, NPV=94%).

Conclusion

The current study revealed that LIV-tilt, as an operable factor during AIS surgery, is not only a determinant in prediction models showing high correlation with the magnitude of immediate postoperative LCs but also a predictor for progression of residual LCs. "Immediately postoperative LIV-tilt angle < 10° and correction rate of MTC Cobb angle >53%", as a united criterion, could serve as a predictor for postoperative progression of residual LCs.

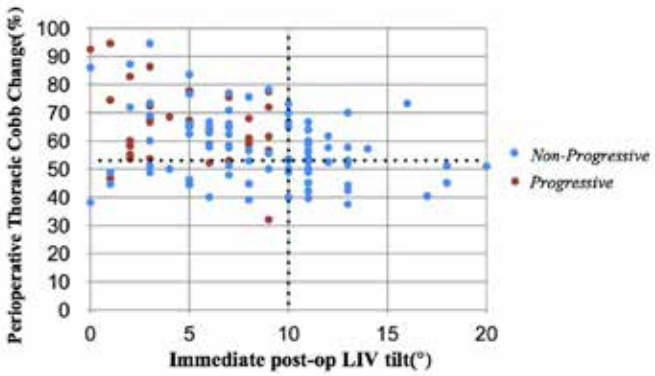

Fig. 1

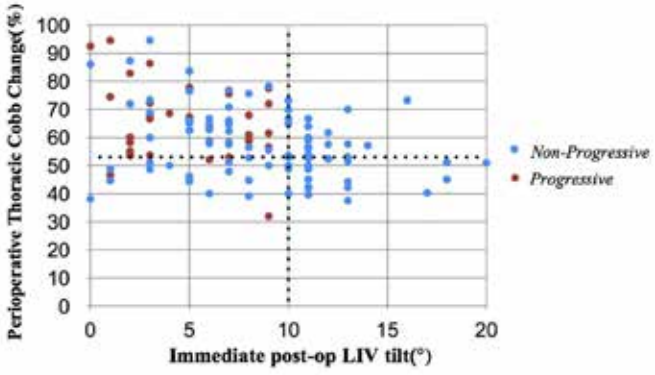

Fig. 1

Fig. 1 "Postoperative LIV-tilt angle < 10° "combined with "correction rate of main thoracic curve >53%" were checked as a united predictor for progression of residual lumbar curve LC. The discrimination is as below: OR=16.3, 95% CI= 5.3 - 50.1; sensitivity=89%, specificity=67%, PPV=51%, NPV=94%; p<.001

116. INCIDENCE AND PREDICTORS OF GROWTH MODULATION AND OVERCORRECTION AFTER ANTERIOR VERTEBRAL BODY TETHERING

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Hypothesis

Growth Modulation (GM) and overcorrection (OC) will occur at a higher rate in smaller, more skeletally immature patients with adolescent idiopathic scoliosis (AIS) after anterior vertebral body tethering (VBT).

Design

Single center retrospective review

Introduction

There is little data on the incidence and predictive factors for patients who will exhibit GM (>10° coronal curve correction after first erect) or OC (coronal curve correction past midline after first erect) after VBT vs. those whose curve correction will remain unchanged (NM: no modulation) after first erect (FE) followup.

Methods

279 AIS patients with minimum 2 year followup (range 2-10 years) after VBT were identified. There were 262 thoracic VBT and 65 thoracolumbar VBT surgeries. Univariate and multivariate regression analyses were performed to identify potential clinical/radiographic predictive factors for GM and OC.

Results

Patients with GM vs. NM after thoracic VBT were significantly more immature: younger, premenarchal, lower Sanders/Risser, open tri-radiate cartilage (OTRC); and smaller: lower height, weight, & body mass index (BMI) (p<0.02). Patients with GM vs. NM after Lumbar VBT had lower preop Sanders, weight, and BMI (p<0.04). Preop and FE thoracic and lumbar curve magnitude did not impact GM vs. NM. Thoracic OC patients were smaller (lower height/weight/BMI) and had lower preop and FE thoracic curve vs. GM patients without OC (p<0.04). Lumbar OC patients had O-TRC and lower FE lumbar curve vs. GM patients without OC (p<0.04). O-TRC (odds ratio: 6.8, p<0.001) and lower BMI (p<0.001) were the only significant predictive factors for thoracic GM with multivariate analysis, none were identified for lumbar GM. 64% of OC patients required a revision surgery vs. 18% of NM (p=<0.001). Thoracic GM and OC occurred in the first year for 74% of patients (p<0.001). Lumbar GM and OC occurred in the first year for 50% of patients and 50% in the second year postop (p>0.5).

Conclusion

AIS patients with an open tri-radiate cartilage and lower BMI had a statistically higher rate of developing thoracic growth modulation (GM) and overcorrection (OC) after VBT with multivariate analysis. Preop and first erect curve magnitude did not impact the incidence of thoracic or lumbar GM. GM and OC occurred primarily in the first year postop. Revision surgery was required in 64% of OC vs. 18% of NM patients.

Thoracic VBT (n=262)						
	GM (n=70)	NM (n=192)	GM v. NM p-value	GMNOC (n=48)	OC (n=24)	GMNOC v. OC p-value
Age	12.4 ± 1.5	12.8 ± 1.2	0.02	12.7 ± 1.5	11.8 ± 1.1	0.01
Gender: Female	57 (81.4%)	170 (88.5%)	0.15	35 (76.1%)	22 (91.7%)	0.19
Pre-menarchal preop	51 (89.5%)	36 (21.2%)	<0.0001	31 (88.6%)	20.0 (90.9%)	0.19
PreOp Height	152.4 ± 10.1	156.5 ± 9.0	0.001	154.4 ± 10.6	148.4 ± 8.0	0.03
PreOp Weight	41.5 ± 9.4	48.9 ± 10.1	<0.0001	44.1 ± 9.3	36.5 ± 7.4	0.01
PreOp BMI	17.8 ± 3.0	19.9 ± 3.5	<0.0001	18.4 ± 3.1	16.4 ± 2.2	0.05
Open Tri-Radiate Cartilage	43 (61.4%)	33 (17.2%)	<0.0001	23 (50%)	20 (83.3%)	0.02
Sanders (mean)	2.8 ± 0.7	3.3 ± 0.8	<0.001	2.9 ± 0.7	2.7 ± 0.6	0.59
Risser (mean)	0.3 ± 0.7	0.7 ± 0.9	0.002	0.4 ± 0.8	0.1 ± 0.3	0.35
Thoracic Cobb PreOp	51.4 ± 10.9	52.8 ± 9.7	0.32	54.3 ± 10.0	45.7 ± 10.7	0.002
Thoracic Curve Flexibility Preop (%)	57.8 ± 21.7%	54.4 ± 19.6%	0.23	52.9 ± 17.7	67.4 ± 25.6%	0.86
Thoracic Cobb FE	27.0 ± 11.0	26.8 ± 9.0	0.86	32.7 ± 7.9	16.3 ± 7.5	<0.0001
Thoracic FE % Correction	48.3 ± 17.6%	49.1 ± 15.6%	0.72	39.6 ± 12.4	64.7 ± 13.4%	<0.0001
Required Revision Surgery	20 (28.6%)	33 (17.2%)	0.06	6 (13.0%)	14 (58.3%)	0.001
Thoracolumbar VBT (n=65)						
	GM (n=18)	NM (n=47)	GM v. NM p-value	GMNOC (n=6)	OC (n=12)	GMNOC v. OC p-value
Age	12.3 ± 1.4	12.9 ± 1.4	0.11	12.6 ± 1	12.1 ± 1.6	0.75
Gender: Female	16 (88.9%)	42 (89.4%)	>0.9	5 (83.3%)	11 (91.7%)	>0.9
Premenarchal preop	16 (100%)	23 (54.8%)	0.001	5 (100%)	11 (100%)	>0.9
PreOp Weight	43.3 ± 7.3	51.1 ± 10.8	0.01	46.5 ± 5.6	41.8 ± 7.8	0.62
PreOp BMI	18.8 ± 3.2	20.9 ± 3.5	0.04	19.5 ± 3.1	18.5 ± 3.3	0.85
Open Tri-Radiate Cartilage	10 (55.6%)	9 (19.1%)	0.01	1 (16.7%)	9 (75.0%)	0.04
Sanders (mean)	2.8 ± 0.6	3.3 ± 0.6	0.002	2.8 ± 0.8	2.8 ± 0.5	0.99
Lumbar PreOp	51.3 ± 7.7	51 ± 9.0	0.92	55.4 ± 7.1	49.2 ± 7.5	0.38
Lumbar Cobb FE	13.8 ± 10.9	18.4 ± 10	0.11	22.2 ± 11.4	9.6 ± 8.2	0.03
Revision	9 (50.0%)	9 (19.1%)	0.26	0 (0%)	9 (75.0%)	0.01

GM: Growth Modulated
NM: No Modulation
GMNOC: Growth Modulation No Overcorrection
OC: Overcorrection

117. PROGRESSIVE INTERVERTEBRAL DISC AND VERTEBRAL BODY ADAPTATIONS INDUCED BY POSTEROLATERAL TETHERING IN A PORCINE SCOLIOSIS MODEL

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Hypothesis
The relative contribution of intervertebral disc (IVD) vs vertebral body (VB) to mechanically modulated spine deformity correction varies with growth over time.

Design
Basic science

Introduction
IVD distortion contributes to AIS early in the disease process, with vertebral wedging ensuing later as deformity progresses. Modulating spine growth by manipulating the mechanical milieu to correct spine pathoanatomy (Heuter-Volkmann Principle) is central to vertebral body tethering, where tension in the tether applies asymmetric compression along the scoliosis convexity. We present a growing pig model where the reciprocal condition is provoked, a posterolateral tether induces a lateral bending moment to elicit a progressive scoliosis. The purpose of this study was to identify the relative contribution of the IVD vs VB over time in response to asymmetric loading.

Methods
Rapidly-growing 12-wk old Yorkshire pigs were instrumented with a subcutaneous flexible CoCr tether spanning the thoracolumbar (TL) and lumbar (L) spine to create an initial scoliosis at 0 wks (Fig 1A,B) that progressed as the pig grew (N=3) and compared to un-instrumented controls (N=2). Changes to IVD and VB anatomy over time were measured with serial 3D CT reconstructions at -2, 0, 4, 6, 8, 12, 19 wks post-op (Fig 1C) and MRI at 5, 19, 22 wks post-op, using T1-weighted FLASH sequence to evaluate geometry and a T2-weighted CPMG echo sequence to evaluate IVD composition based on T2 relaxation time. IVD vs VB wedging and axial torsion were calculated for each spinal unit and across the instrumented spine in n=1 tethered and control animals.

Results
Scoliosis and torsion progressed during growth, modulated by tether induced bending (Fig 1E). The initial 17° Cobb was mediated by lumbar IVD wedging. From 6-12 wks, deformity was anatomically distributed between the TL (45-38%) and L (41-47%) regions, where both IVD (40-46%) and VB (60-54%) wedging accounted for the overall scoliosis (Fig 1D,E). However, at 19 wks, all deformity (41° Cobb) was due to VB wedging. At 18-19 wks, MRI T2 relaxation (290±40 ms) were similar (340±10 ms), suggesting growth modulation (Fig 1F) rather than disc degeneration.

Conclusion
Asymmetric loading using a posterolateral tether provoked asymmetric growth at L & TL spine. Through 12 weeks, deformity occurred in both the IVD and VB; however, by 19 weeks deformity transitioned to only the VB.

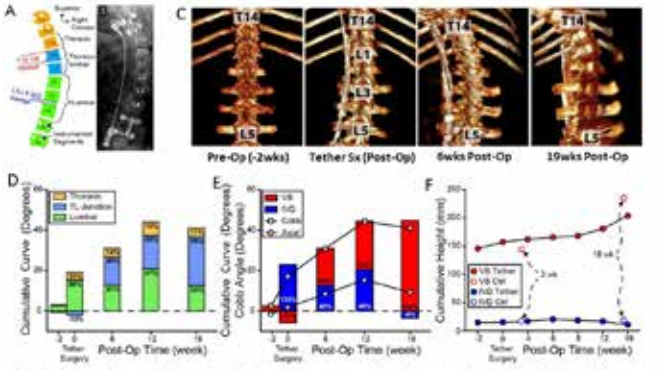

Figure 1: (A) Schematic and (B) radiograph showing bending moment induced by spinal in-line with Co-Cr tether at 6 wks post-op. Analysis conducted on un-instrumented levels from the inferior apophysis T13 to the superior apophysis L5. (C) 3D-C reconstructions demonstrating progressive scoliosis compared to pre-op (-2 wks), at tether surgery immediately post-op (0 wks), and through 6-19 wks post-op. (D-F) Quantification of curve progression as shown in C. Sum of segmental IVD and VB wedge angle by (D) anatomic region and (E) tissue type. Overall Cobb angle & axial torsion shown by black line (E). Regions defined in (A): positive = right curve and counterclockwise rotation. (F) Sum of VB and IVD height between instrumented segments. Control pigs at equivalent age are shown at 8 and 18 weeks post-op.

118. MAJOR COBB ANGLE DID NOT DECREASE IN 92% OF PATIENTS AFTER VERTEBRAL BODY TETHERING SURGERY FOLLOWING FIRST ERECT RADIOGRAPH

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Hypothesis
Growth modulation is not consistently decreasing the Cobb Angle in adolescent idiopathic scoliosis (AIS) patients treated with Vertebral Body Tethering (VBT)

PODIUM PRESENTATION ABSTRACTS

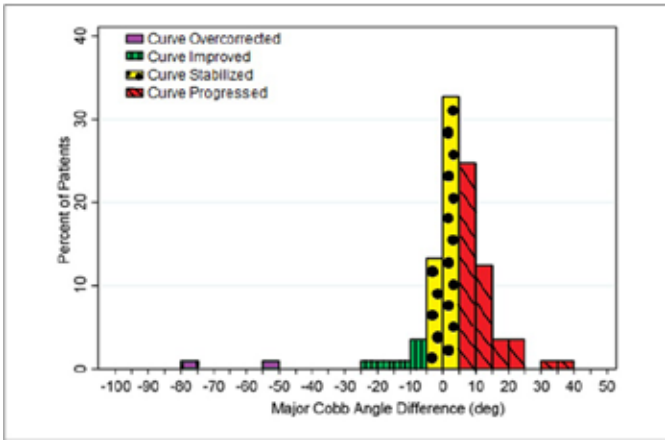
Design
Retrospective, Multicenter

Introduction
Much enthusiasm has been generated around VBT as an alternative to fusion treatment. However, the majority of series report little difference between Cobb angles on the first erect post-operative x-ray and final follow-up (Rushton 2021, Newton 2018), suggesting VBT is not consistently modulating spine growth in a way that significantly effects Cobb Angle.

Methods
AIS patients who underwent VBT with > 2 yrs follow up between Dec 2013- Jan 2020 in a multi-center registry were reviewed. Change in Cobb angle was calculated by subtracting the Cobb angle at final follow up from that on first erect postoperative radiographs. A change in Cobb angle <5° was considered within normal measurement variability (consistent with prior study, Morrissy 1990).

Results
113 patients met inclusion criteria with mean age of 12.9 yrs (SD 1.3) and a mean follow up of 3.7 yrs (2.0 to 6.8). A mean of 6.6 levels were tethered. Preoperative mean major Cobb angle was 51.1°(32° to 75°), which corrected to a mean major Cobb of 27.4° (10° to 53°) on first erect radiographs. At final follow up, mean major Cobb was 31.1°(-50° to 69°). 50.4% (57/113) of curves were stable (Cobb angles within 5° of their first erect radiograph on final follow up). A total of 41.6% (n=47) had > 5° of increase in Cobb angle following the initial erect radiograph. 8% (n=9) showed more than 5° of decrease in Cobb angle during the follow up period, and 4.4% (n=5) had greater than 10° of correction. 2 of those 5 patients that corrected more than 10° overcorrected, ending up with 30° and 50° curves in the opposite direction.

Conclusion
Although this technique holds promise and many of the curves remained stable from first erect to final follow up (50%), only 9/113 VBT patients in this series demonstrated improvement in Cobb angle over time following first erect imaging, including 2 patients that overcorrected. Further research is needed to identify the differentiating factors between those patients that progressed, didn't progress or overcorrected to determine which patients are more likely to benefit from.



Major Cobb angle difference = Major Cobb angle on final follow up radiographs – Major Cobb angle on first erect radiographs

119. DIFFERENTIAL VERTEBRAL GROWTH IS MAINTAINED 4 YEARS AFTER VERTEBRAL BODY TETHERING SURGERY FOR IDIOPATHIC SCOLIOSIS

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Hypothesis
Patients with idiopathic scoliosis who are treated with vertebral body tethering surgery (AVBT) will produce differential vertebral body growth in peri-apical vertebrae, which is maintained at minimum 4 year follow up.

Design
Retrospective review of prospective international, multicenter registry data.

Introduction
AVBT is used to treat select skeletally immature patients with idiopathic scoliosis under the assumption that the Heuter-Volkmann law will induce differential concave vs. convex vertebral body growth. It has recently been published that, at 2-year follow-up, AVBT limits convex spine growth while allowing greater concave growth. Our purpose is to evaluate these effects at longer term follow-up.

Methods
A prospective, international, multicenter database was queried to identify patients with idiopathic scoliosis who were treated with thoracic AVBT. Concave vs. convex vertebral body height, vertebral wedging, and disc wedging of the 3 apical vertebrae were measured by two independent observers pre-operatively and at 4-year post-operative.

Results
67 patients (62 female, mean 12.8 yr old) met inclusion criteria for this study. Mean pre-op scoliosis of 51 ± 9°decreased to 33 ± 10° at 4-yr post-op ($p < 0.001$); while mean pre-op kyphosis of 29 ± 10° increased to 42 ± 14° at 4-yr post-op ($p < 0.001$). Mean individual convex vertebral height increased from 17.7 ± 1.9 mm to 19.8 ± 1.4 mm ($p<0.001$), while the mean individual

concave height increased from 14.8 ± 1.9 mm to 17.5 ± 1.5 mm (p<0.001). Summing the heights of the three peri-apical vertebrae, the difference in height from pre-op to 4 years was greater on the concave (8.9 ± 2.7 mm) than on the convex side (6.6 ± 3.4 mm) (p<0.001). The mean individual vertebral wedging decreased from 6.0 ± 1.8° at pre-op to 3.8 ± 2.0° at 4 years (p<0.001), and the mean total vertebral and disk wedging decreased from 28.8 ± 6.5° at pre-op to 13.8 ± 8.2° at 4 years (p<0.001). These results were not affected by patient BMI or by level of skeletal maturity at time of surgery.

Conclusion
Patients with idiopathic scoliosis who were treated with AVBT demonstrated differential vertebral body growth which was maintained at minimum 4 year follow up.

Measurement	Pre-op	4-year follow-up	p-value
Mean individual convex vertebral height	17.7 ± 1.9 mm	19.8 ± 1.4 mm	<0.001
Mean individual concave vertebral height	14.8 ± 1.9 mm	17.5 ± 1.5 mm	<0.001
Total convex vertebral height	53.2 ± 5.6 mm	59.3 ± 4.2 mm	<0.001
Total concave vertebral height	44.3 ± 5.6 mm	52.6 ± 4.6 mm	<0.001
Delta total concave vs convex height	8.9 ± 2.7 mm	6.6 ± 3.4 mm	<0.001
Mean individual vertebral body wedging	6.0 ± 1.8°	3.8 ± 2.0°	<0.001
Mean total vertebral and disk wedging	28.8 ± 6.5	13.8 ± 8.2	<0.001

Pre-op and 4 year measurements

120. 3-D VERTEBRAL SHAPE CHANGES CONFIRM GROWTH MODULATION AFTER ANTERIOR VERTEBRAL BODY TETHERING FOR IDIOPATHIC SCOLIOSIS

Joshua N. Speirs, MD; Stefan Parent, MD, PhD; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Maty Petcharaporn, BS; Tracey P. Bastrom, MA; Peter O. Newton, MD

Hypothesis
Anterior vertebral body tethering (AVBT) for adolescent idiopathic scoliosis (AIS) results in growth modulation favoring the concavity.

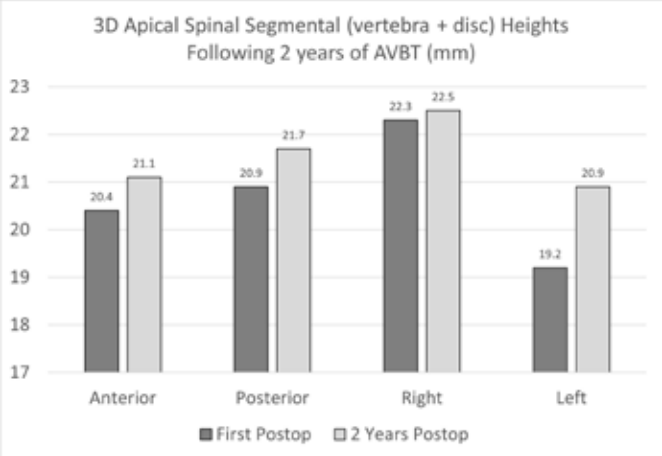
Design
Retrospective Cohort

Introduction
The relative 3D vertebra and disc shape changes that occur in AIS following AVBT are not well understood.

Methods
Immature patients treated for right thoracic AIS with AVBT from 2 centers were evaluated after 3D reconstructions were created from simultaneous biplanar radiographs. Vertebral body and disc shape (wedging angle) and dimensions (height: anterior, posterior, left, right) were recorded over the 3 apical segments (zone of maximal deformity) in the local vertebral reference planes (compensating for axial rotation). Cases with a broken tether around the apex were excluded. Changes in the height and wedging of both the vertebrae and discs were measured for 2 years. Change in patient overall height was also collected.

Results
50 pts (Risser 0-3, Sanders 2-4) were included. The avg. age was 12.3yrs (range 8-14) and the avg. coronal curve was 50±10° preop, 31±9° at first postop which improved to 27±11° (p<0.001) at 2yrs. Avg. height increased 8cm during the 2yrs (p<0.001). During these 2 years, the left side of the spine (vertebra+disc) grew 1.7±4.0mm/level compared to 0.2±3.7mm/level on the right tethered side (p<0.001). This 1.5mm/level of differential growth was made up of 0.5mm/level for vertebra and 1.0mm/level for the disc. All 4 vertebra measurements increased in height (0.8-1.2mm) while ant/post/right disc height measures decreased (0.4-0.6mm); left disc increased 0.4mm. Coronal wedging was reduced 2.4°/level with 1.1°/level in the vertebra (3.6°/level reduced to 2.5°/level) and 1.3°/level within the disc. There was no differential growth in the sagittal plane. Strong correlations existed between overall patient height change and these 3D measures of the vertebra and disc shape changes (r, 0.35-0.67).

Conclusion
Three-dimensional analysis confirms that AVBT in immature patients results in asymmetric growth of the apical spine segments. The left side length increased 8 times greater than the tethered right side with differential effects within the vertebral bodies and discs correlating with overall patient height change.



121. 3D ANALYSIS OF THE PREOPERATIVE DEFORMITY IN AIS CAN BE USED TO GUIDE SURGICAL DECISION MAKING FOR SELECTIVE THORACIC FUSION

Vidyadhar V. Upasani, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Stephen G. George, MD; Stefan Parent, MD, PhD; Peter O. Newton, MD

Hypothesis
3D preoperative radiographic factors are associated with optimal outcomes following STF for AIS.

Design
Review of prospective registry

Introduction
Traditional criteria for performing a STF are based on 2D measurements and include a thoracic curve that is 20% greater in terms of curve magnitude, apical deviation and axial rotation. 3D analysis may provide additional insight into what deformity characteristics are associated with optimal STF outcomes.

Methods
Subjects with primary thoracic curves (Lenke 1-4 with B or C modifiers) fused selectively (LIV of L1 or above) who had preop 3D reconstructions created from simultaneous biplanar

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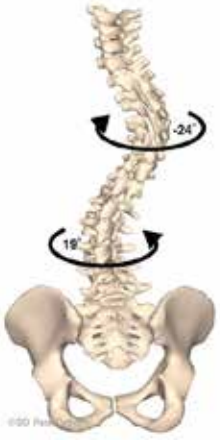
radiographs and min 2yrs of follow-up were included. An optimal outcome at 2yrs was defined as having 4/5 radiographic parameters previously defined in the literature: 1) lumbar curve <26°, 2) deformity flexibility quotient <4, 3) C7-CSVL <2cm, 4) lumbar prominence <5°, and 5) trunk shift <1.5cm. Univariate and CART analyses were performed to identify preop variables associated with achieving an optimal outcome at 2yrs postop.

Results
99 adolescents met inclusion. Mean age was 15±2 years; 88 subjects were female. Fifty-one subjects (52%) met criteria for optimal outcome. No differences were observed in sex, upper instrumented vertebra, LIV, LIV relative to neutral, or LIV relative to stable (p>0.05). Seven measures representing greater preop thoracolumbar/lumbar deformity in the suboptimal group were found to be significant on univariate analysis (p<0.05; Figure). CART analysis identified the following as predictive of outcome: difference in apical rotation >30° = 27% optimal outcomes, difference in apical rotation ≤30° and lumbar apex coronal vertebral wedging >3° = 46% optimal outcomes, and difference in apical rotation ≤30° and coronal vertebral wedging of lumbar apex ≤3° = 80% optimal outcomes (p<0.05).

Conclusion
Preoperative 3D analysis identified 7 measures of lumbar deformity to guide surgical decision making for STF, with CART analysis demonstrating difference in apical rotation between the thoracic and lumbar apices and lumbar apical vertebral wedging as significant predictor variables.

Table includes variables significant on univariate analysis and figure demonstrates the 'Difference in Apical Rotation' variable which was calculated by taking the absolute value of the difference between the thoracic apical rotation and the lumbar apical rotation values (e.g., Absolute Value of -24-19 = 43deg).

	Optimal Outcome (Mean ± SD)	Suboptimal Outcome (Mean ± SD)	p-value
Lumbar Curve (°)	37 ± 6	43 ± 6	<0.001
Lumbar Bend (°)	14 ± 9	20 ± 10	0.002
Lumbar Flexibility (%)	64 ± 22	55 ± 22	0.042
3D T12-S1 Lordosis (°)	-60 ± 12	-65 ± 12	0.019
Thoracolumbar/Lumbar Apical Rotation (°)	11 ± 4	14 ± 7	0.002
Coronal Plane Vertebral Wedging of the Lumbar Apex (°)	2.6 ± 1.7	3.8 ± 2.3	<0.001
Difference in Apical Rotation (Absolute value of Thoracic – Lumbar Rotation) (°)	25 ± 6	29 ± 6	0.001



122. BASELINE VITAMIN D INSUFFICIENCY DURING PUBERTAL GROWTH IS ASSOCIATED WITH LOW PEAK BONE MASS IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A 6-YEAR PROSPECTIVE COHORT STUDY

Kenneth GP Yang, BMed; Wayne YW Lee, PhD; Lik Hang Alec Hung, MD; Jack C. Cheng, MD; Tsz-Ping Lam, MBBS

Hypothesis
Vitamin D insufficiency affects bone mineral accrual and achievement of Peak Bone Mass (PBM) in Adolescent Idiopathic Scoliosis (AIS).

Design
A longitudinal cohort study

Introduction
Patients with AIS have systemic low bone mass especially during peripubertal peak height velocity (PHV) when curve is at the greatest risk of rapid progression. Their low bone mass could persist and affect the attainment of PBM which is an important determinant for osteoporosis and fragility fracture in late adulthood. Evaluation of factors that influence PBM could be helpful to prevent curve progression and for achieving good bone health in adulthood. Vitamin D insufficiency, a globally prevalent condition, was shown to be associated with low bone density among adolescents but mainly with cross-sectional studies. We carried this prospective cohort study to evaluate effect of vitamin D insufficiency on bone mineral accrual using repeated measurements around PHV, and to investigate whether the vitamin D insufficiency around PHV is associated with low PBM.

Methods
110 AIS girls (11-14 years old) were recruited and followed up 1 year, 2 years, and 6 years after the recruitment. Bone qualities and bone maturity stage were evaluated with high-resolution peripheral quantitative computed tomography (HR-pQCT) and thumb ossification composite index (TOCI), respectively. Serum total 25OHD and bone turnover markers were assessed. Mixed-effect models were used for data analysis.

Results
Subjects were followed up from a mean age of 12.9 to 19.2 years old. Low 25OHD level significantly affects (a) increase of total vBMD (p=0.018), cortical vBMD, cortical thickness, cortical area, stiffness, failure load and apparent modulus, and (b) decrease of CTX and P1NP. Seventy subjects completed all four 25OHD measurements and were further grouped based on the number of occasions with 25OHD < 30 nmol/L (none, 1, 2 or >3 times). Subjects with >3 times had significantly lower total vBMD (335.6 ± 37.7 vs 382.1 ± 55.3, p=0.028), aforementioned parameters of cortical bone and mechanical strength at the last visit than those with none.

Conclusion
Vitamin D insufficiency is associated with decreased cortical bone mineral accrual and PBM in AIS. Further studies are warranted to evaluate if therapeutic intervention with vitamin D can have therapeutic effect.(RGC of Hong Kong SAR project no. 14130216)

123. PREDICTORS OF RADIOGRAPHIC SUCCESS WHEN UTILIZING A LOWER INSTRUMENTED VERTEBRA OF L3 IN IDIOPATHIC SCOLIOSIS

Chia-Hung Sze, MTM; *Scott J. Luhmann, MD*

Hypothesis
Preoperative radiographic criteria will be associated with radiographic success following posterior spinal fusion utilizing a LIV of L3.

Design
Retrospective Case Series

Introduction
In posterior spinal fusion (PSF) for idiopathic scoliosis (IS)

involving the lumbar spine, a lower instrumented vertebra (LIV) of L3 is preferable over L4 to optimize spinal motion, but may increase risk of spinal imbalance, pain, and reoperation. The purpose of this study is to evaluate a preoperative radiographic scoring system on predicting the radiographic success of utilizing L3 as the LIV in PSF for IS.

Methods
A single-surgeon database was used to identify all patients (n=67) who underwent PSF for IS with a LIV of L3 and follow up ≥ 2 yrs. Preoperative scoring criteria: 1) Central sacral vertical line medial to or intersects L3 concave pedicle (CVSL), 2) Direction of L3-L4 disc opening (Opening), 3) Difference in Nash-Moe grade between L3 and L4 <= 1 (Rotation), 4) L3 stacking on L4-L5-S1 on any non-weightbearing radiographs defined as CVSL traversing between or intersecting the L3 pedicles (Stacking). On final radiographs, a successful outcome was defined as coronal balance <= 20 mm and L3-L4 disc wedging of <= 10°.

Results
67 patients (86% female) satisfied the inclusion and exclusion criteria, with average age 14.5 yrs (range 12-18 yrs). Average follow up was 3.8 yrs (2.0 to 12.3 yrs). Average major curve of 54.1° preoperatively improved to an average of 17.2° (68% improvement) at most recent follow up. The radiographic success rate was 0% for 1 (n=4), 68% for 2 (n=22), 79% for 3 (n=33), and 100% for 4 (n=8) preoperative criteria met. Individual criteria were met in 25 patients (37%) for CVSL, 31 (46%) for Opening, 67 (100%) for Rotation, and 56 (84%) for Stacking. The radiographic success rate for patients meeting vs failing the CVSL criteria was 92% vs 71% (p=0.045). There were no reoperations in this patient group.

Conclusion
The radiographic success with a LIV of L3 in PSF for IS increases as more preoperative radiographic criteria are met, with 0%, 68%, 79%, and 100% success with 1, 2, 3, and 4 criteria, respectively. In this single-surgeon experience, the data suggest that the proposed scoring system can guide surgical planning (LIV of L3 vs. L4), with a high rate of radiographic success in patients meeting 3 or 4 preoperative radiographic criteria.

Table 1: Preoperative Radiographic Scoring System for L3 LIV in IS

Criteria	# Patients	Success Rate
0 of 4	0	~
1 of 4	4	0%
2 of 4	22	68%
3 of 4	33	79%
4 of 4	8	100%
	# Patients Meeting Criteria	% Meeting Criteria
CVSL	25	37%
Opening	31	46%
Rotation	67	100%
Stacking	56	84%

Preoperative Radiographic Scoring System for L3 LIV in IS

124. CAN WE STOP DISTALLY AT LSTV-1 FOR ADOLESCENT IDIOPATHIC SCOLIOSIS WITH LENKE 1A/2A CURVES? A MINIMUM OF 2-YEAR FOLLOW-UP STUDY

Xiaodong Qin, PhD; Yong Qiu, PhD; Zhen Liu, PhD; Bangping Qian, MD; Zezhang Zhu, MD, PhD

Hypothesis
In some cases, selecting LSTV-1 as LIV could achieve similar outcomes to LSTV.

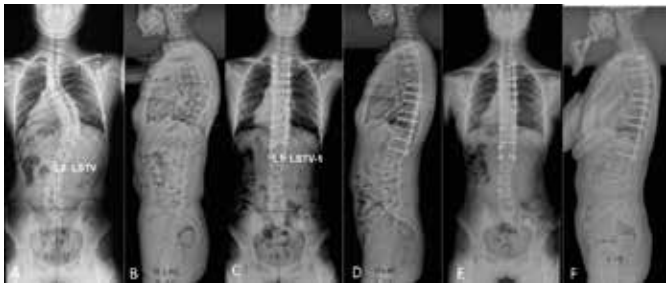
Design
Retrospective study

Introduction
Posterior thoracic fusion to save more lumbar mobile segments has become the mainstay of operative treatment for AIS with Lenke 1A/2A curves. Although previous studies have recommended selecting the LSTV as LIV, good outcomes could still be achieved in some cases when LSTV-1 was selected as LIV. The purpose of the study is to determine in which case LSTV-1 could be a valid LIV, in which case distal fusion should extend to LSTV, and to identify risk factors for distal adding-on.

Methods
Ninety-four patients were included in the study with a minimum of 2-year follow-up after posterior thoracic instrumentation, in which LSTV-1 was selected as LIV. Patients were identified with distal adding-on between first erect radiographs and 2-year follow-up based on previously defined parameters. Factors associated with the incidence of adding-on were analyzed.

Results
The mean follow-up duration was 37.7±15.8 months. Forty patients (42.6%) with LSTV-1 selected as LIV achieved good outcomes at the last follow-up. Several preoperative risk factors significantly associated with distal adding-on were identified, including lower Risser (p=0.001), longer thoracic curve length (p=0.005), larger rotation and deviation of LSTV-1 (p<0.001) and preoperative coronal imbalance (p=0.013).

Conclusion
Skeletally immature patients with long thoracic curve, preoperative coronal imbalance, large rotation and deviation of LSTV-1 are at increased risk of distal adding-on when selecting LSTV-1 as LIV. Under this condition, distal fusion level should extend to LSTV; While in other case, LSTV-1 could be a valid LIV.



(A,B)A 16-year-old girl with Lenke 2A curve. L2 was LSTV, Risser grade was 5, CSVL-C7PL distance was 8mm. (C,D) First erect radiograph postoperatively with fusion to LSTV-1. (E,F)2.5-year postoperative radiograph showed good

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corrective outcome remained without distal adding-on.

125. PRE-OPERATIVE AND SURGICAL FACTORS THAT MAXIMIZE CHANGE IN LUMBOSACRAL TAKEOFF ANGLE (LSTOA)

Keith R. Bachmann, MD; Theodore Rudic; Richard E. Campbell, MD; Alexander Hafey; Monica Arney, MD; Wendy M. Novicoff, PhD; Peter O. Newton, MD

Hypothesis
Change in LSTOA is maximized with correction of thoracic Cobb

Design
Retrospective evaluation of a prospectively collected database

Introduction
Improvement in the angulation of the lumbar spine as it arises from the pelvis (LSTOA) has been shown to be maximized when the distal fusion extends closer to the sacrum. In an effort to spare distal levels of fusion, we sought pre-operative and corrective factors to maximize correction of the LSTOA

Methods
A retrospective analysis of Lenke 1-6, lumbar B and C modifier patients in the Harms Study Group with 2-year follow up. The cases were divided into two groups: End instrumented vertebra (EIV) T9-L1 (552 cases) and L2-L5 (895 cases). Multivariable regression of pre-operative and two year correction variables was performed on the variables noted in Table 1. Variables were considered significant predictors of 2 year change in LSTOA if $p<0.05$, but the clinical relevance based on the coefficient of the effect will require further study

Results
Mean correction of the LSTOA was 1.86° with EIV T9-L1 and 5.16° with EIV L2-L5. In both groups, the pre-operative LSTOA and flexibility of the LSTOA on bend films were significantly related to 2-year change in LSTOA. In the group with EIV L2-L5, the pre-operative translation of the lumbar apex and site were significant. When analyzing corrective measures, correction of the lumbar apex to the midline was a significant predictor in both groups. In the EIV T9-L1 group, correction of coronal balance to the midline was significant. In the EIV L2-L5 group, site and 2-year change in thoracic and lumbar Cobb were also significant. The preoperative measures of the coronal and sagittal curves and curve flexibility were not predictors of change. While these results provide limited insight into correction of the LSTOA, the lack of impact from coronal and sagittal plane measures highlights the independent nature of the LSTOA. If the LSTOA is not mobile on bending x-rays, then there will be residual LSTOA if choosing a more cranial EIV, or the LSTOA can be used as a variable to decide on a more distal fusion level

Conclusion
Flexibility of the LSTOA, pre-operative and change in lumbar apex translation, and correction of thoracic and lumbar Cobb with an EIV L2-L5 were found to be predictors of change in LSTOA. The LSTOA should be considered to help decide on a non-selective fusion in patients with AIS

EIV T9-L1 Variables	P-value	EIV L2-L5 variables	P-value
Variables that resulted in better 2-year LSTOA correction		**Variables that resulted in better 2-year LSTOA correction**	
2 Year Lumbar Apex Correction to Midline	<0.001	Pre-op Lumbar apical translation	<0.001
LSTOA Bend Left	<0.001	LSTOA Bend Left	<0.001
LSTOA Bend Right	0.008	2 Year Lumbar Apex Correction to Midline	<0.001
2 Year Coronal Balance Correction	0.045	2 Year Lumbar Cobb Correction Index	0.045
		LSTOA Bend Right	0.045
		2 Year Thoracic Cobb Correction Index	0.048
Variables that resulted in worse 2-year LSTOA correction		**Variables that resulted in worse 2-year LSTOA correction**	
Pre-op LSTOA	<0.001	Pre-op LSTOA	<0.001
Variables with mixed effect on 2-year LSTOA correction		**Variables with mixed effect on 2-year LSTOA correction**	
		Site	<0.001
Variables without a statistically significant effect on 2-year LSTOA correction		**Variables without a statistically significant effect on 2-year LSTOA correction**	
Pre-op Measures: Upper Thoracic, Main Thoracic, Lumbar Cobb; UT, MT, Lumbar Bending Cobb, Coronal Balance, Thoracic apex translation, Lumbar apex translation, T2-T12 kyphosis, T5-T12 kyphosis, T10-L2 kyphosis, T12-L5 lordosis, EIV Levels to Lumbar Apex, Site, Gender	>0.05	Pre-op Measures: Upper Thoracic, Main Thoracic, Lumbar Cobb; UT, MT, Lumbar Bending Cobb, Coronal Balance, Thoracic apex translation, T2-T12 kyphosis, T5-T12 kyphosis, T10-L2 kyphosis, T12-L5 lordosis, EIV Levels to Lumbar Apex, Gender	>0.05
Post-op measures: Thoracic and lumbar correction index, 2 Year change in kyphosis and lordosis, Thoracic apex correction to midline	>0.05	Post-op measures: 2 Year change in kyphosis and lordosis, Thoracic apex correction to midline, Coronal Balance Correction to Midline	>0.05

Table 1: Variables included in regression

126. A THORACOSCOPIC ANTERIOR APPROACH TO THE SPINE FOR ADOLESCENT IDIOPATHIC SCOLIOSIS DOES NOT HAVE A DETRIMENTAL EFFECT ON PULMONARY FUNCTION AT 2 YEARS COMPARED TO POSTERIOR-ONLY SURGERY

Harold G. Moore, BS; Anna McClung, BSN; David C. Thornberg, BS; Brenda C. Santillan, BS; Daniel J. Sucato, MD, MS

Hypothesis
Patients with a video-assisted anterior thoracoscopic release in addition to posterior spinal fusion (PSF) will have similar pulmonary function at 2 years post-operatively when compared to their posterior-only peers.

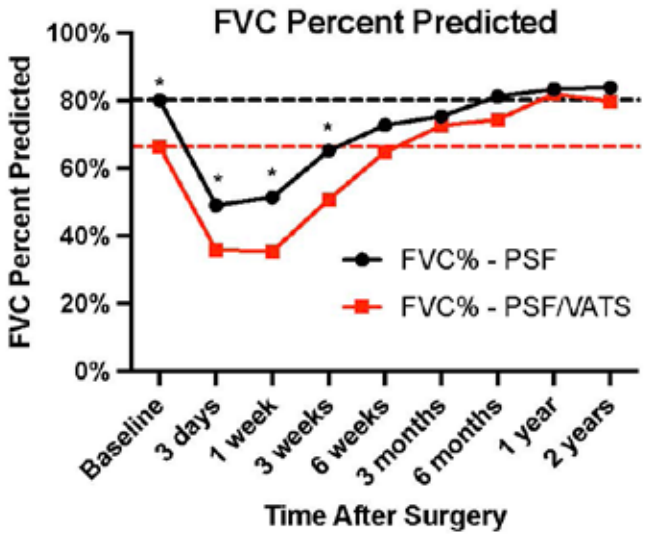
Design
Retrospective cohort study

Introduction
Novel applications of thoracoscopic anterior surgery - such as vertebral body tethering - are being increasingly applied in appropriately selected patients, and these approaches that disrupt the pleura may cause scarring and compromise in long-term pulmonary function. This study aims to examine long-term pulmonary function outcomes in patients with adolescent idiopathic scoliosis (AIS) undergoing PSF with an anterior thoracoscopic release compared to those undergoing PSF alone.

Methods
A retrospective review of patients undergoing surgery for AIS over a 9-year period at a single institution were compared in 2 groups: PSF with video-assisted thoracoscopic surgery (PSF/VATS) and patients undergoing PSF alone. Standard radiographs and absolute and percent predicted Forced Expiratory Volume (FEV1) and Forced Vital Capacity (FVC) were obtained preoperatively and on the 3rd day of admission, at 1 week, 3 weeks, 3 months, 6 months, 1 year, and 2 years postoperatively. Within group and between-group comparisons were performed. Significance was set at $p<0.05$.

Results
A total of 110 patients were included in the study: 12 in the PSF/VATS cohort and 98 in the PSF only cohort. The PSF/VATS group were younger (12.6 vs. 14.6, p=0.003), had larger coronal curves (80.8° vs. 60.7°, p=0.001), and worse preoperative FVC (64.7% vs. 79.6%, p=0.018) and FEV1 (62.3% vs. 77.6%, p=0.003). At 2 years postoperatively, the percent coronal Cobb correction was greater in the PSF/VATS group (67.9% vs. 48.4%, p<0.001) with greater improvement in thoracic height (32.8 mm vs. 20.7 mm, p=0.028). While the 2-year PFTs were the same for FEV1% (75.8% vs. 81.8%, p = 0.368) and FVC% (77.3% vs. 83.7%, p=0.562), there was greater percent improvement in the PSF/VATS cohort: FEV1% (13.5% vs. 4.2%, p=0.082) and FVC% (12.7% vs. 4.1%, p=0.112) (Figure 1).

Conclusion
AIS patients who have a VATS approach in addition to PSF have greater coronal plane correction and improved pulmonary function compared to their baseline and to PSF alone despite more severe spinal deformity and worse baseline pulmonary function.



127. TWO TO FIVE YEARS PULMONARY FUNCTIONS AFTER THORACIC, THORACOLUMBAR AND DOUBLE-CURVE VBT SURGERY

Caglar Yilgor, MD; Burcu Akpunarli, MD; Altug Yucekul, MD; Kadir Abul, MD; Peri Kindan, MD; Gokhan Ergene, MD; Sahin Senay, MD; Tais Zulemyan, MSc; Yasemin Yavuz, PhD; Ahmet Alanay, MD

Hypothesis
Thoracoscopic VBT, as an anterior scoliosis surgery, may cause deterioration in pulmonary function

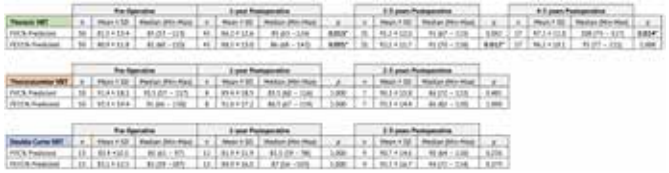
Design
Case Series

Introduction
Previous studies have shown that anterior spinal fusion significantly decreased FVC% and FEV1% values after AIS surgery. Few studies investigate the effects of anterior thoracoscopic VBT surgery on pulmonary function.

Methods
Data were collected preoperatively, at 6-weeks, 1-year and yearly after 2 years follow-up. All-thoracoscopic technique was used to approach thoracic vertebrae, while retroperitoneal flank incision was used to access lumbar vertebrae. Demographic, clinical, radiographic data and complications were analyzed. Curve sizes at each follow-up were compared using repeated measures ANOVA. Preoperative, 1-year, 2-3 years and 4-5 years postoperative FVC% and FEV1% were compared using mixed models.

Results
74 consecutive patients (68F, 6M; 12.7±1.7 years) with a mean follow-up of 39 (24-92) months were included. 77% were Lenke 1 and there were 2, 2, 10 and 3 patients with Lenke 2, 3, 5 and 6 curve patterns, respectively. Preoperatively, median Sanders was 3 (1-7) and median Risser was 0 (0-5)). A mean of 8 (5-11) levels were tethered. Patients grew 6 cm on average; height measurements showing significant increase (p<0.001). 82% of the patients reached skeletal maturity at final follow-up. The mean preoperative MT curve magnitude of 49.6°±11.3° was corrected to 24.9°±7.6° at first erect radiographs, which was modulated to 19.5°±12.9° during follow-up, displaying a significant decrease. A total of 6 (8.1%) patients experienced pulmonary complications (2 ipsilateral and 1 contralateral atelectasis, 1 lobar atelectasis, 1 pleural effusion and 1 chylothorax). Thoracic VBT resulted in improved PFT at 1 year (p=0.015). Further improvements were observed between 1 to 2-3 years, and 2-3 to 4-5 years follow-up for FEV1 and FVC, respectively (p=0.012 and p=0.024). Pulmonary function after thoracolumbar and double-curve VBT; however, were similar between preoperative and 1-year and 2-3 years postoperative follow-up (Figure).

Conclusion
Thoracic-only VBT surgery resulted in improved pulmonary function at 1-year, which further improved at 2-3 years and/or 4-5 years follow-up. Thoracolumbar and double-curve VBT surgeries did not cause worsening nor improvement in pulmonary function 1-year and 2-3 years after surgery.



128. EXPANSION STERNOPLASTY TO TREAT A NOVEL FORM OF THORACIC INSUFFICIENCY

Blake Montgomery, MD; Emily Eickhoff, BS; Christopher Baird, MD; Benjamin Zendejas, MD; Russell W. Jennings, MD; Brian D. Snyder, MD, PhD

Hypothesis
Thoracic insufficiency due to a narrow thoracic inlet leads to airway & esophageal obstruction; increasing upper mediastinum depth by expansion sternoplasty relieves obstruction.

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Design
IRB approved retrospective case series 2015-2021

Introduction
Thoracic insufficiency (TIS), typically attributed to compression of lung parenchyma as a consequence of thoracic deformity, can also be caused by compression of upper mediastinal structures secondary to a narrow thoracic inlet (Fig. 1). Clinical manifestations include exercise intolerance, wheezing, chronic cough, pain, and/or palpitations. Surgery is indicated when symptoms impede quality of life, after failed non-operative treatments. Since the chest is a ring shaped cylinder, distracting open the ring to increase circumference will increase thoracic volume and specifically increase the depth of the upper mediastinum (Fig 2). We describe a novel procedure to treat upper thoracic insufficiency by performing an opening wedge sternal osteotomy.

Methods
Based on CT-angiography, 12 patients were identified with obstructive airway and/or esophageal symptoms provoked by vascular or bony compression induced by a narrowed mediastinum. Distraction through a midline opening wedge sternotomy was maintained by interposing a series of transversely oriented autogenous rib segments (~4 cm) extracted from left ribs 7 and 9. Rib grafts were anchored to each half of the split sternum with braided polyester sutures, re-enforced with contoured rib plates spanning the sternum (Fig 3). Facilitated by added mediastinum depth, tracheo- and aorto-pexies were performed to decompress airway & esophageal obstruction. A pectoralis muscle flap was mobilized over the construct.

Results
Congenital, syndromic and connective tissue etiologies were associated with upper thoracic deformity; median age 14.5 yrs, 7♀ (Table 1). Expansion sternoplasty consistently increased space available for the tracheobronchial tree (Table 2): mean gains in mediastinum depth +24.9% (SD 22.8, p<0.01); Haller index +17.2% (SD 10.6, p<0.01); trachea cross-sectional area +57.5% (SD 69.1, p<0.01). Esophageal and airway symptoms were relieved clinically in all patients.

Conclusion
We describe a novel form of TIS caused by a narrow thoracic inlet that compresses the upper airway and esophagus. This was reliably improved by expansion sternoplasty with interposition of autogenous rib grafts to increase mediastinum depth.

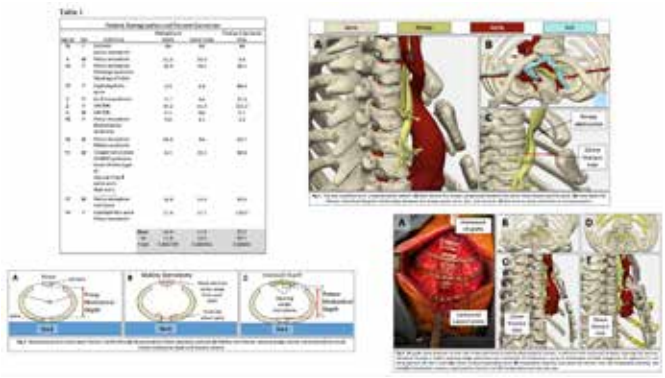


Table and Figures

129. DELINEATION OF DUAL MOLECULAR DIAGNOSIS IN PATIENTS WITH VERTEBRAL DEFORMITIES

Nan Wu, MD; Lian Liu, MD; Huakang Du, BS; *Paul Gerdhem, MD, PhD*; Zhihong Wu, MD; Terry Jianguo Zhang, MD

Hypothesis
Vertebral deformity patients with dual molecular diagnosis have complicated phenotypes.

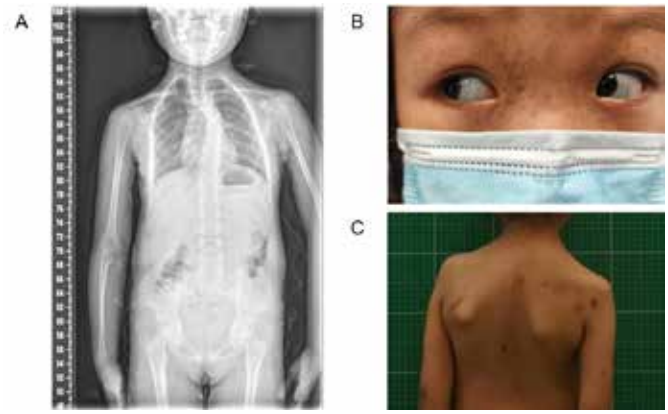
Design
This is a retrospective study which reports the clinical and genetic characteristics of a group of vertebral deformity patients with dual molecular diagnosis.

Introduction
In our previous studies, we have found that a substantial proportion of patients with vertebral deformities could be explained by monogenic disorders. More recently, complex phenotypes caused by more than one genetic defect (i.e., dual molecular diagnosis) have also been reported in vertebral deformities and may complicate the diagnostic odyssey of the patients. In this study, we report the molecular and phenotypic characteristics of patients with dual molecular diagnosis and variable vertebral deformities.

Methods
Cases with vertebral deformities from the DISCO study (http://www.discostudy.org/) who underwent ES were included. Patients with more than one molecular diagnosis from the included patients were selected for analyses. Each molecular diagnosis was manually curated based on the pathogenicity of the variants and the Mendelian expectations for inheritance mode.

Results
From 1108 patients who underwent exome sequencing, we identified eight probands with dual molecular diagnosis and variable vertebral deformities(Figure). All eight patients had dual diagnosis consisting of two autosomal dominant diseases. A total of 16 variants in 12 genes were identified, 5 of which were of de novo origin. Patients with dual molecular diagnosis presented blended phenotypes of two genetic diseases. Mendelian disorders occurred more than once include Osteogenesis Imperfecta Type I (COL1A1, MIM:166200), Neurofibromatosis, Type I (NF1, MIM:162200) and Marfan Syndrome (FBN1, MIM:154700).

Conclusion
This study demonstrated the complicated skeletal phenotypes associated with dual molecular diagnosis. Exome sequencing represents a powerful tool to detect such complex conditions.



Phenotype of a patient carrying pathogenic variants in both NF1 and COL1A1 genes. A:X-ray shows the patient had congenital scoliosis; B:Photo of the patient's blue sclera; C: Photo of the patient's Café au lait spots.

130. CYTOSKELETAL KERATINS ARE OVEREXPRESSED IN A ZEBRAFISH MODEL OF IDIOPATHIC SCOLIOSIS

Elizabeth A. Terhune, MS; Melissa T. Cuevas, MS; Cambria I. Wethey, BA; Denisa Grofova, BS; Anna Monley, BS; Lori Silveira, PhD; *Nancy H. Miller, MD, PhD*

Hypothesis
That specific transcripts will differ between scoliotic and non-scoliotic zebrafish.

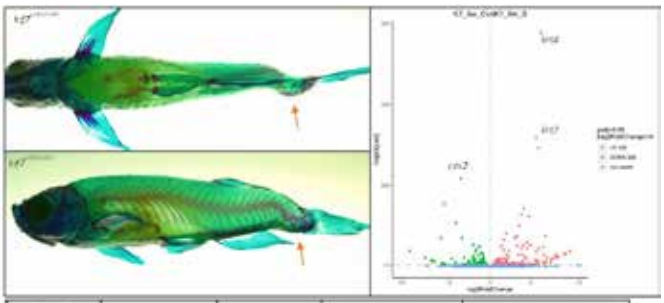
Design
Bulk mRNA sequencing of genetically identical scoliotic and non-scoliotic kif7co63/co63 zebrafish.

Introduction
Idiopathic scoliosis (IS) is a three-dimensional rotation of the spine >10 degrees with an unknown etiology. Our laboratory established a late-onset IS model in zebrafish (Danio rerio) containing a genetic deletion within kif7, which encodes a ciliary kinesin critical for hedgehog signaling [1]. 25% of kif7co63/co63 zebrafish develop spinal curvatures and are otherwise developmentally normal, although the the molecular mechanisms underlying scoliosis development are unknown.

Methods
To define transcripts associated with scoliosis, we performed bulk mRNA sequencing on 6-week old kif7co63/co63 zebrafish with and without a scoliosis phenotype. Additionally, we sequenced kif7co63/co63, kif7co63/+, and AB zebrafish (n= 3 per genotype). Sequencing reads (Novogene, Inc.) were aligned to the GRCz11 genome and FPKM values were calculated. We conducted t-tests between sample groups and calculated log2 fold change values for each recorded transcript.

Results
Principal component analysis showed that transcriptomes clustered by sample age and genotype. kif7 mRNA was reduced in both homozygous and heterozygous zebrafish (-0.7869 log2 fold change, p< 0.001).The top upregulated genes in scoliotic vs non-scoliotic adult zebrafish were cytoskeletal keratins, including krt4 (+7.45 log2 fold change, p<0.0001) (Figure 1). Ces2 was the most significantly downregulated transcript.

Conclusion
We observed that cytokeratins were significantly upregulated in scoliotic zebrafish. Keratin is a major component of the embryonic notochord and has been shown to associate with intervertebral disc degeneration (IVDD) in aged zebrafish. In humans, the krt4 ortholog KRT8 is associated with human notochord cells, and a decrease in expression is associated with IVDD in humans. The role of keratin as a molecular mechanism associated with the onset of scoliosis warrants further study.



Log2 Fold Change	P value	P adjusted	Gene name	Predicted human ortholog
7.45	1.14E-293	2.79E-289	krt4	KRT8
6.75	1.13E-163	1.37E-159	zgc:158846	KRT7
7.04	1.00E-150	8.13E-147	zgc:77517	Unknown
-8.84	8.55E-113	5.20E-109	ces2	CES2
-6.75	1.12E-81	5.44E-78	CABZ01032488.1	Unknown
4.97	9.44E-76	3.83E-72	os9	OS9
4.56	2.27E-68	7.90E-65	si:ch73-308m11.1	GRAMD1B
5.68	9.23E-66	2.81E-62	si:ch211-11p18.6	Unknown
-4.98	8.66E-58	2.34E-54	ttc38	TTC38
4.27	3.68E-54	8.84E-51	CR774195.1	Unknown

Figure 1: mRNA-seq of scoliotic (left) vs non-scoliotic kif7co63/co63 zebrafish. Right: Volcano plot, below: table of top 10 up- and down-regulated transcripts.

131. CODING VARIANTS COUPLED WITH RAPID MODELING IN ZEBRAFISH IMPLICATE DYNEIN GENES, DNAAF1 AND ZMYND10, AS ADOLESCENT IDIOPATHIC SCOLIOSIS CANDIDATE GENES

Yunjia Wang, MD; Hongqi Zhang, MD

Hypothesis
The current variations reported thus far only explain approximately 5% of AIS occurrence.Are there any rare variants associated with AIS susceptibility in Southern Chinese population and can be validated in zebrafish model?

Design
WES data were obtained from 195 sporadic AIS patients. Using distribution comparison filtering and deleterious allele prediction we identified several novel rare variants associated with AIS in independent loci.To functionally verify the role of candidate genes associated with AIS in our cohort,we assayed a group of related genes highly enriched in functional gene families involved in axonemal/cilia biology using CRISPR/Cas9 genome editing in zebrafish

PODIUM PRESENTATION ABSTRACTS

Introduction
AIS is the most common pediatric spine disorder.Human genetic studies suggest complex polygenic disease model for AIS with large genetic and phenotypic heterogeneity. However,the overall genetic etiology of AIS remains poorly understood

Methods
We performed whole exome sequencing(WES) on a cohort of 195 southern Chinese AIS patients.Candidate genes and gene families associated with AIS were identified by bioinformatics analysis.We screened these gene families by comparing our candidate gene list with IS candidate genes in the Human Phenotype Ontology(HPO) database and previous reported studies.The damaging effects of candidate variants in associated genes were functionally analyzed in zebrafish using targeted CRISPR/Cas9 screening.

Results
We identified 237 novel rare variants associated with AIS, located in 232 new susceptibility loci.Enrichment analysis of these variants revealed 10 gene families associated with our AIS cohort.Two candidate gene families,axonemal dynein and axonemal dynein assembly factors,were retained for their associations with ciliary architecture and function.The damaging effects of candidate variants in dynein genes dnali1,dnah1,dnaaf1,zmynd10,as well as in one fibrillin related gene tns1 were functionally analyzed in zebrafish.Knockout of two candidate genes,dnaaf1 or zmynd10,recapitulated scoliosis in viable adult zebrafish

Conclusion
We determined and verified a list of candidate genes that may correlate with AIS susceptibility,and that several gene sets may correlate with AIS initiation or specific clinical phenotypes.The current study may contribute to the comprehensive depiction of genotype-phenotype association in AIS

132. CHARACTERISTICS OF SCOLIOSIS MICE INDUCED BY CHONDROCYTE-SPECIFIC INACTIVATION

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Hypothesis
Mice with chondrocyte-specific inactivation of L-type amino acid transporter 1 (LAT1) have features similar to those of idiopathic scoliosis

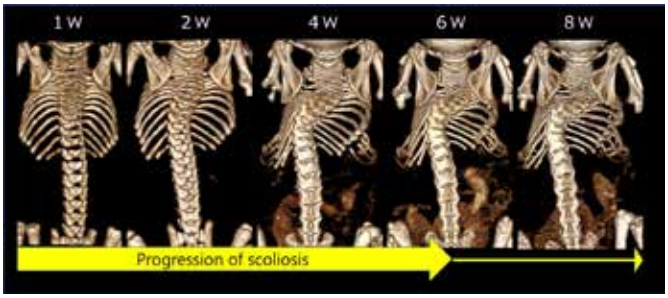
Design
basic study

Introduction
Scoliosis is a disease with a high prevalence (3%) in children, but its etiology and pathogenesis are still unknown. One of the reasons is lack of an ideal animal model that reproduces the condition well. LAT1 is amino acid transporter that mediates cellular uptake of large neutral amino acids, which have been implicated in skeletal homeostasis. We found chondrocyte-specific inactivation of LAT1 in mice resulted in scoliosis. In this study, we observed LAT1-inactivated mice (L mice) and evaluated their usefulness as a model for scoliosis.

Methods
L mice were obtained by deleting Slc7a5, which is a gene encoding LAT1, in a chondrocyte-specific manner using the Cre-lox P system. Total length, body weight, Cobb angle, vertebral body rotation angle, and bone mineral density (BMD) at 1, 2, 4, 6, and 8 weeks of age were examined and statistically compared in 14 L mice (L group) and 8 wild-type mice (W group). Finally, we performed pathological assessment of the 10-week slaughter specimens.

Results
The Cobb and vertebral body rotation angle of L group were significantly larger than those of the W group from 1 week of age, and these spinal deformities progressed rapidly by 6 weeks of age, according to the growth-spurt of mice (Figure). Nine of L group (64%) had scoliosis with Cobb angle >10 degrees (5 mice of them had left convex and 4 mice had right convex scoliosis). The remaining 5 mice (36%) had a Cobb angle <10 degrees and showed only deformity in the sagittal plane. There were no congenital malformations. BMD in the L group were significantly lower than those in the W group after 6 weeks of age. Pathological examination showed thickening of the hypertrophic cell layer in the growth plate. Furthermore, this layer was more thickened on the concave side than on the convex side. The number of osteoblasts on the vertebral surface was significantly lower in L mice, while those of the osteoclast was not significantly different.

Conclusion
L-mice share many similarities with idiopathic scoliosis, such as the absence of malformed vertebrae and progression of scoliosis with rotation in grow-spurt. Impaired endochondral ossification and reduced osteoblasts may be closely related to scoliosis and low BMD.



3DCT

133. MYOKINES IN SERUM CAN PREDICT THE OUTCOME OF BRACE TREATMENT IN GIRLS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Wu Zhichong, PhD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; *Feng Zhenhua, PhD*

Hypothesis
Myokines can serve as predictors of outcome of brace treatment in girls with Adolescent Idiopathic Scoliosis

Design
Case-control study

Introduction
Several risk factors have been documented to be associated with brace failure in AIS patients.However, molecular biomarkers are little reported.The contribution of the trunk muscles to spinal stability is well established. Myokines are skeletal muscle-secreted cytokines, which can regulate muscle function and also can mediate cross talk between skeletal muscle and other organs. So, we assumed that the function of skeletal muscle could have an influence on the outcome of brace treatment as well.

Methods
Inclusion criteria of AIS is initial curve magnitude ranging from 20 to 35; no treatment prior to bracing, Risser grade is 0–3 and aged 10–14 years old. 22 hours each day of brace treatment were prescribed to the subjects. Based on the final outcome of brace treatment, AIS were divided into two groups: Stable Group(Cobb angle decreased or increased no more than 5 degrees) and Progressive Group(Cobb angle increased more than 5 degrees). Progressive group was defined as a curve progression of more than 5 compared to the initial Cobb angle. Using a bead-based Luminex technology, 8 myokines (Apelin,Fractalkine,BDNF,EPO,Osteonectin, FABP3, FSTL1,Musclin) in serum were determined simultaneously.

Results
Totally, 117 AIS girl patients were included, 27 patients were classified as progressive group, and the remaining 90 patients were considered stable. The progressive group had significantly lower intial risser sign than the stable group but displayed no significant differences in intial age, BMI, and Cobb angle(27.2 ± 6.2 vs. 25.8 ± 5.9 degrees). Compared to the stable, the progressive AIS patients had lower Apelin, Fractalkine, Musclin and FSTL-1(1369.3 ± 704.9 vs. 2217.3 ± 617.0 pg/ml).In multivariant logistic regression analysis,lower serum level of FSTL1 and lower risser sign were independent factors associated with curve progression of brace treatment. Furthermore, using ROC curve analysis, serum levels FSTL1, with the area under the curve (AUC) of 0.729, showed good performance to predict the outcome of brace treatment.

Conclusion
AIS patients in the progressive group have significant higher initial serum FSTL1 concerntration which might serve as an independent biomarker to predict the outcome of brace treatment in patients with AIS.

134. BIOMECHANICAL EFFECTIVENESS OF VARIOUS BRACE DESIGNS TO TREAT ADOLESCENT IDIOPATHIC SCOLIOSIS: AN INTERNATIONAL MULTICENTER STUDY

Aymeric Guy, MS; Maxence Coulombe, BEng; Hubert Labelle, MD; Manuel Rigo, MD; M S Wong, PhD; Babak H. Beygi, PhD; James Wynne, CPO, FAAOP; M. Timothy Hresko, MD; Eric Ebermeyer, MD; Philippe Vedreine; Xue-cheng Liu, MD, PhD; John G. Thometz, MD; Benoit Bissonnette; Charlotte Sapaly, MS; Soraya Barchi, BSc; Carl-Eric Aubin, PhD

Hypothesis
The variable corrective design features of commonly used braces affect the effectiveness of the 3D correction.

Design
Multicenter computational study.

Introduction
To treat adolescent idiopathic scoliosis (AIS), many braces are commonly used, with designs varying between centers and orthotists affecting their biomechanical effectiveness. Reported clinical brace treatment studies have different levels of control and management, making the findings difficult to compare. We aim to compare the 3D effectiveness of various brace corrective features, as designed by several centers with diverse practices, using a comprehensive and validated computational model of representative AIS, devoid of confounding variables.

Methods
Six AIS cases with different curve types respecting SRS bracing criteria were provided to expert clinical teams (1 orthotist and 1 orthopedist) from 6 centers in 5 countries. For each case, all teams designed two braces according to their treatment protocol. Numerical simulations were performed to compute the immediate in-brace 3D correction and the pressures applied on the torso. Braces were randomized and labelled according to 21 design features derived from SOSORT proposed descriptors (contact point height and orientation, sagittal design, etc.). Simulated in-brace 3D corrections were compared for each labelled design feature using ANOVAs and linear regressions (significance $p<0.05$).

Results
Seventy-two braces were tested. Overall, 13 design features showed significant differences in 3D correction: e.g., contact points at the apical vertebra corrected the main thoracic Cobb angle better than ones at the apical rib or lower. The most significant impact was observed in sagittal curve management, as lumbar lordosis flattening was correlated with the ventral pressures ($R = 0.54$).

Conclusion
Coronal correction can be increased by aligning the corrective force with the curve apex through a contact point or a strap at the apical vertebra's height. Unselective ventral pressures flatten the lumbar lordosis with no other significant corrective benefit. Coupling latero-posterior contact with an anterior derotation point significantly increases axial rotation correction.

Fig. Brace designs from the 6 clinical expert teams (same case, AP oblique view), showing the variability of the approaches.

PODIUM PRESENTATION ABSTRACTS

135. BRACING IMPROVES CURVES AND AESTHETICS IN RISSER 3-4 ADOLESCENTS WITH 30 TO 45° CURVES. RETROSPECTIVE RESULTS FROM A COHORT OF 1104 CONSECUTIVE PATIENTS

Stefano Negrini, MD; Fabio Zaina, MD; *Sabrina Donzelli, MD*

Hypothesis

Bracing can help Risser 3-4, 30-45° adolescents with idiopathic scoliosis (AIS) to achieve 1) curve reduction (with reduced risks in adulthood) and 2) improved aesthetics.

Design

Retrospective analysis of prospective clinical data (2003 to 2021).

Introduction

The SRS (Richards 2005) developed criteria that provided the minimum standards for bracing research, but 1) they could not be standard for clinical practice, and 2) research should test new hypotheses. The SOSORT-SRS research criteria (Negrini 2014) state that, when surgery is avoided, the aim of treatment is to achieve at the end of growth a curve below or as close as possible to 30° Cobb to minimize risks in adulthood (progression, pain).

Methods

Inclusion: IS, age 10-18, primary curve 30-45°, females > 1-year post menarche, first consultation at our Institute. Exclusion: still in treatment. Treatment: brace (SPoRT concept) ≥18 hours/day w/o Physiotherapic Scoliosis Specific Exercises (PSSE) (SEAS school). Controls: PSSEs or continuing brace weaning. Outcome measures: °Cobb, °ATR, TRACE index (aesthetics). Observations: start and end of treatment; in and post brace. Statistics: paired t-test for continuous variables and Chi-square for proportions. Level of significance $p<0.05$.

Results

Of a cohort of 1104 consecutive AIS, 14 did not accept inclusion and 248 were in treatment (IT). We found 78 controls (9%) and 764 treated, but 176 dropped out (DO 23%). At baseline, controls showed less pathology and risk (age +1 year, -3° Cobb). Results showed curve and aesthetics statistically significant improvements (-4.2° Cobb, -2.2° ATR, -2.6/11 TRACE) and clinically significant positive changes (52% reduction ≥5° Cobb) greater in all groups than in controls (Table). At the end of observation, DO and IT had the same results as treated.

Conclusion

Bracing provides curves' reduction and aesthetics improvement of 30-45° Risser 3-4 AIS more than control (PSSEs or continued brace weaning), even if the drop-out rate is important. Of note: controls were older (more stable) and with less curve than other groups. In a previous identical study of Risser 0-2 patients, we found similar in-brace but better end results due to correction hold during weaning at a younger age.

			Braced		Controls			Drop-out			In treatment		
			Average (count)	SD (%)	Average (count)	SD (%)	P (vs Braced)	Average (count)	SD (%)	P (vs Braced)	Average (count)	SD (%)	P (vs Braced)
Baseline	Age	years	14.5	1.4	15.5	1.5	<0.001	14.5	1.3	NS	14.5	1.5	NS
	Sex	count (%)	496	84%	60	77%	NS	145	82%	NS	211	85%	NS
	Age menarche	years	12.6	1.2	12.7	1.2	NS	12.4	1.2	NS	12.6	1.4	NS
	Main thoracic	count (%)	352	60%	40	51%		97	55%		134	54%	
	Main thoracolumbar	count (%)	125	21%	17	22%	NS	52	30%	NS	64	26%	NS
	Main lumbar	count (%)	92	16%	13	17%		21	12%		38	15%	
	Height	cm	162	12	163	17	NS	159	19	<0.05	162	10	<0.05
	Weight	kg	53	12	58	16	<0.01	53	14	NS	53	12	NS
Cobb degrees	Start		37	5	34	4	<0.001	37	5	NS	37	5	NS
	In-brace		24	7				24	7	NS	24	7	NS
	Post-brace		31	8				32	7	NS	31	6	NS
	End		33	8	32	8	NS	32	7	NS	32	7	NS
	P		<0.001		<0.001			<0.001			<0.001		
	Improved >5°	count (%)	303	52%	18	23%	<0.01	84	48%		136	55%	
	Progressed >5°	count (%)	47	8%	8	10%		11	6%		14	6%	
	End <30°	count (%)	206	35%	26	33%	NS	64	36%		86	35%	
	End >45°	count (%)	34	6%	3	4%	NS	9	5%		9	4%	
ATR degrees	Start		11	4	8	3	<0.001	11	4	NS	11	3	NS
	Post-brace		8	3				8	3	NS	8	3	NS
	End		9	3	8	3	NS	9	6	NS	8	3	0.0008
	P		<0.001		NS								
	Improved >2°	count (%)	353	60%	24	31%	<0.01	102	58%	NS	172	69%	<0.05
	Worsened >2°	count (%)	60	10%	18	23%		12	7%		15	6%	
Aesthetics (TRACE points)	Start		7	2	6	2	<0.001	7	2	NS	7	2	0.7865
	Post-brace		4	2				4	2	0.0266	4	2	0.7681
	End		4	2	5	2	<0.05	4	2	NS	4	2	0.1036
	P		<0.001		<0.001								
	Improved >3p	count (%)	308	52%	17	22%	<0.01	95	54%	NS	143	58%	NS
	Worsened >3p	count (%)	23	4%	4	5%		4	2%		8	3%	
Average results	Cobb in	deg	-12.8	5.4				-12.7	5.5	NS	-13.7	5.8	0.0561
	Cobb post	deg	-12.8	5.4				-12.6	5.5	NS	-13.7	5.8	0.0676
	Cobb end	deg	-4.2	6.1	-2.2	7.2	<0.01	-4.2	5.7	NS	-4.8	5.7	0.1330
	ATR	deg	-2.2	3.0	0.0	2.5	<0.001	-2.3	5.8	NS	-3.0	3.0	0.0005
	TRACE	points	-2.6	2.6	-1.2	2.3	<0.001	-2.9	2.5	NS	-2.9	2.3	0.1207

Results show in the treated group average improvements and clinically significant positive changes greater than in the control group in all parameters.

136. PREDICTING SURGERY: ACCURACY OF THE BRAIST ENDPOINT DEFINITIONS AT 2-YEAR FOLLOW-UP

Lori A. Dolan, PhD; Stuart L. Weinstein, MD

Hypothesis

BrAIST endpoints accurately predict surgery at 2-year follow-up

Design

Prospective prognostic study

Introduction

BrAIST defined "success" as Risser 4+ and Sanders 7 with a Cobb angle of <50 degrees, at which point future surgery would be unlikely, whereas surgery was expected in the "failed" group (>50 degrees prior to maturity). The prognostic accuracy of these endpoints has been questioned, as curves may continue to progress and surgery may still occur post-maturity. Thus, this study evaluated the predictive value of the BrAIST endpoints via a minimum 2-year radiographic/surgical follow-up.

Methods

The 272 subjects who completed BrAIST were eligible for follow-up if surgery occurred or at 2 years-post BrAIST. The 25 BrAIST sites located and consented their own subjects. A pre-op or follow-up film was submitted to the coordinating center for measurement. Progression was calculated as the difference between the maximum Cobb angle at BrAIST exit and at follow-up. The surgery rate, and the mean length of follow-up and curve progression were calculated. Prognostic accuracy was judged via the positive predictive value (PPV, % surgery in the "failed" group) and negative predictive value (NPV,% no surgery in the "success" group).

Results

Of 272 eligible subjects, we obtained documentation of surgery (date only or pre-op x-ray) or a new x-ray for 198 (73%); 115 (85%) in the success group (SG) and 83 (94%) in the failed group (FG). 15% of the SG group underwent surgery compared to 94% of the FG. X-rays were available for 108 patients in the SG; of 83 (78%) with no curve

progression 8 had surgery; 25 curves progressed and 6 of these were operated on. The mean pre-op Cobb angle was 48.1 (range 40-58). Surgery in the SG occurred at an average of 2.5 years (range 6 mo to 4.2 years) after skeletal maturity. In this sample, the PPV was 94% (all but 6% of the FG had surgery) and the NPV was 85% (15% of the SG had surgery). Overall, the BrAIST definitions predicted surgery correctly in 89% of subjects.

Conclusion
BrAIST endpoints were set with future curve behavior in mind, yet surgery decisions not solely based on Cobb angles. Curves as small as 40 degrees were operated in this sample, but one at 63 degrees was not. Despite this variation, the BrAIST definitions of "success" and "failure" were correct for 89% of this sample at a minimum of 2-year follow-up. These endpoints therefore seem reasonable for use in future studies.

137. GUT MICROBIOTA IN ADOLESCENTS WITH SEVERE ADOLESCENT IDIOPATHIC SCOLIOSIS

Jie Li, MD; Yanjie Xu, MD; Zongshan Hu, PhD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; *Zhen Liu, PhD*

Hypothesis
The composition of gut microbiota(GM) isolated from AIS patients differ from that of congenital scoliosis(CS), and age-matched healthy volunteers(Ctr).

Design
prospective study

Introduction
Recently, accumulating evidence suggested an interaction between gut microbiota and bone homeostasis, which was collectively termed as the gut-bone axis. Systemic low bone mineral density and impaired bone homeostasis are important clinical features of AIS. To the best of our knowledge, there is no literature that reported compositional differences of GM in AIS and its potential contribution to the pathogenesis of AIS.

Methods
A total of 48 patients with AIS, 24 patients with CS, and 31 healthy individuals were recruited as the discovery cohort, 9 pairs of siblings where one was affected by AIS were recruited as validation cohort. The GM profile was determined with 16S rRNA sequencing, and the alpha-diversity and beta-diversity metrics were performed with Mothur. Linear discriminant analysis (LDA) analysis was performed to identify the enriched species.

Results
The α diversity (Chao index) was significantly lower in AIS patients with low BMI (<18.5) than those with normal BMI. The α and β diversity showed no difference among AIS, CS, and Ctr groups, while ANOSIM analysis showed higher similarity within AIS than CS and Ctr groups. METASTAT analysis showed Cellulomonadaceae was significantly enriched in AIS groups compared to CS and Ctr. LDA analysis showed 9 enriched species in AIS patients. Compared to Ctr, two species including Hungatella genus and Bacteroides fragilis were significantly enriched, while the Firmicutes versus Bacteroidetes (F/B) ratio and the Ruminococcus genus were significantly decreased in AIS but not CS groups. The significantly reduced F/B ratio and Ruminococcus genus in AIS were replicated in the validation cohort.

Conclusion
Our study elucidated an association between low BMI and GM diversity in AIS patients. The reduced F/B ratio and Ruminococcus genus in AIS patients was identified and validated. The role of GM reconstitution in the pathogenesis of AIS is worthy of further investigation.

138. INCIDENCE AND CAUSES OF INSTRUMENT-RELATED COMPLICATIONS FOLLOWING PRIMARY DEFINITIVE FUSION FOR PEDIATRIC SPINE DEFORMITY

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Hypothesis
The characteristics of instrument-related complications in definitive fusion are different depending on the etiology and type of the procedure.

Design
Retrospective multicenter study

Introduction
A variety of complications in the treatment of pediatric spinal deformity has been reported. As one of them, instrument-related complications could be critical concerns and risks of reoperation. The aim of this study was to identify the incidence and causes following primary definitive fusion for pediatric spine deformity.

Methods
We retrospectively collected the data from 14 institutes in patients who underwent primary definitive fusion between 2015 and 2017. There were 1490 eligible patients (1184 female and 306 male) with a mean age of 13.9 years. The incidence, causes and the reoperation rate of instrument-related complications were analyzed according to 4 etiologies of pediatric spine deformity (congenital, neuromuscular, syndromic, idiopathic; classified by Williams BA et al. JBJS AM 2014). The type of complications were also categorized into screw related, hook related, rod related, implant loosening or backout and junctional problems.

Results
The incidence of overall instrument-related complications was 5.6% (84 cases). Regarding etiology, the incidence was 4.3% (idiopathic), 6.8% (syndromic), 7.9% (congenital), and 10.4% (neuromuscular) respectively ($p < 0.05$). The most common causes were malposition of

pedicle screw (60.7%), followed by junctional problem (13.1%), backout or loosening (10.7%), rod breakage (4.8%), hook related (4.8%) and other (6.0%). Univariate analysis showed that etiology, type of deformity (kyphosis), surgical procedure, operation time and EBL were significant. Multivariate analysis revealed that etiology (neuromuscular), surgical procedure (combined approach) and operation time (> 5hr) remained significant risk factors. In overall instrument-related complications, 45% (38/84) of the cases required revision surgery. Of these, more than 50% of cases were related to the malposition of pedicle screws.

Conclusion

In overall complication and subsequent reoperation rate, the malposition of pedicle screws statistically showed the major cause. As well as more precise screw insertion technique, appropriate selection of the implant and efficient pedicle screw placement might reduce the overall percentage of instrument-related complications and revision rate.

139. MECHANICAL COMPLICATIONS IN THE SURGICAL CORRECTION OF SCHEUERMANN'S KYPHOSIS AND THE RESTORATION OF NORMATIVE SPINAL SAGITTAL ALIGNMENT

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Hypothesis

We hypothesised that reducing mechanical complications could be achieved by restoring the thoracic curves according to the normative sagittal thoracic parameters as described by Roussouly et al.

Design

Retrospective cohort

Introduction

Scheuermann's kyphosis is a common structural hyperkyphosis of the thoracic and thoracolumbar spine in adolescents. Surgical correction is challenging and possesses a high rate of mechanical complications. This study aims to evaluate if restoring the thoracic curves according to the normative sagittal thoracic parameters as described by Roussouly et al. reduced postoperative mechanical complications

Methods

We conducted a retrospective cohort study in which 52 consecutive patients who underwent surgical correction of Scheuermann's kyphosis in our tertiary spinal referral center between 2010 and 2018 were reviewed. Patients were excluded if there was an additional coronal spinal deformity, less than 2 years follow-up, inadequate radiographs and previous spinal procedures. Spinopelvic and spinal sagittal parameters were analyzed at the end point (2 years post-operatively). The rate of mechanical complications was assessed in relation to the deviation from the normative parameters (as per Roussouly).

Results

A total of 35 patients met our criteria and were included in our study group. The mean age was 21.5 years (range 15-37 years). Mechanical complications occurred in 16 patients (45%) with proximal junctional kyphosis 15 patients (42%) to be the most common. Revision surgery was undertaken in 4 patients (11%). Among the radiological parameters that were analyzed in a regression analysis, a higher pelvic incidence (P=0.02), a more cephalad thoracolumbar inflexion point (P=0.005), greater upper thoracic kyphosis Cobb angle (P=0.05) and fewer number of lumbar vertebrae fused (P=0.02) were all significantly associated with a greater risk of a mechanical complications.

Conclusion

Knowing and understanding the normal sagittal alignment plays a key role in pre-operative planning and potentially reducing the complications in patients undergoing surgical correction for Scheuermann's kyphosis

140. LONG-TERM OUTCOMES AND COMPLICATIONS OF ISOLATED ANTERIOR THORACOLUMBAR FUSION FOR NEUROMUSCULAR SCOLIOSIS ASSOCIATED WITH MYELOMENINGOCELE

Daniel Bouton, MD; Michelle C. Welborn, MD; Joseph Ivan Krajbich, MD

Hypothesis

Patients undergoing anterior thoracolumbar fusion for neuromuscular scoliosis associated with myelomeningocele will have high rates of adding on but low infection rates.

Design

Retrospective analysis

Introduction

Neuromuscular scoliosis associated with myelomeningocele is a difficult clinical dilemma for the treating surgeon. Surgical treatment often consists of a posterior spinal instrumented fusion with or without a combined anterior procedure, but this has been associated with high complication rates, mostly related to deep infection. An anterior thoracolumbar fusion is not able to address the entirety of the deformity in many cases but could potentially avoid the devastating infection risks from the posterior approach by avoiding compromised skin. This study aims to evaluate the long-term outcomes and complications associated with isolated anterior thoracolumbar fusion in this high-risk group.

Methods

This study is a retrospective analysis of patients with myelomeningocele-associated scoliosis treated with an isolated anterior spinal fusion over a 20-year time period at a single center. Surgical details, demographics, curve characteristics and complications were recorded. Comparisons were made between patients who required revision surgery and those who did not.

Results

Sixteen patients were enrolled with an average age of 12.7 years at the time of surgery and average follow-up of 5.4 years. The most common levels fused were T10-L4. There were 0 wound infections associated with the anterior surgery. Overall, nine patients (56%) had to be revised posteriorly due to adding on at an average of 3.7 years

after index procedure. Four patients were revised due to proximal adding on, while 1 was extended distally. Four additional patients were extended both proximally and distally. Of the posterior revisions, 2 patients developed deep wound infections, and both of these were in patients extended distally. Preoperative lumbar lordosis was higher in patients who required distal revision (100 vs 69 degrees; p=0.035).

Conclusion
Patients undergoing isolated anterior fusion for scoliosis associated with myelomeningocele have low infection rates but often require posterior revision. The majority of patients can avoid the deep infection risk associated with distal posterior surgery at long-term follow-up.

	No distal revision (n=11)	Distal revision (n=5)	p-value
Age at surgery (years)	13.0	11.8	0.473
# Levels fused	7.5	7.2	0.732
Follow-up (years)	5.4	6.1	0.524
Major curve	72°	70°	0.694
Lumbar lordosis	69°	101°	0.035*
Pelvic obliquity	17°	22°	0.345

A comparison of patients who required distal revision and those who did not.

141. A MATCHED COMPARISON OF 2-YEAR CLINICAL AND RADIOGRAPHIC OUTCOMES IN SYRINX-ASSOCIATED VS. ADOLESCENT IDIOPATHIC SCOLIOSIS: A 30-YEAR EXPERIENCE AT A SINGLE INSTITUTION

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Hypothesis
Patients with syringomyelia-associated scoliosis will have no difference in clinical or radiographic outcomes at 2 years postoperatively.

Design
Retrospective matched cohort study.

Introduction
Surgery in AIS-like scoliosis with a syrinx remains uncertain when compared to AIS patients. The present study aims to evaluate the long-term postoperative clinical and radiographic outcomes of syringomyelia-associated scoliosis (SAS) compared to AIS.

Methods
A single center 30-year retrospective review from 1990-2019 compared patients undergoing posterior spinal fusion (PSF) surgery for syrinx-associated scoliosis (SAS group) with AIS. The SAS group was matched for age, skeletal maturity, preop Cobb, and Lenke class to AIS (AIS group) patients. Between-group comparisons at 2 years were conducted and significance was set at $p<0.05$.

Results
There were 184 patients, with 92 in each group. The SAS and AIS groups had differences in age (14.0 vs 14.1 yrs), BMI (21.3 vs 21.8), Lenke class, thoracic (64.4 vs 62.2°) or thoracolumbar Cobb (40.3 vs 41.1°). The SAS group had less females (65.6 vs 85.2%,p = 0.003) and greater preop thoracic kyphosis (40.6 vs 20.7°, $p < 0.001$). There were no differences in LIV to CSVL distance (17.5 vs 18.1 mm), OR time (322 vs 314 min), levels fused (11.6 vs 10.9), or EBL (741 vs 834 cc). The SAS group were less likely to have good baseline MEPs (94.5 vs 100%, p=0.014) without differences in intraoperative monitoring changes. At two years, there was no difference for the coronal curve correction for thoracic (29.3 vs 29.2°), thoracolumbar/lumbar (18.6 vs 20.0°), LIV-CSVL distance (12.5 vs 11.8 mm), and restoration of thoracic kyphosis (28.8 vs 25.0°). There were no differences in the incidence of neurologic deficits (0.0 vs 0.9%), and radiographic adding on (14.8 vs 19.1%). Despite a lower preop SRS self-image score, the SAS group had similar scores at 2 years (4.1 vs 4.0) without any difference in other domains.

Conclusion
Patients with syrinx-associated scoliosis are more likely to have hyperkyphosis preoperatively and may not have great baseline motor data. However, the selection of the LIV using AIS rules seems to result in the same coronal plane correction while improving the hyperkyphosis seen in these patients without risking adding on, or other complications.

Table 1.

	Adolescent Idiopathic Scoliosis N = 92	Syringomyelia-Associated Scoliosis N = 92	*P*
Neurologic Deficit	0.9%	0.0%	0.465
Surgical Site Infection	2.6%	4.9%	0.422
Implant Failure	1.7%	4.9%	0.227
Distal Adding On*	19.1%	14.8%	0.468

Incidence of complications at 2 years postoperatively.

142. COMPLICATIONS FOLLOWING SCOLIOSIS SURGERY FOR PATIENTS WITH MYELOMENINGOCELE WHO HAVE "AIS LIKE" CURVES ARE SIMILAR TO PATIENTS WITH IDIOPATHIC SCOLIOSIS

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Hypothesis
Patients with myelomeningocele (MM) undergoing spinal fusion for "AIS like" scoliosis will have complication rates similar to patients with Adolescent Idiopathic Scoliosis (AIS).

Design
Single site retrospective matched cohort study

Introduction
Patients with MM have high rates of complications following spinal fusion for scoliosis. Most commonly, these patients are non-ambulatory and require fusion to the pelvis. However, we have encountered a subset of ambulatory patients with MM who have curves radiographically similar to AIS (primarily thoracic or lumbar curves without pelvic obliquity). We sought to compare these "AIS-like" MM patients to AIS patients, focusing on post-operative complications and reoperation rates.

Methods
Ten ambulatory patients with lumbar or sacral level MM and "AIS like curves" had either a posterior spinal fusion (PSF) or a combined anterior/posterior fusion (ASF/PSF)

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between the years 1994-2018 with a minimum of 2 year followup. These patients were matched in a 1:2 ratio to AIS patients based on sex, age, Risser grade, date of surgery, pre-operative Cobb angle, and levels fused. A retrospective chart review was then performed, and complications were classified according to the Modified Clavien-Dindo-Sink (CDS) system.

Results

Average age at surgery was 12.2 +/- 2.9 years (in the MM group and 12.8 +/- 2.0 years in the AIS group. The mean pre-operative Cobb angle was 67 +/- 9.8 degrees for MM and 68 +/- 11.0 degrees in AIS (p=0.69). The MM group had a lower average weight, 38 +/- 9.9 kg compared 51 +/- 13.3 kg in the AIS group (p=0.014). Pre-operative kyphosis was greater in the MM group, 47 +/- 17.6 degrees, compared to 32 +/- 14.7 degrees in the AIS group (p=0.015). 100% of MM patients had an ASA classification of 2 or 3, compared to 30% in the AIS group (p=<0.01). The remaining 70% of AIS patients were ASA 1. Within the MM group, there was one CDS 1 and one CDS 3 complication. The AIS group had three CDS 1, one CDS 2, and two CDS 3 complications. The re-operation rate was 10% in both the MM and AIS groups (p=1.00).

Conclusion

Ambulatory myelomeningocele patients with "AIS like curves" have similar outcomes and reoperation rates compared to AIS patients after spinal fusion surgery.

		AIS-Like Myelomeningocele	Adolescent Idiopathic Scoliosis	p-value
Gender	Female	8 [80%]	16 [80%]	1.00
	Male	2 [20%]	4 [20%]	
Procedure	PSF	6 [60%]	12 [60%]	1.00
	ASF/PSF	4 [40%]	8 [40%]	
Functional Lesion Level	Lumbar	6 [60%]	-	-
	Sacral	4 [40%]	-	
ASA Classification	ASA 1	0 [0%]	14 [70%]	<0.01
	ASA 2	9 [90%]	6 [30%]	
	ASA 3	1 [10%]	0 [0%]	
Height		137 ± 10 [118-147]	152 ± 13 [121-183]	<0.01
Weight		38 ± 10 [26-59]	51 ± 13 [21-72]	0.01
BMI		20 ± 5 [16-28]	22 ± 4 [14-30]	0.43
Posterior Surgical Time		296 ± 110 [191-545]	315 ± 82 [184-450]	0.59
Posterior EBL		800 ± 433 [225-1550]	1062 ± 515 [400-2400]	0.24
Anterior Surgical Time		190 ± 77 [90-250]	186 ± 57 [135-310]	0.91
Anterior EBL		175 ± 151 [75-400]	105 ± 74 [0-250]	0.55
Total Length of Stay		5.5 ± 1.4 [4-8]	5.0 ± 1.9 [3-11]	0.46
Preoperative Major Curve		67 ± 10 [55-86]	68 ± 11 [53-97]	0.88
Preoperative T2-T12 Kyphosis		47 ± 18 [16-82]	32 ± 15 [5-68]	0.02
Final Major Curve		31 ± 14 [10-46]	31 ± 12 [9-49]	0.96
Final T2-T12 Kyphosis		43 ± 13 [28-74]	33 ± 8 [17-50]	0.03
% Correction Major Curve		53 ± 20 [26-84]	54 ± 18 [27-87]	0.94
% Correction T2-T12 Kyphosis		-2 ± 51 [-144-31]	-24 ± 64 [-239-41]	0.35
Complications		CDS 1- Pneumothorax CDS 3 – Hardware failure with reoperation	CDS 1 – Asymptomatic Instrumentation fracture (2x); Minor lumbar crankshaft CDS 2 – Wound dehiscence with outpatient treatment CDS 3 – Pseudarthrosis with reoperation; IOMN changes necessitating abortion & reoperation	

143. COVID-19 SIGNIFICANTLY IMPACTED INITIAL CONSULTATION FOR IDIOPATHIC SCOLIOSIS

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Hypothesis

Delayed face-to-face primary health-care consultation related to COVID-19 pandemic has impacted negatively prompt referral of patients with Idiopathic Scoliosis (IS), larger Cobb angles at initial visit lead to increased posterior spine fusion (PSF) indication rates, preventing other conservative treatment and fusionless techniques to be indicated.

Design

Prospective Cohort study.

Introduction

Since COVID-19, a reduction of social activities and rapid adoption of telemedicine, decreasing face-to-face encounters, seems to have negatively affected the timely IS referral with a spine specialist. We aim to document the progression of IS curves during COVID-19 pandemic reflected by the late presentation of patients at the initial visit with higher Cobb angles.

Methods

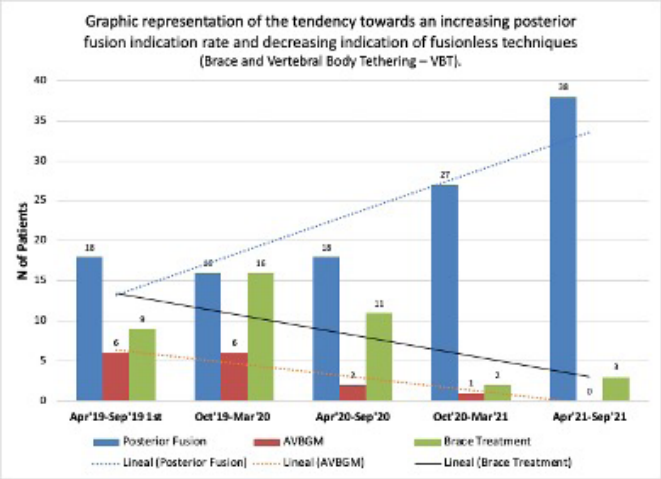
All IS patients scheduled for surgery between Apr 2019-Sept 2021 were recruited. The patients were divided into 5 cohorts of 6-months duration, 2 periods before the 1st COVID-19 wave, 1 period during and 2 periods afterwards. In each cohort, patients were divided in 3: those who were scheduled for PSF at 1st visit, those booked for Vertebral Body Tethering (VBT) at 1st visit, and those scheduled for surgery but who failed brace treatment. Chi2 and ANOVA tests were used for comparison.

Results

173 patients were analyzed. 33 patients (13.1 y.o.±3) were scheduled between Apr-Sept 2019; 38 (13.1 y.o.±2) between Oct 2019-Mar 2020; 31 (13.4y.o. ±3) between Apr-Sept 2020; 30 (14.3 y.o.±2) between Sept 2020–Mar 2021; and 41 patients (13.8 y.o.±2) between Apr-Sept 2021. Non-statistically significant differences were found between periods before, during or after the COVID-19 1st wave regarding patients' age, gender and Risser grade. Average Cobb angles of patients at their 1st visit after the beginning of the COVID-19 pandemic were significantly higher than those before COVID-19 (52.2°±7° and 56.6°±13° vs 47.8°±12° and 45.2°±13°; p=0.0001). More patients were booked for PSF (p<0.0000) through the 5 evaluated periods, while the indication of VBT in patients previously braced progressively decreased (Fig).

Conclusion

Patients presented at the scoliosis clinic for the 1st time after the 1st COVID-19 wave with significantly larger Cobb angles, leading to an increased proportion of PSF, as the window for bracing or VBT was missed due to a delayed consultation.



144. OUTCOMES OF OPERATIVE TREATMENT FOR ADULT CERVICAL DEFORMITY: A PROSPECTIVE, MULTICENTER ASSESSMENT WITH MINIMUM 2-YEAR FOLLOW-UP

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Hypothesis
Operative treatment for adult cervical deformity (ACD) significantly improves health-related quality of life (HRQL) at minimum 2-yr follow-up.

Design
Multicenter, prospective cohort study

Introduction
ACD can have profound impact on HRQL. Operative treatment for ACD is associated with high complication rates due to the complexity of surgery and the frailty of the patients. Very few studies have focused on outcomes of operative ACD treatment.

Methods
Operatively treated ACD patients were assessed at baseline, follow-up, and through mailings. Patient-reported outcomes measures (PROMs) included: NDI, mJOA, EQ-5D, and the numeric rating scale (NRS) for neck and back pain. Complications were classified as perioperative (≤30 days) or delayed (>30 days). Analyses focused on patients with >2-yr follow-up.

Results
Of 169 ACD patients, the 102 (60%) with minimum 2-yr follow-up (mean=3.4 yrs, SD=1.9 yrs, range=2 to 8.1 yrs) had a mean age of 62 yrs (SD=11) and 64% were women. Surgical approaches included anterior-only (22.8%), posterior-only (39.6%), and combined (37.6%). The mean numbers of vertebrae fused anteriorly and posteriorly were 4.3 (SD=1.1) and 9.4 (SD=3.4), respectively, with 16% having a 3-column osteotomy. PROMs significantly improved from baseline to last follow-up, including NDI (47.3 to 33.0), mJOA (12.0 to 12.8; for patients with baseline score <14), neck pain NRS (6.8 to 3.8), back pain NRS (5.5 to 4.8), EQ-5D score (0.74 to 0.78) and EQ-5D VAS (59.5 to 66.6) (Table). Overall, 58 (56.9%) patients had at least 1 complication, 41 (40.2%) had at least 1 perioperative complication, and 35 (34.3%) had at least 1 delayed complication. The most common complications included dysphagia (18.6%), distal junctional kyphosis (6.9%), instrumentation failure (6.9%), cardiac events (6.9%), dysphonia (4.9%), nerve sensory deficit (3.9%), and respiratory failure (3.9%). For patients with at least 2-yr follow-up, 12 patients underwent 15 reoperations. The 67 patients who did not achieve 2-yr follow-up were similar to study patients based on demographics, comorbidities, and baseline PROMs.

Conclusion
This multicenter, prospective analysis demonstrates that operative treatment for ACD provides significant improvement of HRQL at minimum 2-yr (mean 3.4-yr) follow-up. Further studies will be needed to assess the long-term durability and cost-effectiveness of surgical treatment for ACD.

Comparison of Baseline and Minimum 2-Year Follow-Up Clinical Outcomes Parameters for 102 Adult Cervical Spinal Deformity Patients Treated Surgically*

Outcome Parameter	Baseline Mean (SD)	Min 2-Yr Follow-Up Mean (SD)	P-value
Neck Disability Index	47.3 (16.2)	33.0 (20.3)	**<0.001**
mJOA			
All patients	13.9 (2.7)	14.3 (2.9)	0.18
Only patients with baseline mJOA<14 (n=47)	12.0 (1.7)	12.8 (2.3)	**0.026**
Numeric Rating Scale Scores			
Neck Pain	6.8 (2.4)	3.8 (3.0)	**<0.001**
Back Pain	5.5 (2.9)	4.8 (3.1)	**0.043**
EQ5D			
Score	0.74 (0.07)	0.78 (0.09)	**<0.001**
VAS	59.5 (21.7)	66.6 (19.4)	**0.004**

*SD = standard deviation, SRS = Scoliosis Research Society

145. POSTOPERATIVE SVA >4CM HAS NO IMPACT ON NECK PAIN SCORES AFTER C2-T2 FUSION FOR MYELOPATHY: RESULTS FROM A MULTICENTER COHORT STUDY

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Hypothesis
Patients with postoperative C2-7 sagittal vertical axis (SVA) >4cm will have worse neck pain than patients with a C2-7 SVA <4cm.

Design
Multicenter retrospective cohort study

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Introduction
The C2-7 SVA has been utilized as a measure of global cervical alignment, and previous work has suggested that achieving a postoperative SVA of 4 cm or less is ideal with regards to patient outcomes. The purpose of this study was to determine the impact of SVA on postoperative neck pain scores after posterior cervical laminectomy and fusion for myelopathy.

Methods
We performed a retrospective review of a multicenter prospective cohort of patients undergoing posterior cervical decompression and fusion from C2-T2 for degenerative cervical myelopathy from 2011-2018 with at least two years of postoperative follow-up. Cervical alignment was assessed on standing radiographs performed preoperatively as well as at 6 months or greater postoperatively. The cohort was divided into 2 groups based on a postoperative SVA of less than 4 cm or 4 cm or greater based on established criteria. Patient reported outcome measures were then compared between these two subgroups.

Results
173 patients were identified for inclusion. In this cohort, 70 patients were identified as having a postoperative SVA less than 4 cm and 103 patients were identified as having an SVA of 4cm or greater. In both groups, the change in SVA showed a worsening of alignment. This was significantly higher in the SVA > 4 cohort compared to the SVA <4 cohort (-11.6 vs -3.3, p<.001). Of the 173 patients, 108 patients (62.4%) had VAS neck pain scores recorded at greater than 6 months postoperatively. There was no significant difference between the cohorts with respect to neck pain scores at any time point. Using the established minimal clinically important difference for VAS neck pain following cervical surgery, we found that 61.9% of the SVA <4 cohort and 52.9% SVA >4 cohort achieved MCID with no significant difference between the groups (p = .432).

Conclusion
While previous work has established the importance of SVA alignment in treatment of cervical deformity, in this multi-center cohort of patients undergoing C2-T2 posterior cervical fusion for degenerative myelopathy, postoperative SVA >4 cm was not associated with a significant difference in long-term patient reported outcomes with regards to neck pain.

146. AT WHAT POINT DOES DEGENERATIVE BECOME DEFORMITY: WHEN GOOD OUTCOMES NECESSITATE SAGITTAL CORRECTION IN ADULT CERVICAL DEFORMITY SURGERY

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Hypothesis
There are baseline thresholds in cervical parameters that, when exceeded, require surgical correction to achieve ideal clinical outcomes.

Design
Retrospective

Introduction
Patients with less severe cervical deformity who undergo surgical correction often achieve good clinical outcomes. However, it has not been determined whether the clinical improvement is due to the sagittal correction at the time of surgery rather than the correction of degenerative disc changes.

Methods
CD patients with baseline (BL) and 2-year (2Y) data included. Parameters assessed: C2 slope (C2S), C2-C7 Lordosis, C2-C7 SVA (cSVA), T1 Slope (T1S), TS-CL. Outcomes: Virk et al Good Clinical Outcome (GCO): [Meeting 2 of 3: 1) an NDI>20 or meeting MCID, 2) mJOA >=14), 3) an NRS-Neck<=5 or improved by 2 or more points from baseline]. Binary logistic regression assessed each parameter to determine if correction was more likely needed to achieve GCO. Conditional inference tree (CIT) run machine learning analysis generated baseline thresholds for each parameter, above which, correction was necessary to achieve GCO.

Results
Included: 105 CD patients. There were 57 (54%) of patients achieving GCO by 2Y. Correction was necessitated when baseline C2S was above 20° (OR: 6.8, [1.6-28.9]; p=.01) and when baseline C2-C7 Lordosis was below 10° (OR: 16, [2.4-107.5]; p=.004). Patients presenting with a cSVA above 20 mm more often achieved clinical success when corrected (74.2% vs. 0.0%, p<.001). A baseline T1 slope above 23° was 16 times more likely to reach GCO with correction than those below this threshold (p=.005). TS-CL more likely required correction to reach GCO when above 26° at baseline (OR: 7.0, [1.7-29.1]; p=.007). When assessing patients above both the cSVA and C2S threshold versus the remaining cohort, these patients more likely met GCO when corrected in either parameter (OR: 22.5, [3.3-152.0]; p=.001).

Conclusion
Our study highlighted the importance of correction and the threshold at which it dramatically impacts clinical success. These new thresholds delineate patients obtaining superior benefit for sagittal correction and may better increase the utility gained from surgical intervention for cervical deformity.

Cervical Parameter	Threshold	Odds Ratio for Needing Correction to Achieve Good Clinical Outcome	p-value
T1 Slope	above 23°	16	.005
TS-CL	above 26°	7	.007
C2-C7 Lordosis	below 10°	16	.004
C2-C7 SVA	above 20 mm	-	<.001
C2 Slope	above 20°	6.8	.010

147. MULTIFIDUS SARCOPENIA IS ASSOCIATED WITH WORSE PATIENT REPORTED OUTCOMES FOLLOWING POSTERIOR CERVICAL DECOMPRESSION AND FUSION

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Hypothesis
Severe multifidus sarcopenia will be associated with worse patient reported outcomes following posterior cervical decompression and fusion.

Design
Retrospective cohort study

Introduction
While the impact of sarcopenia on patient-reported outcome measures (PROMs) following lumbar spine surgery is well-established, the impact of sarcopenia on PROMs following posterior cervical decompression and fusion (PCDF) has not been investigated. The present study is the first to assess the impact of paraspinal sarcopenia on PROMs following PCDF.

Methods
We performed a retrospective review of patients undergoing PCDF from C2-T2 at a single institution between the years 2017-2020 with at least 2 years of postoperative follow-up. Two independent reviewers who were blinded to the clinical outcome scores utilized axial cuts of T2-weighted MRI sequences to assess fatty infiltration of the bilateral multifidus muscles at the C5-6 level and classify patients according to the Fuchs Modification of the Goutalier grading system. PROMs were then compared between subgroups.

Results
We identified 99 patients for inclusion in this study, including 28 patients with mild sarcopenia, 45 patients with moderate sarcopenia, and 26 patients with severe sarcopenia. There was no difference in any preoperative PROM between the subgroups. Mean postoperative NDI scores were lower in the mild and moderate sarcopenia subgroups (12.8 and 13.4, respectively) than in the severe sarcopenia subgroup (21.0, P<0.001). A higher percentage of patients with severe multifidus sarcopenia reported postoperative worsening of their NDI (10 patients, 38.5%; P=0.003), VAS Neck scores (7 patients, 26.9%; P=0.02), PROMIS Physical Component scores (10 patients, 38.5%; P=0.02), and PROMIS Mental Component scores (14 patients, 53.8%; P=0.02).

Conclusion
Patients with more severe paraspinal sarcopenia demonstrate less improvement in neck disability and physical function postoperatively and are substantially more likely to report worsening PROMs postoperatively.

148. ALL-CAUSE MORTALITY FOLLOWING CERVICAL AND THORACOLUMBAR ADULT DEFORMITY SURGERY: INCIDENCE AND CAUSES

Kevin C. Mo, MHA; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Peter Tretiakov, BS; Shay Bess, MD; Kevin Y. Wang, BS; Samrat Yeramaneni, PhD; Brian J. Neuman, MD; Richard Hostin, MD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; D. Kojo Hamilton, FAANS; Frank J. Schwab, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Alex Soroceanu, MPH; Han Jo Kim, MD; Robert A. Hart, MD; Breton G. Line, BS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Lawrence G. Lenke, MD; Khaled M. Kebaish, MD; International Spine Study Group

Hypothesis
Mortality rates following cervical deformity surgery will be higher than those for thoracolumbar deformity surgery.

Design
Retrospective Review

Introduction
Both cervical and thoracolumbar deformity surgeries are often complex and invasive, with a fairly comorbid patient population. Few studies have assessed mortality rates, frailty, and invasiveness between the two populations. The aim of this study was to determine the incidence density of all-cause mortality as well as 30 and 90-day mortality rates. Secondary objectives were to ascertain causes of death, frailty, and invasiveness.

Methods
Using two prospective, multi-center databases, we identified cervical and thoracolumbar deformity patients. Clinical parameters, surgical parameters and all-cause mortality were analyzed. Incidence density was calculated based on the equation: 100 × (number of deaths)/(sum of total years of follow-up for all patients).

Results
146 cervical deformity patients included. 23 patients died (15.7%). Mean age 61.43 ± 10.45, 34% of patients frail (CD-FI) and mean CD-SR 79 ± 96. The mean time to death 25.46 ± 18.86 months. The mortality incidence density 8.75 deaths/year/1,000 patients. 30-day mortality rate 0.68% (1/146), 90-day mortality rate 1.3% (2/146). The three most common causes of death: pneumonia (9.68%), congestive heart failure (6.45%), and myocardial infarction (6.45%). 1,380 thoracolumbar patients included. 38 patients died (2.75%). Mean age 60.5 ± 14.24, 58% of patients frail (ASD-FI), and mean invasiveness (ASD-SR) 92.7±34.7. Mean time to death 29.68 ± 20.26 months. Average follow-up 1.82 ± 1.5 years. The mortality incidence density 1.5 deaths/year/1,000 patients. 30-day mortality rate. 072% (1/1,380) and 90-day mortality rate 0.22% (3/1,380). The three most common causes of death: pneumonia (13.16%), myocardial infarction (10.53%), and malignancy (7.89%). There were no intraoperative deaths.

PODIUM PRESENTATION ABSTRACTS

Conclusion
Cervical deformity patients had significantly more deaths per year (8.75 cervical vs. 1.5 thoracolumbar) per 1,000 patients than thoracolumbar deformity surgeries. Pneumonia and myocardial infarction were common causes of death in both cervical and thoracolumbar deformity surgery patients. No deaths occurred during surgery. Given these high mortality rates, efforts should be taken to optimize patients and heighten awareness for high risk causes of death.

Cause	Thoracolumbar Mortality (N)	%	Cervical Mortality (N)	%
Pneumonia (PNA)	5	13.16%	3	13.04%
Arrythmia/Cardiac Arrest	4	10.53%	0	0.00%
Malignancy (Non-spine)	3	7.89%	1	4.35%
Respiratory failure (non-PNA)	1	2.63%	0	0.00%
Congestive Heart Failure	1	2.63%	2	8.70%
Pulmonary Embolism	1	2.63%	0	0.00%
Myocardial Infarction	0	0.00%	2	8.70%
Multiple System Atrophy	1	2.63%	1	4.35%
Trauma	2	5.26%	2	8.70%
Sepsis	0	0.00%	1	4.35%
Deep Surgical Site Infection	0	0.00%	1	4.35%
Anoxic Brain Injury	0	0.00%	1	4.35%
Stroke	0	0.00%	1	4.35%
Unknown	20	52.63%	8	34.78%
Total Mortality	38		23	
Total in Cohort	1,380		146	
Total Follow-up (Years)	2,521.15		263	
Mean Follow-Up (Years)	1.83		1.80	
Mortality Incidence Density (deaths per year per 1,000 pts)	**1.51**		**8.75**	

149. RADIOGRAPHIC AND CLINICAL FINDINGS ASSOCIATED WITH KLIPPEL-FEIL SYNDROME

Andrew Megas, DO; Aniruddh Mandalapu; Gabrielle Santangelo, MD; Addisu Mesfin, MD; *Emmanuel N. Menga, MD*

Hypothesis
Patients with Klippel-Feil Syndrome have a high rate of surgical intervention involving levels adjacent to congenital vertebral body fusion.

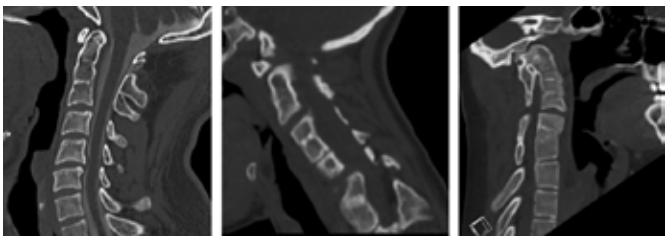
Design
Retrospective cohort study.

Introduction
Klippel-Feil Syndrome (KFS), a congenital disorder involving the fusion of two or more cervical vertebrae, classically involves a short neck, restricted neck mobility, and low posterior hairline. KFS is also associated with degenerative changes in intervertebral discs adjacent to fused vertebrae, which may cause symptomatic degneration or stenosis. KFS patients have been associated with increased rates of surgical spine procedures.

Methods
A database at an academic medical center was used to identify patients with KFS, which was confirmed by the authors' review of imaging. The patient data was categorized by patient demographics, spinal anatomic characteristics, and surgical intervention. Demographic variables, anatomic characteristics, presence of scoliosis, and management were evaluated.

Results
In our cohort of 59 patients with KFS, more females than males (53% vs 48%) were affected. A majority of the patients were Caucasian (78%). The mean age was 40 years old. The most common levels of fusion were C2-C3 (33%) and C5-C6 (22%). Following the Samartzis classification, 31 (53%) were type I, 10 (17%) were type II, and 17 (29%) were type III. There was a 36% prevalence of scoliosis. Among those with scoliosis, 38% had scoliosis in the cervical region with a mean Cobb angle of 28° ± 5.4°, 43% thoracic with 35° ± 13°, and 19% lumbar with 27° ± 4.7°. The average age of diagnosis with scoliosis was at 13 years old. 26% of all patients underwent spine surgery. Of the spine surgeries, there were 11 posterior spinal fusions (PSF), 2 anterior and PSFs, 1 anterior cervical discectomy and fusion, one torticollis release, and one unspecified spinal discectomy. Of the 14 fusion procedures, 85% were at or adjacent to the level of congenital fusion.

Conclusion
KFS is commonly associated with the development of symptomatic degenerative cervical changes. Surgical intervention in patient with KFS largely involved PSFs involving or adjacent to levels of congenital vertebral fusions. This study gives further insight into the natural history, rate of surgical intervention, and prevalence of associated conditions in KFS.



Sagittal CT demonstrating Samartzis classification 1, 2, and 3 respectively.

150. MACHINE LEARNING IDENTIFIES CLUSTERS OF THE ADOLESCENT SPINE BASED ON SAGITTAL BALANCE

Lorenzo Deveza, MD, PhD; Birhiray Dion, BS; Martin Gehrchen, MD, PhD; Benny T. Dahl, DMSc

Hypothesis
Machine learning can be used to identify patterns of sagittal alignment in the normal adolescent spine.

Design
A machine learning unsupervised clustering approach applied to adolescent sagittal spines from a single pediatric institution.

Introduction
Sagittal spinal alignment of the normal adolescent spine is relevant while planning surgical treatment of adolescent idiopathic scoliosis. We sought to explore the variability found in adolescent sagittal alignment using machine learning, which may remove inherent bias and can help determine whether clusters of sagittal alignment exist.

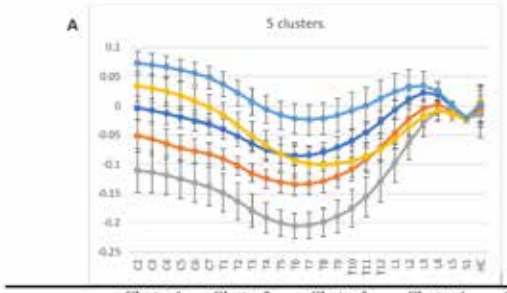
Methods
A total of 111 normal adolescent sagittal spines were analyzed. Centroids were found for each vertebral body (C2 to S1), and the center of the hips; and then normalized for comparison. Multiple unsupervised machine learning

clustering algorithms were applied: a k-means clustering, and three different methods of hierarchical clustering algorithm (i.e., average, complete, ward-d2). A within-group-sum-of-squares (WSS) plot and hierarchical tree was inspected to determine optimal number of clusters. Sagittal parameters for resultant clusters were determined.

Results
The average age was 13.7 ± 2.2 yrs and 64% were females. Machine learning analysis found that the spines did cluster into distinct groups. According to the WSS plot and hierarchical trees, the optimal number of clusters ranged from 3 to 5. We performed an analysis on both 3 and 5 cluster groups. The 3 cluster groups analysis found good consistency between methods with 96 of 111 spines clustered into the same groups for at least three of the four methods. Similarly, the analysis of 5 cluster groups found consistency with 105 of 111 spines. The final groups for the 5-cluster analysis are illustrated in Fig 1A. When assessing for differences in sagittal parameters between the groups for both analyses, the only parameter that was statistically different for all groups was SVA ($p < 0.001$, Fig 1B).

Conclusion
Based on machine learning the adolescent sagittal spine alignments do cluster into distinct groups. While there were distinguishing features with TK and LL, the most important parameter distinguishing these groups was SVA. Further studies may help to understand these findings in relation to spinal deformities.

A



B

	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		
	15		9		32		14		35		
Gender (F:M)	9	6	8	1	22	10	5	9	22	13	0.1092
Age (avg; SD)	13.3	2.8	13.1	2.6	13.3	2.0	13.0	1.4	14.3	2.1	0.1854
T4-12 Kyphosis	28.3	10.0	41.0	9.8	29.9	8.6	32.4	10.1	34.9	9.1	0.007
T1-12 Kyphosis	34.9	13.3	47.5	12.5	37.3	10.4	36.9	13.5	40.8	9.5	0.068
L1-S1 Lordosis	48.5	5.3	62.4	4.4	53.0	10.9	42.1	15.4	58.3	11.7	< 0.001
Pelvic Incidence	48.9	9.6	59.0	13.4	46.9	12.2	41.5	7.7	43.0	9.6	0.095
Sacral Slope	41.8	4.4	34.4	5.4	39.9	7.5	31.2	9.9	38.1	8.0	0.002
Pelvic Tilt	8.8	7.6	10.1	6.7	10.7	7.0	10.4	5.8	7.2	5.2	0.222
SVA	43.7	10.6	-47.3	13.3	6.3	11.6	24.4	7.5	-19.6	10.3	< 0.001*
PI-LL Mismatch	7.5	7.2	23.4	14.0	10.4	8.4	10.1	6.8	15.7	8.4	<0.001
TPA	10.9	6.6	1.7	6.2	8.5	5.9	9.1	4.7	2.3	4.3	< 0.001

*Indicates statistically significant difference between all cluster groups

Figure (A) Cluster groups identified by Machine Learning. (B) Sagittal parameters of cluster groups.

151. COMPARISON OF SPINOPELVIC CONFIGURATION AND ROUSSOULY ALIGNMENT TYPES BETWEEN PEDIATRIC AND ADULT POPULATIONS

Yann Philippe Charles, MD, PhD; Vincent Lamas, MD; Sebastien Pesenti, MD, PhD; Brice Ilharreborde, MD, PhD; Guillaume Riouallon, MD; Federico Solla, MD; Ibrahim Obeid, MD; Emmanuelle Ferrero, MD, PhD; Erik-André Sauleau, MD, PhD; Benjamin Blondel, MD, PhD

Hypothesis
The Roussouly classification was validated for adults. Alignment types may vary during growth.

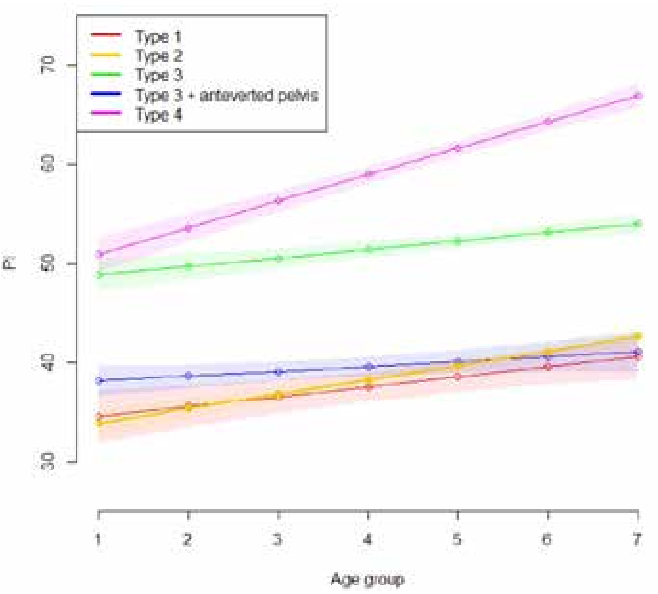
Design
Retrospective cross-sectional study.

Introduction
The aim was to describe spinopelvic alignment types by Pelvic Incidence (PI) and age to compare the Roussouly classification between pediatric and adult populations.

Methods
Radiographs of 1706 individuals were analyzed. Age groups (5-19 years) were stratified by chronological age and skeletal maturity (triradiate cartilage, Risser), and compared to adults. Global and spinopelvic alignment parameters were assessed. Roussouly types 1, 2, 3, 3A (anteverted pelvis) and 4 were determined. The distribution of parameters was analyzed by Bayesian inference. The relationship between PI and age by Roussouly type was modeled by linear regression.

Results
The Sagittal Vertical Axis-C7 decreased during growth and was significantly smaller in adults (20-34years) (Pr>0.99). Thoracic kyphosis and lumbar lordosis increased during growth and were larger in adults (Pr<0.025). Lordosis increased mainly in the cranial arch (Pr<0.025). PI and pelvic tilt increased during growth and were larger in adults (Pr<0.025). In children and adolescents, PI <45° represented the largest proportion, significantly larger compared to adults (Pr>0.99). Proportions of Roussouly types 1 and 2 were similar throughout ages. Types 3 and 4 were rarer during the prepubertal period (Pr<0.025). The proportion of type 3A was significantly higher in children and adolescents (Pr>0.99). Linear regression showed that type 4 had the largest PI increase with age with a significantly higher curve slope compared to other types (Pr>0.9999). Types 3, 3A and 2 had similar slopes and lowest PI increase with age.

Conclusion
Global and spinopelvic alignment changes during childhood and adolescence, leading to different kyphosis and lordosis distribution compared to adults. Growth-related PI increase influences Roussouly types with a typical predominance of type 3A in the pediatric population and a larger PI increase in type 4.



Pelvic Incidence (PI) by age during growth (groups 1-5) and in adults (groups 6-7) by Roussouly type

152. BIOMECHANICAL COMPARISON OF LUMBAR, SACRAL AND ILIAC SCREW STRAIN WITH THE KICKSTAND ROD VS. CONVENTIONAL PELVIC FIXATION IN ADULT SPINAL DEFORMITY SURGERY

Alex Ha, MD; Josephine R. Coury, MD; Andrew J. Luzzi, MD; Daniel Hong, MD; Fthimnir Hassan, MPH; Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Dilip K. Sengupta, MD

Hypothesis
To compare the strain at the iliac and sacral screw with an L5-iliac-anchored conventional fixation vs. the kickstand rod pelvic fixation in adult spinal deformity.

Design
Biomechanical study on spine model

Introduction
One of the most common problems in long spinal fusions for adult spinal deformity is caudal end fixation failure. To address sacral screw loosening, fixation may be extended to the pelvis using iliac screws. Iliac screws provide strong anchor strength, but iliac screw loosening is common due to high strain. A novel kickstand rod(KS) construct with a wider base is introduced to reduce iliac screw strain

Methods
A life-sized saw-bone spine model from the occiput to pelvis was instrumented with pedicle screws and rods from T9-S1. L5 and S1 screw strain was measured using strain gauges with application of 25Nm loading in flexion, extension, lateral bending and rotation at the T9 level. Screw strain was measured for L5, S1 and iliac screws after the fixation was extended to the pelvis. The conventional model used a short bridge to connect a screw in the medial iliac crest to the main rod at a point superior to L5. In the KS configuration, two flared rods connected to the main rods at L1 and to two screws in the lateral superior iliac crest. Each test was repeated 6x.

Results
S1 strain was reduced by 65% by the conventional(conv.) and by 77% by the KS fixation technique. The effect of S1 screw strain reduction was significantly greater with the use of KS fixation compared to the conv. pelvic fixation in all loading directions, such as in flexion(1601±202 vs 218±15) and extension(3577±292 vs 492±58). Conv. pelvic fixation reduced the S1 screw strain at the cost of a high iliac screw strain (S1-Con: 625.7±130.2; I-Con: 3244.3±275.7). The KS fixation reduced the S1 screw strain while maintaining low iliac screw strain (S1-KS: 218.4±125.1; I-KS: 565±262.4). The iliac screw strain was significantly lower with KS fixation compared to the conv. fixation in all loading directions. The conventional fixation also increased L5 screw strain compared to the native fixation, but the KS fixation did not.

Conclusion
KS configuration reduced S1 strain to a greater extent when compared to conventional methods. The terminal fixation at the iliac screw suffered a higher load in the conv. fixation relative to the KS technique.

		L5 strain+/- SD	S1 strain +/- SD	I-Con +/- SD	I-ET +/- SD
Flexion	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Extension	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Mean Lat bending	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Tension Lat bending	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Compression Lat	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Mean Rotation	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Right Rotation	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Left Rotation	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]
Composite	Native fixation	[illegible]	[illegible]		
	Pelvic fixation - conventional	[illegible]	[illegible]	[illegible]	
	Pelvic fixation - E-T	[illegible]	[illegible]		[illegible]

Table 1. Individual screw strain at the L5, S1, I-Con, and I-ET for different movements with native fixation, conventional pelvic fixation and novel pelvic fixation (E-T configuration) averaged across 6 trials, measured in Microstrain. The composite row depicts screw strain after the average screw strain in all movements.

153. THE H2-FAILS SCORE ACCURATELY PREDICTS 30-DAY MORTALITY AFTER SURGERY FOR METASTATIC DISEASE OF THE SPINE

Farah Musharbash, MD; Jawad Khalifeh, MD; Micheal Raad, MD; Varun Puvanesarajah, MD; Sang Hun Lee, MD; Brian J. Neuman, MD; Khaled M. Kebaish, MD

Hypothesis
Risk of 30-day mortality following surgery for metastatic spinal disease can be accurately predicted using a simple scoring system.

Design
Retrospective Review

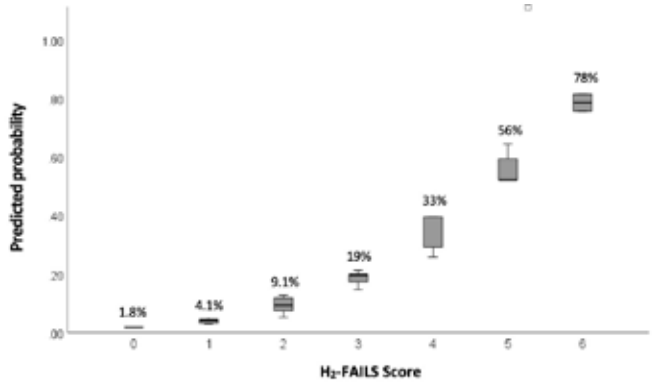
Introduction
Preoperative risk assessment for patients undergoing surgery for spinal metastasis remains difficult, with few validated tools to guide decision making. Our goal was to develop and evaluate a simple yet accurate tool to predict 30-day

mortality in patients undergoing surgery for metastatic spine disease, which is the most salient variable for guiding the decision-making process for spine surgeons.

Methods
Using the National Surgical Quality Improvement Program database, we identified 1,195 adults who underwent surgery for metastatic spine disease from 2010–2018. The incidence of death within 30 days after surgery was 8.7% (n = 104). Factors identified on univariate analysis as predictors of 30-day mortality were included in the multivariate regression, from which the significant variables were used to derive the risk model equation and H2-FAILS score. H2-FAILS is an acronym derived from the variables it considers: Heart failure (2 points), Functional dependence, Albumin deficiency, International normalized ratio elevation, Leukocytosis, and Smoking within the previous 12 months (1 point each). Discrimination was assessed using area under the receiver operating characteristic curve (AUC). The H2-FAILS score was compared with the American Society of Anesthesiologists Physical Status Classification (ASA Class), the 5-item modified Frailty Index (mFI-5), and the New England Spinal Metastasis Score (NESMS). Internal validation was performed using bootstrapping, and an optimism-corrected AUC was calculated. Alpha = 0.05.

Results
Predicted 30-day mortality increased stepwise from 1.8% for an H2-FAILS score of 0 to 78% for a score of 6. No patients had the maximum score of 7. The AUC of the H2-FAILS was 0.77 (95% confidence interval: 0.72–0.81), which was significantly higher than those of mFI-5 (AUC 0.58, $p < 0.001$), ASA Class (AUC 0.63, $p < 0.001$), and NESMS (AUC = 0.70, $p = 0.004$). Internal validation showed an optimism-corrected AUC of 0.76.

Conclusion
The H2-FAILS score is a simple and accurate tool for predicting 30-day mortality risk after surgery for spinal metastasis and performed better than other similar scoring systems in this patient population.



Box plot of the predicted probability of 30-day mortality for each H2-FAILS score.

154. DOES FUNCTIONAL OUTCOME IMPROVE AFTER SURGERY FOR METASTATIC SPINE TUMORS IN PATIENTS WITH SINS 7-12 AND SINS >12?

Saman Shabani, MD; Enrique Vargas, BS; Alma Rechev Ben Natan, BA; Alex Aabedi, MD; Nitin Agarwal, MD; Praveen V. Mummaneni, MD; Dean Chou, MD

Hypothesis
Patients with SINS 7-12 and > 12 will benefit from surgery and have improvement in their KPS score post-operatively.

Design
Retrospective, single center

Introduction
In potentially unstable and unstable patients with metastatic spinal tumor with Spinal Instability Neoplastic Scores (SINS) 7-12 and > 12, it is unclear if surgery improves Karnofsky Performance Score (KPS).

Methods
Total of 132 patients with metastatic spinal tumor with SINS 7-12 (N: 66) and SINS > 12 (N:66) were retrospectively reviewed with pre- and post-operative KPS. Baseline clinical characteristics including SINS score, Bilsky compression grade, neurologic function, and preoperative KPS were collected. 27/132 patients preoperatively had radiation with N: 12 in SINS 7-12 cohort and N:15 in SINS > 12. KPS scores were obtained pre-radiation, post-radiation, pre-operatively, and post-operatively. Paired, nonparametric Wilcoxon signed-rank test and ordinal logistic regression was for statistical analysis.

Results
In SINS 7-12 cohort (N:66), the median SINS score was 11 with a mean follow-up of 3.7 years. The survival rate was 94% at 1-year and 88% at 2-year. In SINS > 12 cohort (N:66), the median SINS score was 14 with a mean follow-up of 2.19 years. The survival rate was 85% at 1-year and 82% at 2-year. In this cohort, postoperatively significant improvement in KPS occurred from a median of 50 to 70 ($p = 0.0003$). In patients who did not receive radiation preoperatively, Wilcox test showed significant improvement in KPS post-operatively (P=0.006). In patients who received radiation preoperatively, there was not any improvement in the KPS. On ordinal logistic regression, Bilsky compression grade and ASIA motor did not predict the degree of KPS improvement, and this effect was maintained after controlling for Bilsky cord compression grade. In SINS > 12 cohort, postoperatively significant improvement in KPS occurred from a median of 50 to 60 ($p = 0.001$). On ordinal logistic regression, Bilsky compression grade as well as ASIA motor did not predict the degree of KPS improvement. Patients with a preoperative Bilsky compression grade 3 had a statistically significant improvement in KPS ($p = 0.001$), while patients with grade 2 did not ($p = 0.22$).

Conclusion
Surgical intervention can improve functional outcome in metastatic spine tumor patients with SINS 7-12 and SINS > 12 as assessed by the change in KPS postoperatively.

PODIUM PRESENTATION ABSTRACTS

155. DEVELOPMENT OF A SPINAL DEFORMITY SURGICAL CHECKLIST: AN SRS SAFETY AND VALUE COMMITTEE SURVEY INVESTIGATION

Rafael De la Garza Ramos, MD; Justin K. Scheer, MD; Nabil Matmati, PhD; *Lloyd A. Hey, MD*; Douglas C. Burton, MD; Marinus De Kleuver, MD, PhD; Christopher P. Ames, MD; Vijay Yanamadala, MBA

Hypothesis
A survey investigation may aid in the development of a safety surgical checklist specific for deformity patients.

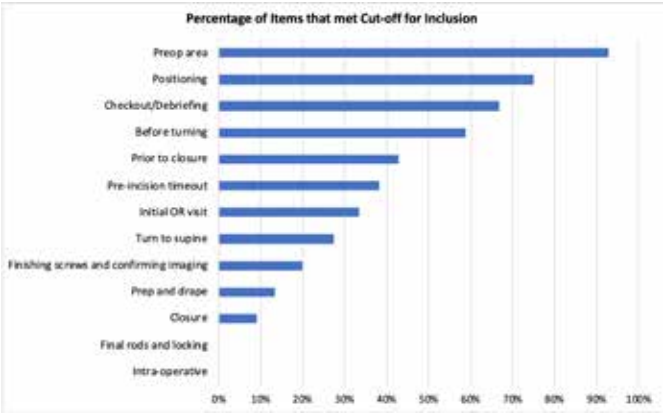
Design
An electronic survey administered to Scoliosis Research Society (SRS) Safety and Value Committee (SVC) membership.

Introduction
Deformity surgery has a relatively high complication rate. The use of safety checklists can potentially reduce perioperative adverse events, but these lists are varied and non-specific for patients with scoliosis. Thus, the purpose of this study was to develop a comprehensive surgical checklist for deformity surgery by identifying the most important features to be included.

Methods
An electronic survey consisting of 187 items was administered to SRS SVC membership. The survey sections included: 1) Preop area, 2) Initial OR visit, 3) Before turning, 4) Positioning, 5) Prep and drape, 6) Pre-incision timeout, 7) Intraoperative, 8) Finishing screws and confirming imaging, 9) Final rods and locking, 10) Prior to closure, 11) Closure, 12) Turn to supine, and 13) Checkout/Debriefing. Respondents graded each item on a 5-point Likert scale based on its perceived importance for inclusion. Features graded as "moderately important" or "very important" to include by at least 70% of respondents were considered to meet the cut-off for inclusion based standard Delphi practices.

Results
A total of 25 surgeons completed the survey in its entirety. There were 74/187 items (40%) that met the cut-off for inclusion; 17 of these were graded as "very important" to include. The Preop area section had 93% of its items meet the threshold to include in the checklist; this was followed by the Positioning section with 75% and Checkout/debriefing with 67%. None of the items in the Intraoperative or Final rods and locking sections met the cut-off for inclusion. Some of the "very important" items included checking for skin infections, and allergies preoperatively; reviewing the surgical plan and positioning with the OR staff; and making sure the endotracheal tube was positioning adequately and patient positioned safely in the OR bed.

Conclusion
Development of a spinal deformity surgical checklist relies on feature selection. In this study, 74 items were considered important for inclusion; 17 were considered "very important". A second round of survey administration via Delphi approach will be needed to further optimize this list.



Percentage of items included in the checklist per section

E-POSTER ABSTRACTS

200. NEUROMONITORING DURING SCHEUERMANN'S KYPHOSIS SURGERY: UPPER EXTREMITY CHANGES ARE MORE COMMON THAN LOWER EXTREMITY

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Hypothesis
The incidence of intraoperative neuromonitoring (IONM) changes in Scheuermann's kyphosis (SK) is similar to adolescent idiopathic scoliosis (AIS), and postoperative neurologic deficit is rare.

Design
Single-center, retrospective chart review.

Introduction
Given the risk of neurologic deficit in patients undergoing posterior spinal fusion (PSF), IONM plays a critical role in this patient population. The purpose of this study is to determine the incidence of IONM changes and postoperative neurologic deficit in patients with SK undergoing PSF.

Methods
Clinical, surgical and IONM (somatosensory evoked potential (SSEP) and neurogenic motor evoked potential (NMEP) or transcranial motor evoked potential (TcMEP)) data from patients with SK undergoing PSF from 1993-2021 were reviewed.

Results
127 SK patients (mean 16.3±1.8 years) underwent PSF with correction of kyphosis from mean 79.4±10.4° to 42.3±12.1°. Osteotomies were performed in 40.2% of cases. MEP data was obtained in 81.9% (MEPs were being introduced during the course of this series) of patients using either NMEP (34.6%) or TcMEP (65.4%) while 100% of patients had SSEPs performed. 3.1% cases had lower extremity (LE) IONM changes during surgery, with no postoperative neurologic deficits in those patients. One occurred during implant placement and returned to baseline with an increase in mean arterial pressure, and 2 occurred during deformity correction and returned to baseline after correction was decreased. One case was aborted due to persistent reduction of SSEP and TcMEP signals and required a return to the OR for completion. IONM changes occurred more frequently in the upper extremities (UE) with 14 (11.0%) patients having transient changes in UE SSEPs that resolved with arm repositioning. One patient had a postoperative UE neurapraxia that resolved by 6 weeks. There was 1 postoperative transient femoral nerve palsy without IONM changes.

Conclusion
The incidence of critical LE IONM changes during PSF for SK is 3.1%, similar to that reported in AIS. UE IONM changes are significantly higher at 11%, revealing that these patients are more vulnerable to malpositioning of the arms. IONM in SK identifies impending neurologic deficits which were avoided in the LE by increasing blood pressure and decreasing deformity correction and in the UE with repositioning of the arms.

201. TRANSFORMING ELECTRONIC HEALTH RECORDS (EHR) OF SCOLIOSIS PATIENTS INTO CLINICAL REGISTRIES USING NATURAL LANGUAGE PROCESSING (NLP) AND COMPUTER VISION METHODS*

Shi Yan, MS; Elham Sagheb Hossein Pour, MS; Caroline Constant, DMV; Taghi Ramazanian, MD; Carl-Eric Aubin, PhD; Sunghwan Sohn, PhD; Hilal Maradit Kremers, MD; A. Noelle Larson, MD

Hypothesis
We hypothesized that (a) surgery classification by a scoliosis-specific NLP-enabled algorithm will be highly correlated with manual chart review and (b) a previously published model for Cobb angle prediction may not work well on our external dataset due the limitations of training data.

Design
Cross-sectional study for development an NLP-algorithm for extraction of surgery type from operative notes and external validation of a deep learning method of cobb angle prediction.

Introduction
There is significant interest in understanding the effectiveness of different implant technologies in scoliosis. However, it is not possible to distinguish surgical details using procedure codes alone or structured EHR data. Cobb angle guides treatment planning but manual measurement is time consuming and prone to observer variation. Registries rely on labor-intensive manual chart review and radiographic measurements by trained individuals. Secondary use of EHRs and application of state-of-the-art technologies has potential to establish sustainable registries that can provide real-time information on surgical outcomes.

Methods
For the NLP algorithm, surgery-related keywords were compiled from a domain expert and refined further in the training phase. The procedure section of 831 operative notes along with exclusion criteria were used to improve accuracy. The performance on the test set (n=327) was compared with manual chart review. For Cobb angle prediction, we used YOLOv5 for extraction the Region of Interest (RoI) from 2278 AP X-rays. We predicted the landmarks using a previous published method. The model was trained on 2019 MICCAI challenge dataset and test on our scoliosis dataset. Model performance was evaluated qualitatively.

Results
The NLP algorithm achieved F1 score greater than 0.91, and micro and macro average F1 score 0.98 and 0.94 respectively. The YOLOv5 model performed well on RoI

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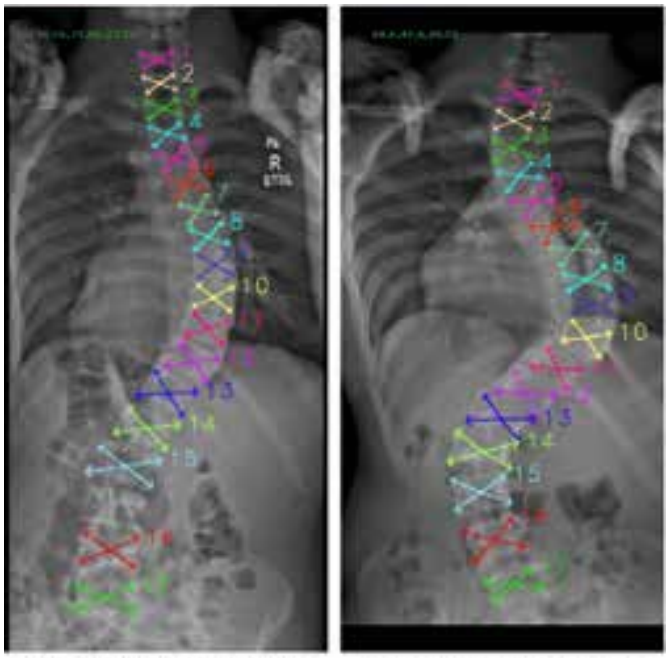
extraction, but the performance of the previously published model was poor on X-rays with severe scoliosis (Figure). The model typically missed T1 and vertebrae at the thoracolumbar junction.

Conclusion
Our promising findings demonstrate the potential of NLP and computer vision methods for extraction of scoliosis data elements from text and imaging EHR records.



(a) Poor Model Performance (b) Good Model Performance

Two illustrative examples of poor and good performance for landmark detection

202. TRI-CORTICAL OBLIQUE SCREW FIXATION IN ADULTS WITH NORMAL SPINAL ALIGNMENT, ANATOMICAL STUDY OF AN OPTION FOR PROXIMAL JUNCTIONAL KYPHOSIS PREVENTION

YinQi Cai, MS; Zhen Liu, PhD; Ziyang Tang, MD; Zongshan Hu, PhD; Changwei Liu, MD; Yong Qiu, PhD; Zezhang Zhu, MD, PhD; Yanjie Xu, MD

Hypothesis
It is safe and feasible to place the tri-cortical oblique screws in people's thoracic vertebrae.

Design
Retrospective study

Introduction
To simulate placing tricortical oblique screws in the thoracic vertebrae of normal adults and measure the imaging parameters of the screws, and to investigate the feasibility and safety of such technique.

Methods
The imaging data of patients who received plain CT scan and three-dimensional reconstruction of the thoracic vertebrae in our hospital from January 2019 to December 2021 were selected, 100 patients included 50 males and 50 females which aged from 23 to 65 years old with an average of 40.2±11.3 years old with no anatomical abnormalities in the thoracic vertebrae were also selected. After the construction of the trajectories, the imaging parameters were measured, including the range of sagittal angle (SA) and transverse angle (TA), maximal length (MaxL) and minimum length (MinL). Paired-samples' t test was used.

Results
There was significant difference between men and women in the longest screw trajectories and the shortest screw trajectories ($P < 0.05$). On each thoracic vertebra, except for the longest and shortest screw trajectories, there was no significant difference between the data of the middle thoracic segment (T5-T10) and the sagittal angle and the maximum range sagittal angle at the longest screw trajectories ($P > 0.05$). The range of TA was 13.6-25.3°, the minimum value of SA was 25.3±2.2°, the maximum value of SA was no significant difference at T5-T8 level, 39.8±2.3°, and the TA at the longest screw trajectories was 19.5±1.1°. The length of the screw trajectories in lower thoracic vertebrae was 53.1-64.3mm in men and 50.1-60.2mm in women, and the angle range of TA was 13.5-29.7°. The middle thoracic vertebrae range was 49.5-58.5mm for men and 45.9-54.1mm for women, and the angle range of TA was 14.0-25.5°. The upper thoracic vertebrae range was 42.4-50.3mm for men and 39.3-47.5 for women, and the angle range of TA was 18.9-30.6°

Conclusion
The females' screw trajectories are more shorter than males'. TA and screw trajectories are also different between lower thoracic vertebrae, middle thoracic vertebrae and upper thoracic vertebrae. It is safe and feasible to place the tri-cortical oblique screws in thoracic vertebrae by free-hand.

203. SUPINE CORRECTION INDEX: A NOVEL PREDICTOR FOR BRACE OUTCOME IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Lester P. Wong, MBBS; Prudence Wing Hang Cheung, BDSc (Hons); *Jason Pui Yin Cheung, MD, MBBS, MS, FRCS*

Hypothesis
The correction rate and curve flexibility can predict the outcome of bracing.

Design
Prospective study.

Introduction
Bracing is the standard nonoperative treatment for adolescent idiopathic scoliosis (AIS) with curve magnitude of ≥20°±5. The correction rate and flexibility of the curve can guide clinicians to the outcomes of bracing. We

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established a novel supine correction index for guiding brace treatment.

Methods
A prospective cohort of patients with AIS prescribed with either Boston or Milwaukee brace treatment between December 2016 and December 2018 were recruited and followed-up until brace weaning. Patients were braced according to the SRS bracing criteria. Patients who were lost to follow-up or had incomplete radiographic record were excluded. Curve progression at the end of follow-up was used as outcome and defined by ≥5° increase of Cobb angle. The supine correction index (SCI) was defined as the ratio between correction rate and flexibility. Receiver operating characteristic (ROC) curve analysis was performed to assess the optimal thresholds for flexibility, correction rate and SCI in predicting lower risk of progression.

Results
207 patients with mean age 12.8±1.2 years at recruitment were included. Baseline Cobb angle was similar (p=0.374) between progressed (32.7°±10.7) and stable patients (31.4°±6.1). High supine flexibility (OR=0.947; 95% CI:0.910-0.984; p=0.006) and correction rate (OR=0.926; 95% CI: 0.890-0.964; p<0.001) were significantly predictive of lower incidence of progression after adjusting for Cobb angle, Risser sign, curve type, menarche status, distal radius and ulna grading and brace compliance. ROC curve analysis identified a cut-off of 18.1% for flexibility (sensitivity=0.682, specificity=0.704) while a cut-off of 28.8% is found for correction rate (sensitivity=0.773, specificity=0.691) in predicting lower risk of curve progression. Cut-off for SCI was found to be 1.21 by ROC curve analysis (sensitivity=0.583, specificity=0.591) and an SCI greater than 1.21 is significantly predictive of lower risk of progression (OR=0.4; 95% CI: 0.251-0.955; p = 0.036).

Conclusion
High supine flexibility (18.1%) and correction rate (28.8%) predicts lower risk of curve progression. A SCI of 1.21 was found to be predictive of bracing outcomes in patients with AIS. This may serve as a guide for achieving the target correction rate during brace fabrication to optimize brace outcome.

204. DETERMINANTS FOR PREDICTING BRACING OUTCOMES IN EARLY ONSET IDIOPATHIC SCOLIOSIS (EOIS)†

Rufina Wing Lum Lau, PT; Lik Hang Alec Hung, MD; Victor Kin Wai Chan; Ho Man Kee, MS; Bosco Kin Pok Chau; Jerry Kwok To Chan; Derek Wai Yin Chung; Jack C. Cheng, MD; Leo Chung Hei Wong; Tsz-Ping Lam, MBBS; Stanley Ho Fung Leung

Hypothesis
Determinants could be identified for predicting clinical outcomes of bracing in EOIS

Design
A retrospective cohort study

Introduction
Bracing is one of first-line treatment for Early Onset Idiopathic Scoliosis (EOIS) to control curves from progression. Few studies examined the effects of bracing for EOIS. This study aimed to explore the determinants that govern bracing effectiveness in EOIS.

Methods
One hundred and eleven EOIS patients below 10 year old, treated with bracing and with final follow-up beyond skeletal maturity were identified from records between 1988-2021 for intention-to-treat analysis. Demographic data (gender, age, maturity, and bracing duration) and clinical features (curve type, Cobb angles and in-brace correction) were obtained. Multiple linear regression was used to determine the predictors for final curve outcomes.

Results
Ninety-five of EOIS were female (85.6 %) and 16 were male (14.4%). When first diagnosed, mean age was 8.6 years old (SD=1.25) with an average follow-up period of 9.41 years (SD=4.04), almost all were Risser 0 (99.1%) and mostly had major curve at left side (67%). The mean baseline Cobb angle of major curves was 21.73° (SD=7.92) with a mean Cobb angle progression of 18.05° (SD=19.11). Average bracing duration was 5.3 years (SD=1.9). Only 6 (23.4%) of them underwent surgery. Female EOIS had an average 3.04 years (SD=1.98) before menarche when first diagnosed and an average of 5.91 years (SD=4.05) post-menarche at last follow-up. Statistically significant negative correlation was found between the largest Cobb angle at last follow-up and the initial in-brace correction (r=-0.22, p=0.021). Curve type at onset, curve type just before bracing, age of stopping bracing and age at last follow-up were significant predictors of final Cobb angle of more than 55°(p<0.05) accounting for 75% of the variance.

Conclusion
Most EOIS had a final Cobb angle less than 50° which was considered as a successful bracing outcome. In-brace correction has been shown to predict bracing outcomes in AIS. This study also observed a favourable positive correlation between in-brace correction and the final Cobb angle in EOIS. The curve type at onset and just before bracing, age when stopping bracing and age at last follow-up were predictors of the final Cobb angle of more than 55°. Future multi-centre studies with longer follow-up after weaning are warranted.

205. FRACTURE RISK ASSESSMENT TOOL (FRAX) IS INEFFECTIVE IN IDENTIFYING ADULT SPINAL DEFORMITY PATIENTS AT RISK FOR OSTEOPOROSIS

Josephine R. Coury, MD; Yong Shen, BS; Meghan Cerpa, MPH; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

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E-POSTER ABSTRACTS

Hypothesis
Fracture Risk Assessment Tool (FRAX) is an ineffective screening tool for identifying adult spinal deformity patients at risk for osteoporotic fracture.

Design
Retrospective cohort

Introduction
Osteoporosis (OPO) and osteopenia (OPE) are frequently under diagnosed and under treated in adult spinal deformity surgery (ASD), leading to potentially avoidable complications. The Fracture Risk Assessment Tool (FRAX) is a validated tool to identify patients at risk for osteoporotic fracture based on individual risk factors with or without bone mineral density (BMD). The goal of this study was to analyze the efficacy of FRAX in screening ASD patients at risk for osteoporotic fracture.

Methods
A retrospective review was performed of all patients seen by 2 spinal deformity physicians at a single institution within two years. 354 ASD patients over age 30 were identified and underwent chart review. Data extracted included demographics, medical comorbidities, and bone density testing. FRAX score without BMD was calculated for the 211 patients who had a preoperative DXA scan.

Results
52.6% of patients had OPE, 23.2% OPO, and 24.2% normal bone density. According to FRAX, only 15% of patients had a 10-year probability of a hip fracture ≥ 3% or major osteoporosis-related fracture ≥ 20%. It did not identify 73% of patients with OPO based on DXA. Comparing FRAX 10-year probability of a hip or major osteoporosis-related fracture to DXA as the gold standard, FRAX had a 26.53% sensitivity and 88.27% specificity (AUC 0.61) for detecting patients at risk for osteoporosis.

Conclusion
The prevalence of OPO or OPE is high (76%) in ASD patients. While FRAX is validated for use in the general population, its utility in patients undergoing spine surgery has not been determined. We found that FRAX is an ineffective screening tool for osteoporosis complications in patients with ASD. Alternate screening tools for ASD patients should be developed and used prior to spinal deformity surgery.

206. DETERMINING THE BEST VERTEBRA FOR MEASURING PELVIC INCIDENCE AND SPINOPELVIC PARAMETERS IN TRANSITIONAL ANATOMY

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Hypothesis
In sacralized L5 transitional anatomy, PI should be measured at S1

Design
Retrospective analysis of a prospective multicenter ASD database and a database of asymptomatic subjects

Introduction
Sacralization of L5 is a condition that affects 15% of the Population. Because of the increased L5 articulations to the sacrum, it is unclear how pelvic incidence and spinopelvic parameters should be measured

Methods
Linear regression modeling was used to determine normative TPA and PI-LL based on PI and age in a database of asymptomatic subjects. In an ASD database, patients with radiographic evidence of L5 Sacralization, had PI, LL and TPA measured from the superior endplate S1 and then also from L5. The differences in TPA and PI-LL from normative were calculated in the sacralization cohort relative to L5 and S1 and correlated to ODI. Patient were grouped based on PI-LL Schwab modifier (0, +, ++) utilizing their L5 PI-LL and S1 PI-LL. Baseline ODI and SF36 PCS were compared across and within groups

Results
Among 1179 ASD patients, 276 (23.4%) had transitional anatomy, 176 with sacralized L5 (14.9%) and 100 (8.48%) with lumbarization of S1. The 176 with sacralized L5 were analyzed. PI (24.5 ± 11.0 vs 55.7 ± 12.0, p=0.001), TPA (11.2 ± 12.0 vs 20.3 ± 12.5, p=0.001) and PI-LL (0.67 ± 21.1 vs 11.4 ± 20.8, p=0.001) measured utilizing the L5 superior endplate were significantly smaller than those measured relative to S1. When measured from S1, 76 (43%) of patients were SRS Schwab 0, 45 (25.6%) were +, and 55 (31.3%) were ++ compared to 124 (70.5%), 22 (12.5%), and 30 (17.0%) measured from L5, respectively. There were significant differences in ODI and PCS as the Schwab grade increased regardless of L5 or S1 measurement. The L5 group had higher PCS functional scores for Schwab 0 and ++ relative to same grades in the S1 group. Offset from normative TPA (0.5 ± 11.1 vs 9.6 ± 10.8, p=0.001) and PI-LL (0.67 ± 21.1 vs 11.4 ± 20.8, p=0.001) were smaller when measuring from L5. Moreover, S1 measurements were more correlated with disability by ODI (TPA offset from normative, S1: R=0.326 vs L5: R=0.285; PI-LL Offset from normative, S1: R=0.318 vs L5: R=0.274)

Conclusion
Measuring the PI at L5 in sacralized anatomy results in underestimating the PILL Schwab grade in a percentage of patients and less correlation with HRQLs. Patients with sacralized L5s should have spinopelvic parameters measured relative to S1

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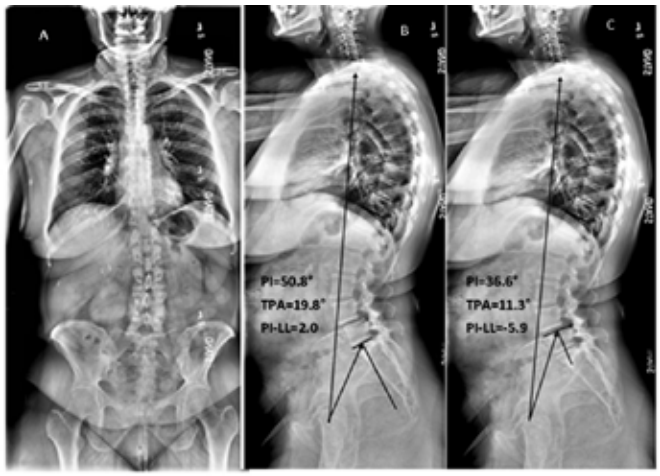

Radiographs of a patient with sacralization of L5 at baseline in AP (a), lateral with parameters measured relative to S1 (b), and lateral with parameters relative to L5.

207. DO LENGTH AND POSITION OF ILIAC SCREWS MATTER IN ADULT SPINAL DEFORMITY?

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Hypothesis
In adult spinal deformity (ASD) surgery, both position and length of iliac screws matter in preventing screw loosening and mechanical complications, such that closer proximity to the sciatic notch and longer screws lead to decreased loosening and decreased mechanical complications.

Design
Retrospective cohort study

Introduction
Iliac screws are important anchors in ASD operations, and optimal position and length of iliac fixation remains unknown. We sought to evaluate the association between iliac screw position and screw length with the following outcomes: 1) radiographic lucency, 2) mechanical complications, and 3) 2-year patient-reported outcomes (PROs).

Methods
A single-institution ASD registry was queried for patients undergoing ASD surgery from 2013-2017. Inclusion criteria: ≥6-level fusions and a fixed sagittal/coronal deformity. Either S2-alar-iliac or medial iliac screws were placed in all patients and two variables were recorded: 1) distance of the screw to the sciatic notch, and 2) screw length. Shortest distance to notch and longest screw length between the right and left iliac screws were included in the regression analysis.

Results
In 145 patients undergoing ASD surgery, mean age was 63.9±11.3 and mean total instrumented levels was 9.8±2.6. A total of 223 S2AI/iliac screws were placed. Screw position was an average of 10.1±7.2mm to the sciatic notch (range=2-36). Screw length average was 70.4±8.8mm (range=50-90). A total of 71 (31.8%) screws showed evidence of radiographic lucency at 2-years. No significant association was found between distance to the sciatic notch and screw loosening or mechanical complications, except for implant failure, such that a decreased odds of implant failure were seen when screws were closer to sciatic notch (OR=0.66, 95%CI 0.45-0.97, p=0.036), with a threshold of 8mm (AUC=0.62, 95%CI 0.52-0.72, p=0.044). Screw length was not associated with screw loosening or mechanical complications. There was no association between PROs and distance to notch or screw length.

Conclusion
Iliac screws closest to the sciatic notch were independently associated with a decreased odds of implant failure, though no association was seen between screw length and other mechanical complications. This preliminary study provides early evidence that iliac screws within 8mm of the sciatic notch may decrease the risk of implant failure.

		Univariate		Multivariate	
Outcome variable	**Independent Variable**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Screw haloing	Screw position	0.99 (0.92, 1.06)	0.793	0.99 (0.91, 1.09)	0.977
Mechanical complications		1.01 (0.94, 1.08)	0.831	0.98 (0.90, 1.06)	0.672
PJK		0.97 (0.89, 1.05)	0.459	0.93 (0.84, 1.03)	0.222
DJK	Screw position	0.98 (0.66 ,1.4)	0.919	-	0.998
Rod fracture/Pseudarthrosis		1.03 (0.96, 1.10)	0.341	1.02 (0.94, 1.1)	0.505
Implant Failure		0.27 (0.64, 1.06)	0.137	0.66 (0.45, 0.97)*	0.036*
Outcome variable	**Independent Variable**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
PROs at 2-years					
ODI	Screw position	-0.15 (-0.81, 0.496)	0.633	-0.21 (-1.05, 0.61)	0.607
EQ-5D		-	0.795	-	0.869
NRS-back		0.02 (-0.72, 0.127)	0.058	-	0.910
NRS-leg		0.04 (-0.07, 0.15)	0.463	0.05 (-0.10, 0.22)	0.480

Association of iliac screw position with screw haloing, mechanical complications and PROs

208. THE IMPORTANCE OF INCORPORATING PROPORTIONAL ALIGNMENT IN ADULT CERVICAL DEFORMITY CORRECTIONS RELATIVE TO THE CERVICOTHORACIC JUNCTION AND GLOBAL ALIGNMENT: STEPS TOWARD DEVELOPMENT OF A CERVICAL-SPECIFIC SCORE

Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Oscar Krol, BS; Rachel Joujon-Roche, BS; Bailey Imbo, BA; Peter Tretiakov, BS; Andrew J. Schoenfeld, MD; Shaleen Vira, MD; Bassel G. Diebo, MD; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Ekamjeet Dhillon, MD; Virginie Lafage, PhD

Hypothesis
Incorporating regional along with global alignment into deformity realignment schema will maximize clinical outcomes and lower complications.

Design
Retrospective

Introduction
The Global Alignment and Proportion (GAP) Score is widely used in adult spinal deformity surgery. However, it is not specific to the parameters used in adult cervical deformity (ACD).

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Methods
Surgical CD pts with 2Y data were included. We used univariate logistic regression to develop a candidate RAP score consisting of: relative McGregor's Slope [RMGS = (MGS*1.5)/0.9], relative cervical lordosis [RCL=CL – Thoracic Kyphosis (TK)], Cervical Lordosis Distribution Index (CLDI = C2-Apex*100/C2-T2), relative pelvic version (RPV = SS – PI*0.59+9), and a frailty factor (greater than 0.3). RAP was scored between 0-13 and patients were categorized accordingly: ≤3 (Proportional), 4-6 (Moderately Disproportionate), >6 (Severely Disproportionate). Binary logistic regression assessed RAP Score development of distal junctional kyphosis (DJK), failure (DJF), reoperation, and outcomes by 2 years.

Results
105 operative CD patients were included (61.0 yrs, 69% F, mean levels fused: 8.1, CCI: 1.1). Assessment of three-month RAP score found a mean of 5.2/13 possible points. There were 24 (22.7%) patients were proportional, 52 (49.5%) moderately disproportionate, and 29 (27.8%) severely disproportionate. Regarding cohort outcomes, 34.5% developed DJK, 8.7% DJF, 20.0% underwent reoperation, and 55.7% achieved optimal outcome. The outcomes of each proportionality group are displayed in Table 2. Patients severely disproportioned in RAP Score had higher odds of DJK (OR: 6.0, 2.1-17.7, p=.001), DJF (OR: 9.7, 1.8-51.8, p=.008), and reoperation (OR: 6.0, 2.1-17.7, p=.001), and less odds of meeting the optimal outcome (OR: 0.3, 0.1-0.7, p=.007).

Conclusion
The regional alignment and proportion score is a method of analyzing the regional proportionality of the cervical spine in the context of global alignment that predicts radiographic complications, reoperations, and, ultimately, optimal clinical outcomes in cervical deformity patients receiving surgery. Therefore, it is important for the surgeon to focus optimizing upper cervical distribution to maintain horizontal gaze, while matching overall cervical to thoracolumbar alignment.

SCORING			SCORING
Horizontal Gaze Subgroups			
<-7.8	Upward Neck Tilt	+1	
-7.8 to 1	Neutral and Erect	+0	
1 to 16.2	Moderate Downward Tilt	+2	Total Score: 0-3
>16.2	Severe Downward Tilt	+3	**Proportioned**
Relative Cervical Lordosis			
<35	Moderately Malaligned	+3	
35-44	Mildly Malaligned	+2	
44-68	Aligned	+0	
> 68	Severely Malaligned	+1	
Cervical Lordosis Distribution Index			Total Score: 4-6
<40	Severely Hypolordotic	+3	**Moderately Disproportioned**
40 to 70	Mildly Hypolordotic	+1	
70 to 100	Aligned	+0	
>100	Hyperlordotic	+3	
Relative Pelvic Version			
<-15	Severe Retroversion	+3	
-15 to -7.1	Moderate Retroversion	+2	
-7 to 5	Aligned	+0	Total Score: ≥7
>5	Anteversion	+1	**Severely Disproportioned**
Age Subgroups			
mFI-CD < 0.33	Not Frail	+0	
mFI-CD ≥ 0.33	Frail	+1	

209. OUTCOMES OF MULTILEVEL ANTERIOR AND POSTERIOR APPROACHES TO THE CERVICOTHORACIC JUNCTION: A SINGLE CENTER'S EXPERIENCE ON WHETHER TO CROSS THE CERVICOTHORACIC JUNCTION

Daniel Coban, MD; Stuart Changoor, MD; Conor J. Dunn, MD; Michael Pompliano, MD; Kumar Sinha, MD; Ki S. Hwang, MD; Michael J. Faloon, MD; Arash Emami, MD; *Neil Patel, BS*

Hypothesis
Clinical and radiological outcomes will be similar between patients receiving multilevel cervical constructs that cross versus those that do not cross the cervicothoracic junction.

Design
Retrospective comparative study

Introduction
Long cervical fusion is commonly utilized to treat various pathologies of the cervical spine. In cases of multilevel disease where posterior-based constructs may necessitate crossing the CTJ, the literature is inconclusive as to whether surgeons should terminate in the lower cervical or in the upper thoracic spine. The purpose of this study is to report the 5-year minimum outcomes of a single-center retrospective cohort undergoing multilevel ACDF ending at C7, long posterior cervical fusion (PCF) ending at C7, and long PCF ending at T1 or T2.

Methods
A retrospective review was performed to identify all patients between 2005-2013 who underwent multilevel fusion to

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the CTJ. Patients were divided into three groups: 1) ACDF to C7, 2) PCF to C7, and 3) PCF to T1/T2.

Results

There were no significant differences regarding total operative time or length of hospital stay between groups (p= 0.885; p= 0.073). Groups 2 and 3 had a statistically higher blood loss than group 1 (p=0.001), and group 3 had a statistically higher blood loss than group 2 (p= 0.006). Radiographic analysis showed a statistically significant difference (p<0.001) in both early and late change in C2-C7 lordosis between the ACDF group and the PCF groups. Overall revision rates were 10.3%, 10.3%, and 11.0% (p = 0.788) for groups 1, 2, and 3, respectively. There were no significant differences in final patient outcome score or change in score between groups. The rate of pseudoarthrosis was 4.9% in Group 1, 2.6% in Group 2, and 8.2% in Group 3 (p= 0.198). ASD was noted in 1.9% of patients in Group 1, 2.6% of patients in Group 2 and 1.4% of patients in Group 3 (p= 0.251).

Conclusion

Our study demonstrates no statistically significant differences in the rate of reoperation, final/change in patient outcome score, rate of pseudarthrosis, or rate of ASD between cohorts in which the CTJ was instrumented or not instrumented. Anterior procedures ending at the CTJ demonstrated better restoration of lordosis than posterior procedures ending at the CTJ. Our study suggests similar clinical and radiographic outcomes, regardless of inclusion of the CTJ.

210. VARIATIONS IN THE NUMBER OF VERTEBRAE AMONG ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS: AN ANALYSIS OF 998 RADIOGRAPHS

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Hypothesis

There is a presence of variation in number of thoracic and lumbar vertebrae, lumbosacral transitional vertebrae (LSTV) and cervical ribs among adolescent idiopathic scoliosis (AIS) patients

Design

Retrospective

Introduction

There is high prevalence of wrong-level surgery performed by spine surgeons and one of the reasons is the presence of variation in the number of vertebrae. Inaccurate identification of appropriate vertebral levels is a common reason for wrong-level spine surgery. Hence, it is crucial to perform vertebral numbering accurately prior to surgery to reduce surgical error

Methods

998 patients diagnosed with AIS who underwent posterior spinal fusion (PSF) between 2015 to 2021 were retrospectively reviewed. Pre-operative or post-operative plain radiographs and computed tomography (CT) scans were reviewed for vertebral numbering and identification of LSTV and cervical ribs. Vertebral numbering starts from C2 vertebrae by identifying the odontoid process and continue caudally while LSTV was classified according to Castellvi classification

Results

Mean age, height, weight, body mass index, Cobb's angle were 16.11 years, 1.57cm, 46.30kg, 18.79kg/m2, 66.4o, respectively. Among 998 patients, total number of vertebrae were grouped into 3 groups, in which Group 1 [43 (4.3%)] had 23 vertebrae include 7C11T5L (31, 3.11%) and 7C12T4L (12, 1.2%). Group 2 [900 (90.2%)] had 24 vertebrae include 7C11T6L (56, 5.6%), 7C12T5L ((842, 84.37%) and 7C13T4L (2, 0.2%). Group 3 [55 (5.5%)] 25 vertebrae include 7C12T6L (48, 4.8%) and 7C13T5L (7, 0.7%). Prevalence of atypical total vertebrae apart from 7C12T5L was 156 patients (15.63%). Prevalence of cervical ribs and LSTV was 2 (0.2%) and 250 (25.05%). Furthermore, LSTV was 6.5 times likely to be present in 7C11T6L (OR=6.5,P=0.004) and 8.9 times in 7C12T6L (OR=8.9,P=0.001)

Conclusion

Prevalence of atypical vertebrae, cervical ribs and LSTV was 156 (15.63%), 2 (0.2%) and 250 (25.1%). LSTV was 6.5 times likely to be present in 7C11T6L and 8.9 times in 7C12T6L. Vertebral numbering should be calculated starting from C2 vertebrae and continue caudally to avoid missing cervical ribs

Table 1. Radiological results

Parameters	Total (n=998) [Mean ± SD or n(%)]
Radiological data	
Total number of vertebrae	
Group 1: 23	**43(4.3)**
- 7C11T5L	- 31(3.1)
- 7C12T4L	- 12(1.2)
Group 2: 24	**900(90.2)**
- 7C11T6L	- 56(5.6)
- 7C12T5L	- 842(84.4)
- 7C13T4L	- 2(0.2)
Group 3: 25	**55(5.5)**
- 7C12T6L	- 48(4.8)
- 7C13T5L	- 7(0.7)
LSTV	250(25.1)
Cervical Ribs	
- Yes	2(0.2)
- No	996(99.8)
Thoracic Vertebrae	
- 11	87(8.7)
- 12	902(90.4)
- 13	9(0.9)
Lumbar Vertebrae	
- 4	14(1.4)
- 5	880(88.2)
- 6	104(10.4)

Table 2. Multinomial Logistic Regression

Parameters		Exp (B) (95% CI)	P
Dependent Variables	**Independent Variables**		
- 7C11T6L	LSTV	6.530 (1.825, 23.360)	0.004
- 7C12T6L	LSTV	8.933 (2.463, 32.393)	0.001

Table 1: Radiological results. Table 2: Multinomial logistic regression

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E-POSTER ABSTRACTS

211. CLINICAL AND RADIOGRAPHIC OUTCOMES FOLLOWING CORRECTION OF IDIOPATHIC SCOLIOSIS IN ADOLESCENCE VS. ADULTHOOD

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Hypothesis
Adults undergoing surgical correction of idiopathic scoliosis will achieve worse postoperative coronal and sagittal plane correction than adolescents and will have more complications and a prolonged hospital course.

Design
Retrospective cohort study

Introduction
The natural history of adolescent idiopathic scoliosis (AIS) has been well documented, but the impact of age at the time of surgical correction is relatively understudied. In this study, we matched patients undergoing surgical correction of adult idiopathic scoliosis (AdIS) with a cohort of AIS patients to compare: 1) coronal and sagittal radiographic correction, 2) operative variables, and 3) postoperative complications.

Methods
A single-institution scoliosis registry was queried for patients undergoing idiopathic scoliosis surgery from 2000-2017. Inclusion criteria: patients with idiopathic scoliosis, no previous spine surgery, and 2-year follow-up. AdIS patients were matched 1:2 with AIS patients based on Lenke classification and curve characteristics. Independent sample t-test, Chi-square test, and univariate/multivariate regression was used to analyze the data.

Results
31 adults underwent surgical correction of idiopathic scoliosis and were matched with 62 adolescents. Mean age of adults was 26.2 ± 11.05, mean BMI was 25.6 ± 6.0, and 22 (71.0%) were female. Mean age of adolescents was 14.2 ± 1.8, mean BMI was 22.7 ± 5.7, and 41 (66.7%) were female. AdIS had significantly less postoperative major Cobb correction (63.9% vs 71.3%, p=0.006) and final major Cobb correction (60.6% vs. 67.9%, p=0.025). AdIS also had significantly greater postoperative T1PA (11.8 vs 5.8, p=0.002). AdIS had longer operative times (p=0.003), higher amounts of pRBCs transfused (p=0.005), longer LOS (p=0.016), more ICU requirement (p=0.013), higher overall complications (p<0.001), higher rate of pseudarthrosis (p=0.026), and more neurologic complications (p=0.013).

Conclusion
Adult patients undergoing surgical correction of idiopathic scoliosis had significantly worse postoperative coronal and sagittal alignment when compared with adolescent patients. Adult patients also had higher rates of complications, longer operative times, and longer hospital stays. The results of our study can be utilized when counseling patients and families regarding the optimal timing of surgical correction of idiopathic scoliosis.

	AdIS N=31	AIS N=62	P-value
Operative variables			
Total instrumented levels, mean ± SD	10.4 ± 2.2	10.5 ± 1.9	0.746
Total screws, mean ± SD	17.8 ± 3.9	17.7 ± 4.3	0.931
Screws/level, mean ± SD	1.7 ± 0.2	1.7 ± 0.3	0.662
PCO, mean ± SD	2.8 ± 3.0	3.4 ± 3.0	0.314
Operative time (min), mean ± SD	351.5 ± 129.4	277.4 ± 66.1	0.003*
Estimated blood loss (cc), mean ± SD	1056.0 ± 566.6	726.8 ± 391.2	0.005*
ICU requirement, n (%)	3 (9.7)	0 (0)	0.013*
Length of stay, mean ± SD (days)	4.6 ± 1.6	3.8 ± 1.1	0.016*
Follow-up period, mean ± SD (months)	49.9 ± 26.7	42.0 ± 18.3	0.149
Outcome variables			
Overall complications, n (%)	13 (41.9)	6 (9.7)	<0.001*
Pseudarthrosis, n (%)	5 (16.1)	2 (3.2)	0.026*
Hardware failure, n (%)	5 (16.1)	2 (3.2)	0.026*
Infection, n (%)	5 (16.1)	3 (4.8)	0.067
Neurologic complication, n (%)	3 (9.7)	0 (0)	0.013*
Readmission, n (%)	13 (41.9)	6 (9.7)	<0.001*
Reoperation, n (%)	13 (41.9)	6 (9.7)	<0.001*
Transfusion, n (%)	11 (35.5)	13 (21.0)	0.132
Number of PRBC units, mean ± SD	0.9 ± 1.4	0.3 ± 0.6	0.005*

Operative and outcome variables for AdIS and AIS patients

212. THE DEFORMITY ANGULAR RATIO: CAN THREE-DIMENSIONAL CT IMPROVE PREDICTION OF INTRAOPERATIVE NEUROMONITORING EVENTS?

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Hypothesis
A novel deformity angular ratio (DAR) calculated using preoperative 3D CT is more accurate than total DAR (T-DAR) radiographic measurements when predicting IONM events during vertebral column resection (VCR).

Design
Prospectively collected cohort

Introduction
VCRs are complex surgical procedures reserved for severe, angular deformities. Given the significant destabilization and subsequent correction inherent to this procedure, high rates of neurological complications have been observed. The DAR, which was originally described as a measurement on plain radiographs, has been shown to enhance a surgeon's ability to preoperatively predict intraoperative neuromonitoring (IONM) events. However, measurements of complex spine deformities can be challenging when restricted to two planes.

Methods
Consecutive, unique patients undergoing thoracic VCR by a single center from 2015 to 2021 were identified. The DAR was calculated by dividing the total radiographic Cobb angle by the number of vertebral segments the angle subtends. 3D CT DAR was calculated for each patient from a preoperative CT scan by finding the maximum angle subtended by three contiguous vertebral segments

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and dividing by three (Figure 1). All patients were further assessed for any positive IONM event. A binary threshold of 25 was used for both T-DAR and 3D CT DAR measurements for predictive analysis. $p < 0.05$ indicated significance.

Results
We identified 68 patients with a mean age of 28 years. Mean levels fused was 15. Twenty-one patients (31%) had IONM events. In patients, with and without an IONM event, mean T-DAR was 26.6 ± 9.8 and 21.5 ± 8.8 ($p = 0.04$), respectively. Similar 3D CT DAR mean values were 26.4 ± 10.8 and 18.4 ± 5.6, respectively ($p < 0.001$). 3D CT DAR accurately classified 81% of patients with a positive predictive value (PPV) of 75%. In comparison, T-DAR accurately classified 60% of patients with a PPV of 39%.

Conclusion
This is the first study to show that 3D CT substantially improves preoperative intraoperative neuromonitoring (IONM) event prediction when compared to traditional radiographic measurements. A 3D CT DAR of 25 or greater was correlated with an increased rate of IONM events.

Standing AP (A) and lateral (B) scoliosis radiographs of an 11-year-old male who underwent T8-9 VCR and instrumented fusion from T1 to the ilium. His coronal and sagittal Cobb angles subtend 5 vertebral segments and his T-DAR is 37.1. His three-dimensional reconstruction (C) demonstrates a 3D CT DAR of 44.7. This patient had intraoperative loss of signals.

213. PREDICTION OF THE OPTIMAL UPPER INSTRUMENTED VERTEBRA (UIV) TILT ANGLE BASED ON THE PRE-OPERATIVE ERECT RADIOGRAPHS FOR LENKE 1 AND 2 ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS

Chris Yin Wei Chan, MSOrth; Tian Fu Chin, MBBS; Weng Hong Chung, MSOrth; Chee Kidd Chiu, MSOrth; Mun Keong Kwan, MSOrth

Hypothesis
We hypothesize that the Optimal UIV Tilt Angle can be predicted from the pre-operative erect radiographs

Design
Retrospective

Introduction
The Optimal UIV Tilt Angle had been shown to correlate with post-operative medial shoulder and neck balance. This parameter was derived from the supervised supine side bending films that required the physician's direct supervision and exposed the patient to additional radiation/cost

Methods
The post-operative UIV tilt angle (at final follow up) that was measured in 133 Lenke 1 & 2 AIS patients who underwent posterior spinal fusion (PSF) surgery and had good radiological medial shoulder balance (T1 tilt measurement between -3 and +3) was considered the Optimal UIV Tilt Angle. Patients with medial shoulder imbalance, distal adding-on, coronal imbalance or lumbar decompensation were excluded. All patients had a minimum follow up duration of 2 years. Pre-operative parameters such as clavicle angle, cervical axis, coronal balance, T1 tilt angle, UIV tilt angle, UIV level, Cobb angle, side-bending Cobb angle and flexibility rate were included as predictive factors. Parameters with $p<0.25$ from univariate linear regression were included in multivariate linear regression. Independent predictive factors with $p<0.05$ from multivariate analysis were used to formulate regression formula for the Optimal UIV Tilt Angle

Results
The study population comprised of 118(88.7%) female, 15(11.3%) male patients, 99 Lenke 1 patients(74.4%) and 34 Lenke 2 patients(25.6%), respectively. The mean follow-up duration was 3.2±0.7 years. From the multivariate regression analysis, the significant predictors from the pre-operative erect radiograph were pre-operative UIV tilt angle(β=0.396,P<0.001) and pre-operative T1 tilt angle(β=-0.349,P<0.001). A regression formula with an R2 value of 0.583 was derived. The regression formula for Optimal UIV Tilt Angle was [(0.396 x pre-operative UIV tilt angle)–(0.349 x pre-operative T1 tilt angle)–0.871]

Conclusion
Preoperative UIV tilt angle and preoperative T1 tilt were significant predictors for Optimal UIV Tilt Angle. The Optimal UIV Tilt Angle can be predicted with the formula: [(0.396 x pre-operative UIV tilt angle)–(0.349 x pre-operative T1 tilt angle)–0.871] and had a R2 value of 0.583

Table 1: Pre-operative Parameters, Univariate and Multivariate Linear Regression Analysis of Factors affecting Post-operative UIV tilt angle

Parameters	Overall(n=133) [Mean±SD or n(%)]	Univariate Analysis		Multivariate Analysis	
		B(95%CI)	P	B(95%CI)	P
Pre-operative Parameters					
Clavicle Angle	-1.3±2.8	0.28(0.010,0.46)	0.003		
Cervical Axis	1.9±3.7	0.22(0.08,0.36)	0.003		
Coronal Balance	13.1±15.6	0.02(-0.02,0.95)	0.329		
T1 tilt angle	-0.7±5.5	0.27(0.19,0.36)	0.000*	-0.349(-0.485, -0.212)	0.000
UIV angle	-8.4±9.8	0.22(0.18,0.26)	0.000*	0.396(0.320,0.472)	0.000
Sagittal Cobb Angle	21.7±11.6	0.04(-0.01,0.09)	0.084		
Cobb Angle(MT)	66.8±17.5	0.04(0.01,0.07)	0.004		
Cobb Angle(UT)	32.3±12.9	0.12(0.08,0.16)	0.000		
Side Bending Cobb Angle(MT)	29.6±17.3	0.03(-0.00,0.06)	0.063		
Side Bending Cobb Angle(UT)	18.1±11.0	0.11(0.07,0.16)	0.000		
Flexibility(MT)	58.1±17.7	-0.02(-0.05,0.01)	0.258		
Flexibility(UT)	45.8±20.4	-0.01(-0.04,0.02)	0.444		
UIV Level					
T2	52(39.1)	3.18(2.24,4.12)	0.000		
T3	56(42.1)	-2.43(-3.42,-1.45)	0.000		
T4	18(13.5)	Reference	Reference		
T5	5(3.8)	1.00(-1.78,3.79)	0.477		
T6	1(0.8)	-0.03(-6.17,6.10)	0.991		
T7	1(0.8)	-2.05(-8.18,4.08)	0.509		
R2: 0.583					
Optimal post-operative UIV tilt angle = (0.396 x Pre-operative UIV Tilt Angle) – (0.349 x Pre-operative T1 tilt Angle) – 0.871					

Preoperative parameters and analysis of factors affecting postoperative UIV tilt angle

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E-POSTER ABSTRACTS

214. DOUBLE MAJOR CURVATURE TREATED WITH VERTEBRAL BODY TETHERING OF BOTH CURVES: HOW DO OUTCOMES COMPARE TO POSTERIOR SPINAL FUSION?

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Hypothesis
PSF is associated with better curve correction than VBT but comparable rates of curvatures <35° at 2 year FU.

Design
Retrospective review of consecutive matched PSF and VBT cases in a multi-center registry.

Introduction
VBT is a non-fusion motion sparing alternative to PSF, the current gold standard surgical treatment for AIS. There have been few reports with small numbers of patients on VBT of two curves from bilateral approaches. We aim to compare the radiographic outcomes between VBT and PSF in patients with double curvatures in which both curves have been instrumented in the index surgery.

Methods
31 consecutive patients with AIS were matched by Lenke curve type, age (± 2 years), major Cobb (± 7), and T5-T12 kyphosis (± 10). Continuous variables were compared using Wilcoxon Rank Sum tests and student t-tests. Categorical variables were compared using Chi-Square.

Results
Group baseline demographics were similar (Table). There was > EBL (VBT 234.2±152.0 vs PSF 616.4±358.2; p<0.0001), levels instrumented (VBT 10.8±0.7 vs PSF 12.0±1.0; <0.0001) and cell saver returned (VBT 76.3±115.9 vs PSF 207.1±159.0; p<0.0001) in PSF and > operative time in VBT (VBT 377.2±169.4 vs PSF 266.6±79.1 min; p=0.0044). Major T curve types (Lenke 1, 3, 4) had significantly better major (VBT 51.5±7.9° to 31.6±12.0° [40%] vs PSF 53.2±5.7° to 15.8±6.4° [70%]; p<0.0001) and secondary curve correction in the PSF group. 71% of VBT patients had a major Cobb ≤ 35° as compared to 100% in PSF (p=0.0445). Major TL curve types (Lenke 5, 6) experienced comparable major (VBT 50.4±8.1° to 19.1±10.9° (62%) vs PSF 51.4±6.1° to 23.4±10.1° (55%); p=0.2815) and secondary curve correction. 93% of VBT patients had a major Cobb ≤ 35° as compared to 86% in the PSF group (p<0.999). There was no difference between groups in T5-12 kyphosis and lumbar lordosis at any time point for any curve type. There were 5 patients (16%) with major complications in the VBT group compared to 2 (6%) in the PSF group. In VBT group, 1 patient converted to PSF, 1 was pending PSF.

Conclusion
Patients with double major AIS who underwent VBT with major T curve types had less correction than PSF of both major and secondary curves; however, those with major TL curves experienced similar radiographic outcomes regardless of procedure. More complications were seen in VBT patients.

		VBT	PSF	P Values
Age		13.1±1.7	13.4±1.5	0.575
Sex (F)		29 (94%)	27 (87%)	0.6713
Sanders 1|2|3|5|6|7		1 | 1 | 9 | 4 | 3 | 1 *	-	-
Risser 0|1|2|3|4		8 | 4 | 6 | 10 | 3	2 | 2 | 7 | 9 |11	0.0619
Lenke 1|3|4|5|6		8 | 8 | 1 | 6 | 8		-
Mean FU		24.1±2.2	25.5±4.3	0.2394
Entire Cohort				
Major Cobb (°)	Pre	51.0±7.9	52.4±5.9	0.4452
	2 YR	25.9±13.0 (49.6±21.6%)	19.2±9.0 (63.5±15.7%)	**0.0216 (0.0053)**
Major Thoracic Curves (N=17)				
Major Cobb (°)	Pre	51.5±7.9	53.2±5.7	0.4919
	2 YR	31.6±12.0 (39.9±16.8%)	15.8±6.4 (70.4±11.3%)	**<0.0001 (<0.0001)**
Minor Cobb (°)	Pre	45.8±8.3	43.5±9.9	0.4691
	2 YR	25.3±10.0 (45.8±15.8%)	15.6±6.8 (62.5±18.7%)	**0.0084 (0.0095)**
3-D T5-T12 Kyphosis (°)	Pre	10.3±13.7	10.4±13.1	0.9891
	2 YR	24.4±12.5	29.2±6.6	0.1771
Lumbar Lordosis (°)	Pre	-58.1±18.9	-60.3±16.0	0.8147
	2 YR	-59.9±13.2	-62.9±12.0	0.5209
Major Thoracolumbar Curves (N=14)				
Major Cobb (°)	Pre	50.4±8.1	51.4±6.1	0.7145
	2 YR	19.1±10.9 (61.5±21.2%)	23.4±10.1 (55.1±16.6%)	0.2815 (0.3831)
Minor Cobb (°)	Pre	46.1±8.4	41.1±10.6	0.1787
	2 YR	20.6±9.5 (55.5±18.6%)	19.2±10.3 (53.6±20.2%)	0.7122 (0.9817)
T5-T12 Kyphosis (°)	Pre	18.7±12.3	17.3±12.0	0.766
	2 YR	21.7±13.5	22.6±8.7	0.837
Lumbar Lordosis (°)	Pre	-61.3±8.7	-58.1±14.3	0.4983
	2 YR	-58.7±12.1	-66.5±13.8	0.1397
Major Complications by Patient				
Overall		5 (16%)	2 (6%)	0.4248
	Reoperation	3 (10%)	2 (6%)	-
	Readmission	1 (3%)	-	-
	Pulmonary	1 (3%)	-	-

*12 patients missing Sanders score

Table. Radiographic outcomes between VBT and PSF groups

215. COMPARISON OF LONG-TERM OUTCOMES BETWEEN THORACIC FUSION WITH AND WITHOUT EXTENDED LUMBAR FUSION FOR PATIENTS WITH MODERATE LUMBAR MODIFIER C CURVES IN ADOLESCENT IDIOPATHIC SCOLIOSIS LENKE 1–3

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Hypothesis
Lenke type 1–3C curves of 40~55° can be treated with selective thoracic fusion to achieve good long-term postop. results.

Design
Retrospective cohort study

Introduction
In patients with AIS Lenke 1–3 and lumbar curves of 40~55°, the question of whether selective thoracic fusion should be chosen to preserve more mobile segments in the lumbar spine or if fusion should be extended down to the L3 to correct not only thoracic curves but also lumbar curves remains controversial. The study aim was to compare the outcomes of selective thoracic fusion (STF) and fusion extended (nonselective) to the lumbar spine (NSF) in those patients.

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Methods
The inclusion criteria were 1) AIS Lenke type 1–3, 2) lumbar modifier C, 3) lumbar curve between 40° and 55°, and 4) treated surgically. Of 61 consecutive patients treated at a single institution, 52 were followed up by performing examinations at postop. 10 years. The patients were divided into two groups according to the location of distal fusion segments: the STF group (LIV of T12 and L1), and the NSF group (LIV of L3).

Results
There were 26 patients each in the STF and NSF groups. There were no significant differences in age at op., Lenke type and preop. magnitude of MT curve and TL/L curve between the groups. Preop. TL/L AVT, AVT (MT:TL/L) ratio, L4 tilt, and TL/L curve flexibility were significantly greater in the NSF group than in the STF group. At 10 years postoperatively, the TL/L curve magnitude, L4 tilt, and coronal balance were significantly corrected in the NSF group. ROM of the unfused segments was significantly greater in the NSF group. The incidence of lumbar DD at postop. 10 years was significantly lower in the STF group (35%) than in the NSF group (58%). The SRS-30 domains of self-image, satisfaction, and total score at postop. 10 years were significantly higher in the STF group.

Conclusion
STF for AIS Lenke 1–3C with a moderate lumbar curve, which preserved the mobile segment, had a lower rate of DD of the unfused lumbar segments at postop. 10 years despite larger lumbar residual curvatures, and better SRS scores than that for correction by fusion extended down to the lumbar curvatures. Further long-term follow-up assessment is needed to determine the effects of residual lumbar curve and coronal shift.

		STF (26)	NSF (26)	P value
MT Curve	Preop.	57.7°	58.3°	0.99
	PO10y	21.1°	19.9°	0.47
TL/L Curve	Preop.	45.5°	47.0°	0.18
	PO10y	20.0°	14.2°	0.001
L4 tilt (°)	Preop.	14.4°	17.8°	0.03
	PO10y	8.8°	6.5°	0.02
Coronal Balance	Preop.	11.1mm	12.9mm	0.75
	PO10y	10.5mm	4.0mm	0.001
TL/L AVT	Preop.	20.3mm	30.4mm	0.001
	PO10y	15.0mm	11.7mm	0.14
AVT(MT:TL/L) ratio	Preop.	2.2	1.6	0.004
	PO10y	0.9	1.8	0.13
Preop. TL/L curve	bending	14.1°	18.0°	0.03
	Flexibility	69.4%	59.8%	0.03
L3-S ROM	Sum.	21.1°	33.9°	0.02
	Avg.	7.0°	11.3°	0.02
SRS-30 at PO 10y	Self Image	3.5	3.2	0.01
	Satisfaction	4.1	3.7	0.04
	Total	4.1	3.7	0.02
Disc Degeneration at PO10y	L3/4	4% (1/26)	12% (3/26)	
	L4/5	0% (0/26)	27% (7/26)	
	L5/S	31% (7/26)	42% (11/26)	
	Total	35% (9/26)	58% (15/26)	

Comparison between STF and NSF

216. THE EFFECTS OF ANTERIOR SPINAL FUSION ON THORACIC MORPHOLOGY AND PULMONARY FUNCTION IN PRIMARY THORACIC ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

Marcus Malmqvist, MD; Ludvig Vavruch, MD, PhD; Tom P. Schlösser, MD, PhD

Hypothesis
Anterior spinal fusion (ASF) for AIS normalizes thoracic morphology and this predicts long-term pulmonary function.

Design
Retrospective cohort study.

Introduction
Chest deformation is associated with ventilatory dysfunction and patient dissatisfaction in preoperative AIS. This study aims to investigate the changes in spinal and chest morphology before and after ASF in relation to pulmonary function.

Methods
Pre- and postoperative radiographs, low-dose thoracic CT and pulmonary function tests (PFTs) of 25 patients who

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underwent ASF for Lenke 1 type AIS with a minimum 2-year follow-up were collected. Pre- and postoperative CT and pre-operative PFT's were part of the standard protocol. In addition, at a mean of six years follow-up PFT's were repeated. CT based parameters included axial rotation (AR), thoracic rotation (TR), hemithoracic-width ratio (HWr), rib-hump index (RHi), spinal penetration index (SPi), endo-thoracic hump ratio (EHr) and were semi-automatically measured.

Results

Thoracic Cobb angles improved from 57° to 30°, lumbar from 39° to 24°, T4-T12 kyphosis from 29° to 37° and axial rotation from 15° to 10°(p<0,01). HWr improved from 0,52 to 0,67 (p<0,01) and RHi from 0,29 to 0,20 (p=0,01), SPi and EHr remained unchanged (0,14, p=0,79; 0,80 to 0,77, p=0,10). %FEV1 and %FVC showed no changes from pre-operative to final follow up (Table). Pre- and postoperative thoracic Cobb angles were related to pre- and postoperative HWr (r=-0,76; r=-0,74, p=<0,01) but not Rhi, SPi or EHr. Pre- and postoperative T4-T12 kyphosis was associated with pre- and postoperative SPi (r=-0,56 p=0,04; r=-0,45 p=0,02). %FEV1 and %FVC at 6-year follow-up did not correlate to postoperative curve severity, however, %FVC strongly correlate with postoperative AR (r=-0,72 p=0,03), RHi and SPi (r=-0,73 p=0,03 and -0,73 p=0,03).

Conclusion

ASF corrects the spinal deformity in all 3 planes, decreases the rib-hump and improves the thoracic rotation and hemi-thoracic width. The penetration of the spine into the chest (SPi and EHr) and pulmonary function at a mean of 6 years follow-up remained unchanged. While spinal parameters were unpredictive of postoperative pulmonary function at a mean of 6 years follow-up, CT-based chest parameters that represent the size of the rib hump and spinal penetration into the chest at the level of the apex, were.

Population data	Gender	Age	Thoracic apex	Upper instrumented vertebra	Lower instrumented vertebra
	4/21	15,9 ± 2,8	T8(n=10) T9 (n=8) T10(n=4) T7 (n=3)	T5 (n=12) T6 (n=10) T7 (n=2) T4 (n=1)	T12 (n=13) T11 (n=8) L1 (n=3) T10 (n=1)
Radiograph measurements	**Thoracic cobb**	**Lumbar cobb**	**T4-T12 kyphosis**	**L1-S1 Lordosis**	
Pre-operative	57 ± 9	39 ± 8	29 ± 11	55 ± 9	
Post-operative	29 ± 8	24 ± 8	37 ± 15	55 ± 10	
2-year follow-up	30 ± 7	23 ± 8			
CT measurements	**HWr**	**Rhi**	**Pre-op SPi**	**Ehr**	**TR**
Pre-operative	0,53 ± 0,08	0,29 ± 0,19	0,14 ± 0,03	0,80 ± 0,19	32,9 ± 6,78
Post-operative	0,68 ± 0,08	0,21 ± 0,18	0,14 ± 0,03	0,77 ± 0,15	20,8 ± 5,7
PFT's	**FVC**	**FVC**	**FEV1**		
Pre-operative	78 ± 14		71 ± 10		
Post-operative	73 ± 12		72 ± 8		

Table of descriptive data and statistical analysis.

217. WHICH LEVELS SHOULD YOU INSTRUMENT IN LENKE 1AR VS 1AL VBT CASES?

Michelle C. Welborn, MD; A. Noelle Larson, MD; Laurel C. Blakemore, MD; John T. Smith, MD; Firoz Miyanji, MD; Joshua M. Pahys, MD; Stefan Parent, MD, PhD; Ron El-Hawary, MD; Pediatric Spine Study Group

Hypothesis

We hypothesized that Lenke 1AR curves treated with AVBT would have a higher rate of adding on than Lenke 1AL curves

Design

Retrospective review of prospective multicenter database from a large pediatric spine registry

Introduction

Although VBT is growing in use, reoperation rates remain high occurring in 16-44% of pts in part due to adding on and lumbar curve progression. When treated with thoracic fusion, Lenke 1AR cases were 2x more likely to add on overall but 6.7x more likely to add on with poor level selection. Thus, better understanding of level selection in VBT for Lenke 1AR curves may help guide surgeons minimizing adding on and reoperation

Methods

251 pts were treated with VBT. Inclusion criteria were Lenke 1A curves patterns and 2 yr minimum follow-up. 43 pts met criteria, 20 1AL and 23 1AR. A successful result was defined as curve at latest follow-up <35 degrees, coronal balance within 2cm of the CSVL and no reoperations. Outcomes based on level selection were compared

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between pts with Lenke 1AR vs. 1AL curve patterns. Digital radiographic software was used to assess Cobb angle, coronal alignment on preop, postop and subsequent follow-up radiographs. Coronal alignment was assessed by measuring the distance from the CSVL to the midpoint of the LIV, curve apex and C7

Results
17/20 Lenke 1AL pts had a successful result (85%) vs. 15/23 Lenke 1AR pts (65%, p=0.13). There was one reoperation in each group. The Lenke 1AL pt was instrumented to LEV+1, all remaining 1AL pts were instrumented to LEV (p=0.04). The Lenke 1AR pt was due to insufficient correction and this pt was instrumented to the LEV. 8 1AR pts did not meet the criteria for success, 6/8 were coronally decompensated, this did not correlate with the LIV as 1/8 was instrumented to LEV-1 (vs 3 pts instrumented to LEV-1 had a successful result) and none were instrumented to LEV+1. Success in the Lenke 1AR group was associated with % correction of the thoracic spine, with 47% correction in the successful group vs. 36% in the unsuccessful group (p=0.02) and thoracic Cobb at 1st erect 26 vs. 36 degrees

Conclusion
Instrumentation to LEV rather than LEV+1 was associated with success for Lenke 1AL curve patterns. There was no association with LEV and success in Lenke 1AR curve patterns; however, intraoperative correction on 1st erect imaging was associated with surgical success in the Lenke 1AR group. There were equivalent revision rates, but more decompensation in the 1AR group

	Lenke 1AL (20)	Lenke 1AR (23)	P-Value
Age	13.7 years (11 to 17)	12.8 (9.8 to 14.5)	0.04
Preop Curve (Thoracic)	46 (35-67)	51 (32-79)	0.04
Preop Curve (Lumbar)	31 (22-44)	31 (22-42)	0.85
% Curve Correction Thoracic	47% (8-80)	43% (19-65)	0.43
Best Curve Correction (Thoracic)	19 (7 to 29)	19 (-34-53)	0.8
Latest F/up (Thoracic)	24 (9-56)	24 (-34 – 66)	0.91
Latest F/up (Lumbar)	18 (1-33)	19 (4-35)	0.72
Latest F/up Alignment at LIV	8 mm (-13-27)	15 mm (-11 to 47)	0.15
LIV	LEV: 19 LEV+1: 1	LEV: 19 LEV – 1: 4	
Success	17	15	0.14

218. RACIAL DEMOGRAPHICS OF A PEDIATRIC SPINE REGISTRY AND IMPACT ON FOLLOW-UP

Bharadwaj Jilakara, BA; Michelle Claire Marks, PT; Nicholas D. Fletcher, MD; Peter O. Newton, MD; A. Noelle Larson, MD; Harms Study Group

Hypothesis
Racial distribution of patients enrolled in a multicenter scoliosis registry would be reflective of the general U.S. population and there would be no association between race/ethnicity, pre-operative parameters, and loss to follow-up.

Design
Retrospective review of prospectively collected data.

Introduction
A recent emphasis in medical research is to ensure that diverse racial and ethnic groups are reflected in studies. There is limited data regarding whether the racial distribution of a large multicenter scoliosis registry is reflective of the US population. Potential healthcare barriers could affect the diversity of enrollments in prospective registries and completion of follow-up (FU), presuming that the prevalence of adolescent idiopathic scoliosis (AIS) is similar among US racial/ethnic groups.

Methods
Racial/ethnic distribution, preoperative parameters, 2-year FU rates were evaluated for prospectively enrolled AIS patients undergoing spinal fusion in a multicenter North American registry at US sites. The race/ethnicity of 2816 patients aged 10-24 were compared to granular 2010-2018 US Census data for similar age groups.

Results
65% (n=1466) of 2249 AIS patients enrolled between 2010-2018 were white. 75%(n=1698) of patients achieved 2-year FU with 66.5%(n=1121) reporting white racial background, while constituting 52.5% of the 2010-2018 U.S. pediatric population. Asian, White and Hispanic patients had statistically significant higher 2-year FU rates, at 78%(n=69), 76%(n = 1109), 75%(n=203), respectively (p<0.02). Only 67% of Black patients and 1 of 3 Native Americans reached 2-year FU. Native American and Black patients had the highest BMIs at 23 and 22, (p<0.001). Native American and Black patients had the highest average pre-op thoracic Cobb angle of 65(p<0.001) and 54(p=0.01), respectively. Pre-op ages of Black (14.6 y.), Hispanic(14.7 y.) and Native American(14.0 y.) patients were statistically lower than White(15.1 y.) and Asian(15.1, p<0.001).

Conclusion
This registry recruited a diverse group of patients with high 2-year follow-up rates. Compared to US Census data, Hispanics and Native American patients were under-represented. Lower rates of 2-year follow-up rates were noted in Black patients. Ongoing investigation of racial and other social determinants on surgical outcomes are needed to understand differences in study enrollment and retention among racial and ethnic groups.

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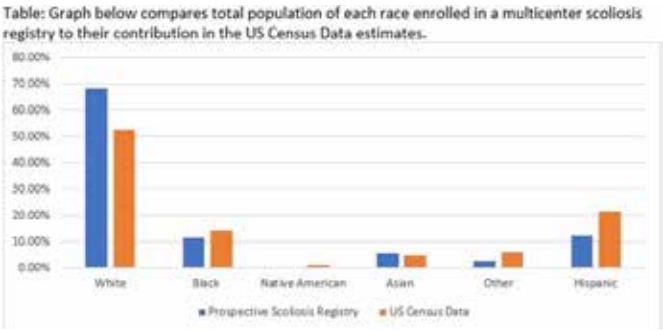


219. PRE-OPERATIVE CARBOHYDRATE DRINK FOR EARLY RECOVERY IN PEDIATRIC SPINE FUSION: RANDOMIZED CONTROL TRIAL†

Jennifer M. Bauer, MD; Kathryn B. Anderson, BS; Eliot B. Grigg, MD

Hypothesis
A pre-operative carbohydrate drink is safe in pediatric spine fusion patients and improves time to return of bowel function and comfort.

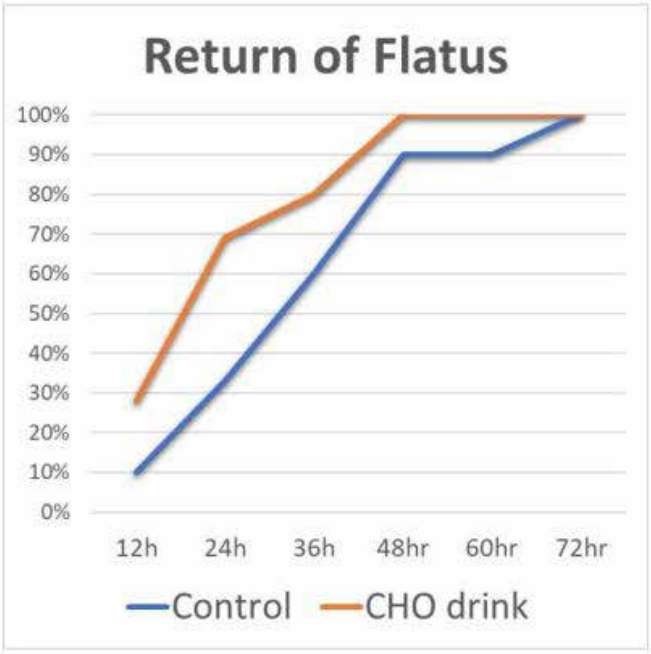
Design
Blinded randomized control trial

Introduction
As rapid discharge protocols for pediatric spine fusion shorten stays, gastrointestinal (GI) limitations including constipation, emesis, and paralytic ileus are uncovered and cause delays in discharge or readmission. A pre-operative carbohydrate drink has been shown to improve perioperative GI symptoms and function return in some patients, but has not been examined in pediatric nor spine patients.

Methods
We prospectively blindly randomized ASA 1+2 pediatric spine fusion patients >7yr to either pre-anesthesia carbohydrate drink 2h prior to surgery, or to a control group of standard 8h NPO. We documented time to return of flatus and first bowel movement, as well as GI symptoms such as emesis events or extra GI treatment such as suppository. We also collected comfort scores pre-operatively and twice daily for 72h post-op or until discharge, and standard spine surgery related variables, morphine equivalents, and patient reported outcomes.

Results
14 patients were randomized to the control group and 20 to the carbohydrate drink. There was no significant difference between the groups in total anesthesia duration; the drink group averaged 1.9 less levels fused (p=0.38) and 72cc less EVL (p=0.13). There were no perioperative aspiration or other anesthetic complications related to ingestion of preoperative drink. The group that received the drink had earlier return of flatus, with 69% vs 33% return at 24hr (p=0.04), and 100% by 48hr vs 100% by 72hr. There was no difference in return of bowel movement prior to discharge (15% drink vs 14% control, p=0.9). Pre-op and 12h post-op comfort scores were no different, but the drink group reported less nausea on a 0-100 scale at 24hr (p=0.03), and less anxiety at 24 (p=0.001) and 36hr (p=0.017).

Conclusion
Pre-operative carbohydrate drink is safe in pediatric spinal fusion patients and in our pilot study significantly improved time to return of flatus, as well as resulted in at least a positive trend in post-operative comfort measures.



220. DATA MINING FOR PREDICTING MECHANICAL COMPLICATIONS IN POSTOPERATIVELY WELL-ALIGNED ADULT SPINAL DEFORMITY PATIENTS USING XGBOOST MODELLING*

Baris Balaban; Caglar Yilgor, MD; Altug Yucekul, MD; Tais Zulemyan, MSc; Ugur Sezerman, PhD; Javier Pizones, MD, PhD; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; European Spine Study Group

Hypothesis
Factors not related to alignment also play a role in mechanical complication prediction

Design
Retrospective analysis of prospectively collected data

Introduction
Effect of sagittal alignment on complications is well established. Yet, demographic and technical factors also play an important role. Survival analyses have shown that ~20% of patients having a proportioned spinopelvic shape and alignment will experience mechanical complications. Aims were to detect such factors and to determine thresholds for each.

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Methods
Patients with ≥4-levels fusion and ≥2years f-up having a postop GAP Score of 0, 1 or 2 were included. XgBoost Trees with binary logistic objective were built using 75%-25% train-test sampling. Multiplication was used to test combined effects of parameters. 5 times 3-fold repeated cross-validation was used for parameter tuning. Rough grid search was followed by feature selection using expert-guided machine learning principles. Maximum tree count was set to 6, with a maximum depth of 3 where each leaf cannot have <10 patients following cross-validation. The key metric for model selection was F-score. Performance metrics were area under the ROC curve, sensitivity, specificity and precision. Importance matrix was built to stratify the significant factors. Patients satisfying all thresholds in both ends were used to calculate their cumulative effect.

Results
244 patients (200F, 44M, 44±19 yrs) with a mean f-up of 41 (24-101) months were included. 42 (17%) patients experienced a mechanical complication. 5 trees with a total of 22 leaves were built. In the test set, accuracy, sensitivity and specificity were 0.72, 0.80 and 0.71, respectively; while precision was 0.35. Five parameters, in order of importance, that drive mechanical complications in well-aligned patients were identified to have these thresholds: 1) LIV: pelvis vs sacrum and above; 2) BMI: 23; 3) age: 50 years, 4) Coronal malalignment: 2 cm and 5) pre-op ODI walking: 0-1 vs 2-5. The cumulative effect of having all 5 parameters above these thresholds was 10-folds increase in complication rates.

Conclusion
Approximately one fifth of sagittally well-aligned patients will suffer from mechanical complications. Technical factors such as pelvic fixation and post-op coronal malalignment, and demographic factors such as age, BMI and pre-op walking ability can stratify the complication risk within this group.

221. THE POSTERIOR CRANIAL VERTICAL LINE (PCVL): A NOVEL RADIOGRAPHIC MARKER FOR CLASSIFYING GLOBAL SAGITTAL ALIGNMENT

Paul J. Park, MD; Cole Morrissette, MS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Meghan Cerpa, MPH; Han Jo Kim, MD; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD

Hypothesis
We propose a novel radiographic marker, the Posterior Cranial Vertical Line (PCVL), to help quantify global sagittal alignment based on the PCVL distance to the thoracic apex and posterior sacrum.

Design
Multi-center retrospective review of prospectively collected radiographic data on asymptomatic adult volunteers.

Introduction
The use of sagittal vertical axis (SVA) for assessing global sagittal spinal alignment excludes critical factors such as skull position and its relative position to the lower extremities. We define a novel radiographic measurement, the PCVL, in an asymptomatic adult population to better understand global sagittal alignment.

Methods
Standing, full-length radiographs were reviewed among asymptomatic adult volunteers age 20-79. The PCVL is a vertical line drawn from the posterior-most aspect of the occiput to the floor. The distances of the PCVL to the thoracic apex (TA), posterior sagittal vertical line (PSVL, posterosuperior endplate of S1), femoral head center, and tibial plafond were measured. Classification was either grade 1 (PCVL posterior to TA and PSVL), grade 2 (PCVL anterior to TA and posterior to PSVL), or grade 3 (PCVL anterior to TA and PSVL).

Results
334 asymptomatic pts were evaluated with a mean age of 41yrs. 83% of subjects were PCVL grade 1, 15% were grade 2, and 3% were grade 3. Increasing PCVL grade was significantly associated with increased age ($p<0.0001$), C7-S1 SVA ($p<0.0001$), C2-C7 SVA ($p<0.0001$). Additionally, it was associated with decreased SS ($p=0.045$), increased PT ($p=0.0001$), increased PI-LL mismatch ($p=0.0001$), and increased knee flexion ($p<0.0001$).

Conclusion
Increasing PCVL grade was significantly associated with expected changes and compensatory mechanisms in the aging population such as decreased SS, increased PT, increased PI-LL mismatch and increased knee flexion. It corresponds with the current gold standard C7-S1 SVA, but importantly incorporates cervical alignment parameters such as C2-C7 SVA. The PCVL defines global sagittal alignment in adult volunteers and naturally distributes into 3 grades, with only 3% being grade 3 where the PCVL lies anterior to the TA and PSVL.

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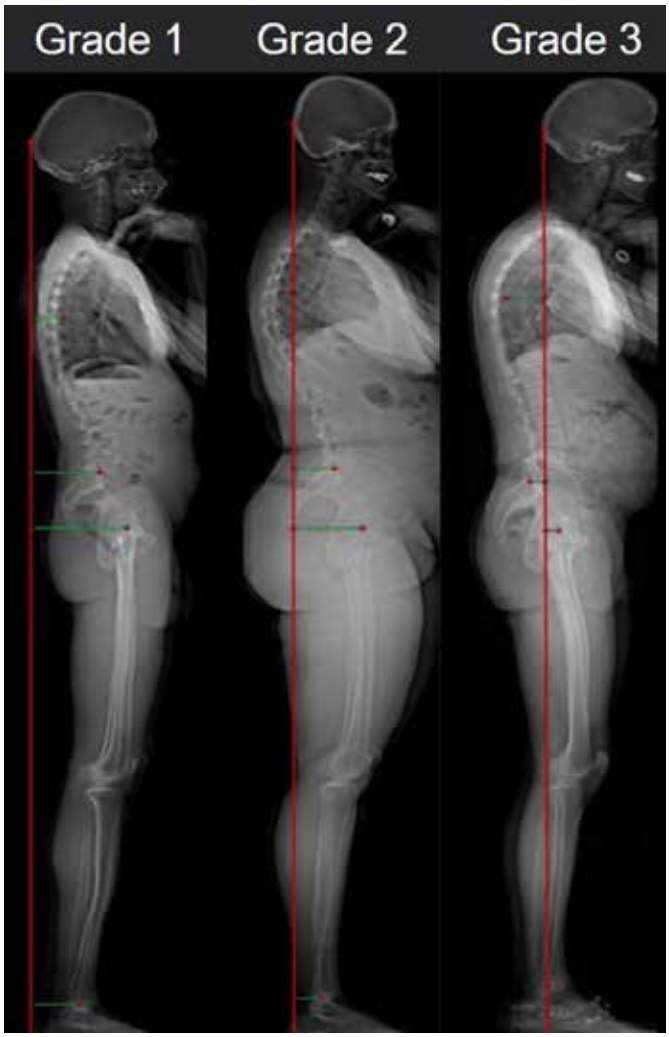

PCVL (A) Grade 1: PCVL posterior to TA and PSVL, (B) Grade 2: PCVL anterior to TA and posterior to PSVL, and (C) Grade 3: PCVL anterior to TA and PSVL.

222. SUBLAMINAR DECOMPRESSION: A LAMINA-PRESERVING TECHNIQUE FOR LUMBAR SPINAL DECOMPRESSION IS ASSOCIATED WITH LOWER PSEUDARTHROSIS RATE IN ADULT SPINAL DEFORMITY SURGERY

Micheal Raad, MD; Amy L. Xu, BS; Kevin C. Mo, MHA; Brian J. Neuman, MD; David B. Cohen, MD; Lee Riley, MD; Hamid Hassanzadeh, MD; Floreana N. Kebaish, MD; Khaled M. Kebaish, MD

Hypothesis
Preserving the bony posterior elements with a lamina-sparing decompression approach lowers the pseudarthrosis rate in long posterior spinal fusion.

Design
Retrospective Analysis

Introduction
A wide laminectomy is the most commonly used method to decompress the neural elements in posterior spinal fusion for adult spinal deformity (ASD). It entails removing a valuable bony surface, which limits the surface area of bone available for fusion. Recently, the Sublaminar Decompression (SLD) Technique was developed to allow for effective decompression of the neural elements while preserving the lamina (Figure 1A-B).

Methods
ASD patients undergoing primary posterior spinal fusion between 2014 and 2018 at an academic center were identified. Patients either underwent decompression with SLD or laminectomy (Lami) as dictated by surgeons' preference. The two groups were otherwise similar with respect to the approach, implants, and instrumentation technique used. Comparison of patient demographics, surgical variables, radiographic parameters and patient reported outcomes was performed. Primary outcome was reoperation for symptomatic pseudarthrosis. A logistic regression controlling for possible confounders ($p<0.2$) was used to evaluate the independent association between decompression technique and pseudarthrosis.

Results
106 patients were included (51 SLD vs 55 Lami). Follow-up time was 3.2 years (1–8 years). Age, gender, and preoperative patient-reported outcomes were similar between the two groups ($p>0.05$). The SLD group had a higher mean number of levels fused (11±3.1 vs 9.6±3.2, $p=0.03$) and higher pedicle subtraction osteotomy (PSO) use (18% vs 4%, $p=0.02$). Bone Morphogenic Protein (BMP) use, vertebral column resection, and L5-S1 anterior lumbar interbody fusion rates were similar ($p>0.05$). C7 coronal balance (C7PL) was worse in the SLD group (3.3±3.3 cm vs 2±2.1 cm, $p=0.02$) but other radiographic parameters were similar. The rates of pseudarthrosis were significantly lower in the SLD group (14% vs 40%, $p<0.01$). After controlling for C7PL, BMP use, PSO, number of levels fused, and age, SLD was associated with a significantly lower rate of reoperation for pseudarthrosis (OR=0.2, 95%CI: 0.07–0.64, $p<0.01$).

Conclusion
Preserving the bony posterior elements with a SLD technique lowers pseudarthrosis rate in ASD surgery.

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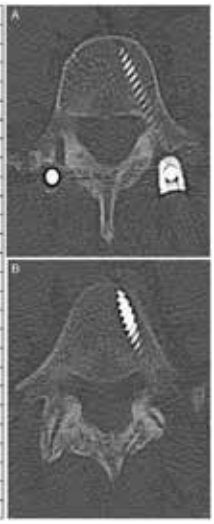
	SLD	Lami	p-Value
Demographics			
Age	57 ±16	62 ±14	0.13
Women (%)	67	62	0.6
Surgery			
Number of Levels Fused	11 ±3.1	9.6 ±3.1	0.03
Vertebral Column Resection (%)	6	7.3	0.77
Pedicle Subtraction Osteotomy (%)	4	18	0.02
BMP Use (%)	36	22	0.13
Staged L5-S1 ALIF (%)	34	45	0.23
Radiographic Deformity			
Major Cobb Angle (°)	34 ±22	33 ±28	0.81
Coronal Balance (cm)	3.3 ±3.3	2 ±2.1	0.02
Sagittal Balance (cm)	6.7 ±6.2	7.5 ±8.4	0.58
Thoracic Kyphosis (°)	33 ±28	33 ±20	0.99
Pelvic Tilt (°)	27 ±10	26 ±13	0.59
Sacral Slope (°)	37 ±12	35 ±12.8	0.34
Pelvic Incidence - Lumbar Lordosis (°)	22 ±29	18 ±22	0.46
Patient Reported Outcomes			
Preoperative Back Pain (0-10)	8 ±2.2	7.7 ±1.8	0.56
Final Back Pain (0-10)	4 ±3.4	5.8 ±3	0.06
Preoperative Leg Pain (0-10)	5.7 ±3.6	4.9 ±3.7	0.36
Final Leg Pain (0-10)	4 ±3.7	2.9 ±3.3	0.29
Preoperative ODI	43 ±22	42 ±19	0.73
Final ODI	35 ±21	28 ±19	0.26
Outcomes			
Pseudoarthrosis (%)	14	40	<0.01



223. USING NORMATIVE PELVIC TILT TO DETERMINE PELVIC COMPENSATION, OVERCORRECTION/UNDERCORRECTION, AND THEIR EFFECT ON OUTCOMES AND PJF AFTER ASD SURGERY†

Fares Ani, MD; *Themistocles S. Protopsaltis, MD*; Arnaav Walia, BA; Renaud Lafage, MS; Alex Soroceanu, MPH; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; D. Kojo Hamilton, FAANS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis
Normative pelvic tilt (PT) can be used to determine over- and under-correction in ASD surgery

Design
Retrospective analysis of a prospective multicenter ASD database and a database of asymptomatic subjects

Introduction
PT varies by pelvic incidence (PI), age and alignment. This study utilizes normative values of PT derived from asymptomatic subjects to determine alignments corresponding to overcorrection and PT thresholds corresponding to moderate disability to determine undercorrection in ASD surgery. TPA which is the sum of T1 spinopelvic inclination and PT, allows the surgeon to target a spinal alignment that matches the PT that is appropriate for PI and age.

Methods
Linear regression modeling was used to determine normative PT based on PI and age in asymptomatic subjects (normative PT). The differences in PT from normative were calculated in the ASD cohort and linear regression was used to determine normative PT-offset based on ODI scores. Moderate disability (ODI-20) was used in this formula to determine the threshold of pelvic compensation. Pts were grouped based on their TPA alignment that matched the PT thresholds: Overcorrected (TPA<normative PT), Undercorrected (those exerting pelvic compensation: TPA>offset from Normative PT corresponding to ODI=20) and Well-aligned (pts between over-and under-corrected). To account for overcorrections in patients that suffered a PJK prior to the 6-week postoperative time point, a similar analysis was performed with LPA to determine overcorrected, well-aligned and undercorrected. For each group, the rate of PJF was determined.

Results
There were 1454 pts in the baseline analysis and 1013 in the post-op analysis (mean age 60.9y; 10.4 ±4.4 Levels fused, 72.2% Female). Well-aligned pts had worse baseline HRQL scores by SF36 PCS (p=0.05) and ODI (p=0.01). There were no differences in the improvements in SF36 PCS and ODI from baseline to 2-years between groups. Patients in both the over- and under-corrected cohorts were more likely to develop PJF by 2-years (14.2% and 15.9% vs 8.3%, p=0.028) but there were no differences in PJK revision rates.

Conclusion
While all patient groups improved their HRQL from baseline to 2 years, PJF was more prevalent in both the over- and under-corrected compared to well-aligned. Surgeons can target TPA alignments close to but not less than normative PT to minimize PJF.

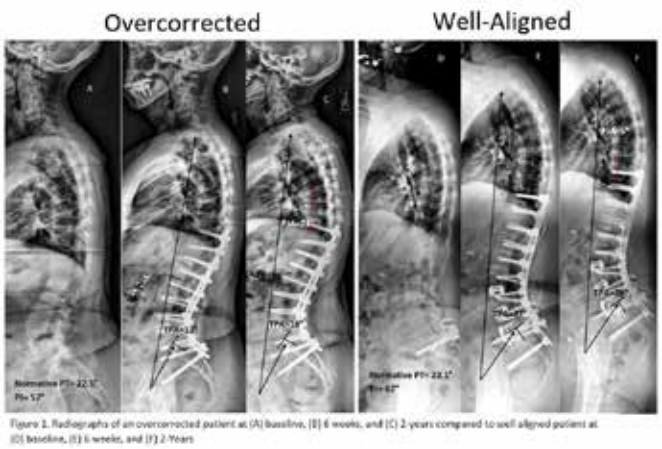


Figure 1. Radiographs of an overcorrected patient at (A) baseline, (B) 6 weeks, and (C) 2 years compared to well aligned patient at (D) baseline, (E) 6 weeks, and (F) 2 Years

224. THORACOLUMBAR SPINAL FUSION TERMINATING AT L4 OR L5 FOR ADULT SYMPTOMATIC LUMBAR DEFORMITY PATIENT -MEAN 7-YEAR FOLLOW-UP†

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Hypothesis
Long-term surgical outcome for thoracolumbar spinal fusion terminating at L4 or L5 (TLF) for adult symptomatic lumbar deformity (ASLD) will be favorable with less complication

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

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and revision rate in a selected ASLD population.

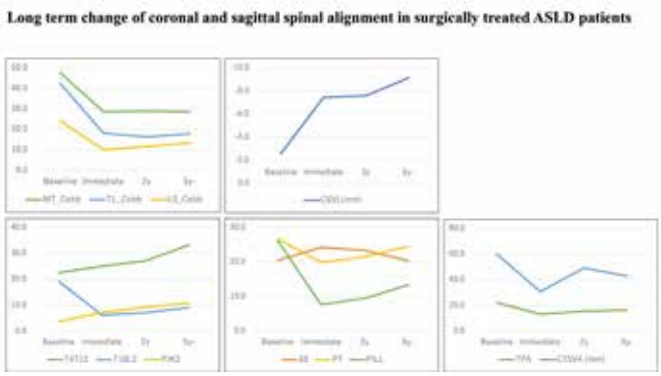
Design
Multicenter retrospective case series.

Introduction
The long-term outcome of TLF for ASLD has not fully identified while short term outcomes have been described. The purpose of this study was to report the long-term surgical outcomes of TLF in ASLD patients.

Methods
68 consecutive ASLD patients (>50y) who had TLF (LIV; L5 or L4) at 3 different hospitals and reached 5 years f/u were included (f/u rate 97%, mean f/u 7.3y, age 65±9y, 97% female, level fused 8±3, Schwab-SRS classification [D29: L26: N13]). The radiographic and clinical outcomes were analyzed. The disc degeneration of L5-S was assessed using Weiner grades and Grade 2-3 were considered disc degeneration (DD). The risk analysis of mechanical failure (MF) was performed using ROC analysis.

Results
The SRS22 improved at 2y and maintained until to final f/u (baseline:2y:final; 2.8±0.7 vs 3.8±0.6 vs 3.9±0.6). Sagittal alignment improved significantly post-op and spinopelvic alignment was consistent after 2y, while thoracic kyphosis increased (baseline:2y:final; C7SVA; 60: 49: 43mm, PI-LL; 26: 10: 13°, TK; 22: 28: 34°). L5-S disc angle decreased 3 ± 2°, and prevalence of DD slightly increased at final f/u (38 to 46%). Coronal balance also slightly worsened at final f/u (CSVL; -3: -8: -9mm, L4 tilt; 23: 10: 14°). The overall major complication rate was 43% and the late complication developed 9%. MF developed 19% (n=13) and the overall revision rate was 16% (n=9). 2 late revisions (3%) were required due to DJK, while the vast majority developed within 2y (n=7, 10%). PJF developed 3 cases and RF developed 5 cases, while 3 RFs developed at late stage did not required revision. DJF developed 3 cases and all required PSO. The ROC analysis indicated that higher BMI (22.9kg/m2 [sensitivity0.73, specificity0.8]), older age (71y [0.73, 0.74]), and frailty (mFI:0.14 [0.6, 0.76]) were the risk of MF following TLF for ASLD.

Conclusion
Long-term surgical outcome of TLF for ASLD was favorable with acceptable complication and revision rate in a selected ASLD patients. Higher BMI, older age, and advanced frailty were identified as the risk of long-term MF following TLF for ASLD.



Change of spinal alignment in ASD surgery

225. GLOBAL ALIGNMENT AND SURGICAL OUTCOMES OF ADULT SPINAL DEFORMITY PATIENTS WITH TOTAL HIP ARTHROPLASTY

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Hypothesis
Total hip arthroplasty (THA) patients may have worse postoperative global alignment after ASD surgery secondary to unresolved hip flexion contracture or muscular imbalance

Design
Retrospective review of prospectively collected data.

Introduction
Patients with hip-spine syndrome remain a challenge for spinal deformity surgeons. The impact of THA on surgical outcomes of ASD remains unclear.

Methods
ASD patients with available radiographic and PROM data at baseline and 2-year postop were included. Patients with available THA information were grouped into THA vs. no THA. Outcomes were compared for radiographic alignment, ODI, SF36, and revision surgery.

Results
702 patients were included, of which 60 patients (9.6%) had THA at baseline. THA patients were older (69.9 vs. 63.5 years, p<0.001) but had similar gender, BMI, frailty scores, and baseline spino-pelvic alignment (SVA, PT, PI-LL; P>0.05). Patients with THA had a significant improvement from baseline to 2-year FU for PI-LL (20 vs. 5.8°) and SVA

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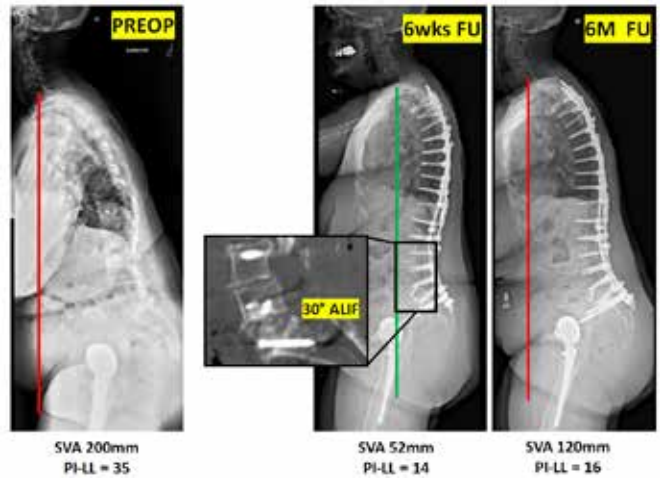
(87 vs. 51.3mm) (p< 0.05). However, at 2-year-follow-up, THA patients had significantly worse SVA (51.3 vs. 33.5mm, p=0.012) for a comparable PI-LL. The THA group did not experience an improvement in PT (24.9 vs. 23.2°, p=0.074). Specifically, 75% of THA pts had no PT improvement vs. 55.6%, p=0.006. Both groups had comparable coronal malalignment at baseline and 2-years (C7PL range: 30-40mm). However, THA patients had significantly greater baseline leg length discrepancy (11.8 vs. 7.7mm) which persisted at follow-up (10.2 vs. 7.3mm). At 2-year follow-up, both groups had significant improvement of ODI (THA: 49.4 vs. 28.7; no THA: 46.6 vs. 28.7) and SF36 (THA: 25.6 vs. 33.8; no THA: 28.2 vs. 37.2), all p<0.05. However, patients with THA had worse SF36 (37.1 vs. 33.8, p=0.035), and higher revision rate for persistent ASD (3.3 vs. 0.5%, p=0.012%).

Conclusion
Patients with total hip arthroplasty are at increased risk of persistent global malalignment following ASD surgery. The etiology of persistent deformity is likely multifactorial and may be due to residual anterior soft tissue contracture of the hip altering pelvic tilt and global spinal alignment. Patients with THA achieved largely comparable clinical outcomes at two-year follow-up, despite a lower SF36 and higher incidence of revision for persistent ASD.



226. SOCIAL AND ECONOMIC DEPRIVATION DOES NOT NEGATIVELY IMPACT PRE-OPERATIVE PROMIS SCORES FOR ADULT SPINE DEFORMITY

Mitchell Fourman, MPhil; Shay Bess, MD; Michael P. Kelly, MD; Eric O. Klineberg, MD; D. Kojo Hamilton, FAANS; Christopher P. Ames, MD; Douglas C. Burton, MD; Alan H. Daniels, MD; Renaud Lafage, MS; Lawrence G. Lenke, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Stephen J. Lewis, MD, FRCS(C); Khaled M. Kebaish, MD; Han Jo Kim, MD; Richard Hostin, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis
Social and economic deprivation are associated with a negative impact on baseline PROMIS scores for adult spinal deformity (ASD).

Design
Retrospective analysis of a prospective multi-center study

Introduction
Spine surgery in underserved populations has been associated with poor outcomes. Little data exists evaluating associations between social and economic deprivation and patient reported quality of life.

Methods
Surgically treated ASD patients prospectively enrolled into a multi-center study were evaluated for zip code-level social and economic deprivation using the Area Deprivation Index (ADI). Multivariate linear regression modeling was performed using preoperative PROMIS-CAT scores (physical function, pain interference, participation in social roles, satisfaction with social roles, depression, and anxiety) for associations with ADI, demographics, 6-meter timed get-up-and-go (GO), Edmonton and Clinical Frailty Scales, narcotic use, and magnitude of radiographic deformity. Variables with a univariate p-value < 0.1 were included in the multivariate regression. Data are reported as odds ratio, 95% CI.

Results
288 patients enrolled from 2018-2021 (mean age 60.0 years) were evaluated. Seventy-one had below 50th percentile ADI scores (24.7%). Age (-0.1), clinical frailty scale (CFS; -1.4), preoperative narcotic use (-2.1) and leg pain score (-0.3) with physical function. Non-white ethnicity (-4.0), GO (0.2) and CFS (1.3) were associated with pain interference. CFS (-1.9), GO (-0.2) and disability/unemployed status (-2.9) were associated with participation in social roles/activities. Non-white ethnicity (4.1), CFS (-1.8) and disability/unemployed status (-2.8) were associated with satisfaction with social roles. No factors were predictive of depression or anxiety.

Conclusion
Social deprivation was not associated with poor preop PROMIS-CAT scores of patients with ASD. Non-white ethnicity was independently associated with better social satisfaction and pain interference scores. These findings highlight the erroneous historical prejudices that exist against patients classified as socially deprived. Further work is needed to facilitate treatment access for socially deprived ASD patients.

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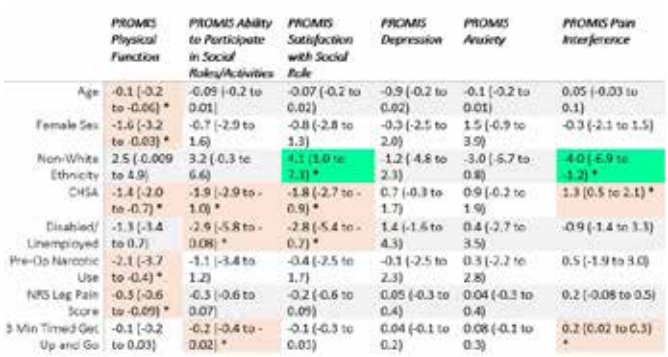

	PROMIS Physical Function	PROMIS Ability to Participate in Social Roles/Activities	PROMIS Satisfaction with Social Role	PROMIS Depression	PROMIS Anxiety	PROMIS Pain Interference
Age	-0.1 [-0.2 to -0.06] *	-0.09 [-0.2 to 0.01]	-0.07 [-0.2 to 0.02]	-0.9 [-0.2 to 0.02]	-0.1 [-0.2 to 0.01]	0.05 [-0.03 to 0.1]
Female Sex	-1.6 [-3.2 to -0.03] *	-0.7 [-2.9 to 1.6]	-0.8 [-2.8 to 1.3]	-0.3 [-2.5 to 2.0]	1.5 [-0.9 to 3.9]	-0.3 [-2.1 to 1.5]
Non-White Ethnicity	2.5 [-0.009 to 4.9]	3.2 [-0.3 to 6.6]	4.1 [1.9 to 7.3] *	1.2 [-4.8 to 2.3]	-3.0 [-6.7 to 0.8]	-4.0 [-6.9 to -1.2] *
CHSA	-1.4 [-2.0 to -0.7] *	-1.9 [-2.9 to -1.0] *	-1.8 [-2.7 to -0.9] *	0.7 [-0.3 to 1.7]	0.9 [-0.2 to 1.9]	1.3 [0.5 to 2.1] *
Disabled/ Unemployed	-1.3 [-3.4 to 0.7]	-2.9 [-5.8 to -0.08] *	-2.8 [-5.4 to -0.2] *	1.4 [-1.6 to 4.3]	0.4 [-2.7 to 3.5]	-0.9 [-3.4 to 1.3]
Pre-Op Narcotic Use	-2.1 [-3.7 to -0.4] *	-1.1 [-3.4 to 1.2]	-0.4 [-2.5 to 1.7]	-0.1 [-2.5 to 2.3]	0.3 [-2.2 to 2.8]	0.5 [-1.9 to 3.0]
NRS Leg Pain Score	-0.3 [-0.6 to -0.09] *	-0.3 [-0.6 to 0.07]	-0.2 [-0.6 to 0.09]	0.05 [-0.3 to 0.4]	0.04 [-0.3 to 0.4]	0.2 [-0.08 to 0.5]
3 Min Timed Get Up and Go	-0.1 [-0.2 to 0.03]	-0.2 [-0.4 to -0.02] *	-0.1 [-0.3 to 0.03]	0.04 [-0.1 to 0.2]	0.08 [-0.1 to 0.3]	0.2 [0.02 to 0.3] *

Factors Influencing the Baseline Health-Related Quality of Life Scores of Patients with ASD (Red = Negative, Green = Positive)

227. DEVELOPMENT OF ETHNICITY-ADJUSTED GLOBAL ALIGNMENT AND PROPORTION (GAP) SCORE SYSTEM TO PREDICT THE RISK OF MECHANICAL FAILURE FOLLOWING CORRECTIVE SURGERIES FOR DEGENERATIVE SCOLIOSIS

Abdukahar Y. Kiram, PhD; Jie Li, MD; Zongshan Hu, PhD; Yanjie Xu, MD; Zezhang Zhu, MD, PhD; Yong Qiu, PhD; *Zhen Liu, PhD*

Hypothesis
Ethnicity-adjusted global alignment and proportion (GAP) score for the Chinese population was an accurate and reliable system for predicting mechanical failure in degenerative scoliosis (DS) patients

Design
retrospective

Introduction
Surgery for DS is a complex procedure with high complications and revision rates. Failure to restore appropriate sagittal alignment was reported to be the main cause of mechanical failure.GAP score were developed with the data collected from European populations to achieve ideal sagittal profile reconstruction.However,GAP score may not be applicable to Chinese populations, given pelvic incidence (PI) varies among different ethnic groups

Methods
healthy volunteers were enrolled to develop ethnicity-adjusted GAP scores. DS patients who underwent corrective surgery in our institution from December 2016 to January 2020 were retrospectively reviewed. Clinical data such as age, sex, BMI, and radiological data including PI, lumbar lordosis (LL), sacral slope (SS), the sagittal vertical axis (SVA), and global tilt (GT) were collected. Linear regression analysis between the PI and SS, LL and GT of healthy volunteers were conducted. Ideal LL,SS and GT for DS patients were calculated using the equations,and the Chinese population-adjusted GAP score (GAP-C) was developed. The predictability of GAP-C to mechanical failure was evaluated.Cochran-Armitage Test for Trend was used to evaluate the correlation between GAP-C and mechanical complications.

Results
61 healthy volunteers with a mean age of 58.4±5.4 were enrolled. SS=0.40×PI+12, LL=0.46×PI+22, and GT=0.46×PI-5 were obtained using healthy volunteers.A total of 114 DS patients with a mean age of 60.7±7.1 were enrolled. According to the GAP-C score, the sagittal parameters were proportional in 25 (21.9%) cases, moderately disproportional in 68 (59.6%), and severely disproportional in 21 (18.5%) patients. Mechanical complications rate was statistically different among proportioned, moderately disproportional, and severely disproportional GAP-C score groups (P=0.03). In addition,there is a significant linear correlation between mechanical complication rate with GAP-C score (χ=0.102, P=0.02)

Conclusion
Ethnicity-adjusted GAP-C score was developed,which provide an accurate and reliable prediction for mechanical complications after corrective surgeries for DS

228. VALIDATION OF THE AGE FACTOR IN DETERMINATION OF TOTAL GLOBAL ALIGNMENT AND PROPORTION (GAP) SCORE

Woojin Cho MD, PhD; Adam Nessim, MD; Ariella Gartenberg MD; Doruk Somuncu MD; Jeffrey Kim, MD; Andrew Baddoo, BS

Hypothesis
Age Factor is a valid parameter in calculation of GAP scores among healthy United States adult volunteers with no prior spinal pathology.

Design
Retrospective review of prospectively collected data.

Introduction
Proximal Junctional Kyphosis has been a well-known complication following adult spinal deformity correction surgery. The Global Alignment and Proportion (GAP) score was thus developed to predict such mechanical complications following spinal correction surgery. The GAP score is a pelvic-incidence based method of analyzing the sagittal plane. The GAP parameters include relative pelvic version, relative lumbar lordosis, lordosis distribution index, relative spinopelvic alignment (RSA), and an age factor of 60. An age >= 60 years old receives a score of 1, while age <60 receives a score of 0.

Methods
GAP-A were assessed in 87 healthy volunteers that met inclusion criteria. Parameters without age factors included relative lumbar lordosis (measured minus ideal lumbar lordosis), relative pelvic version (measured minus ideal sacral slope), lordosis distribution index (L4-S2 lordosis divided by L1-S1 lordosis, multiplied by 100), relative spinopelvic alignment (measured minus ideal global tilt), and an age factor of 60. The average GAP-A scores per various age groups were compared using two-tailed t-test.

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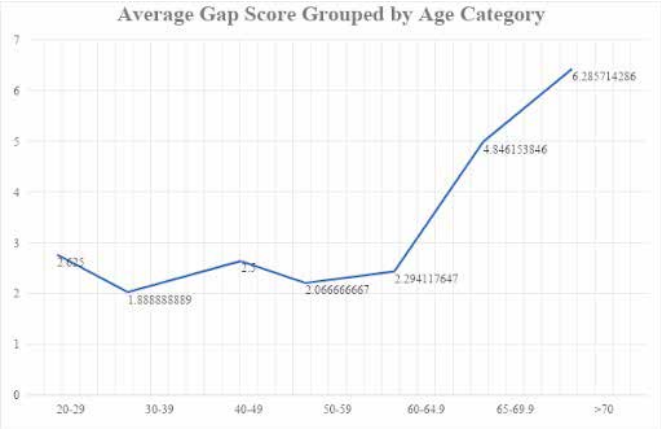
Results
The average GAP-A score in healthy individuals ages 20-29 was 2.63, ages 30-39 was 1.89, ages 40-49 was 2.50, ages 50-59 was 2.07, ages 60-64.9 was 2.29, ages 65-69.9 was 4.85, and ages >=70 was 6.29. See Table 1. Mean GAP-A scores of individuals <70 was significantly different from GAP-A scores of those >70.

Conclusion
Our study examined the age factor parameter in calculation of GAP scores in a healthy U.S. population. Utilizing an age cut-off of 70 may be better in identifying individuals at risk for development of complications after spinal deformity correction surgery. Further studies with larger population are needed to confirm using age of 70 as the new cut-off as compared to the previous age factor of 60.



Average Gap Score Grouped by Age Category

229. AUTOMATED VERTEBRAL SEGMENTATION AND COBB ANGLE MEASUREMENTS FROM RADIOGRAPHS FOR EOS PATIENTS

Girish Viraraghavan, MS; Ausilah Alfraihat, MS; Patrick J. Cahill, MD; Sriram Balasubramanian, PhD

Hypothesis
Accuracy of automated clinical measurements of Cobb angle from radiographs will be comparable to current manual methods.

Design
Retrospective

Introduction
Radiographs are routinely used to evaluate Early-Onset Scoliosis (EOS). Manual measurements of Cobb angle, kyphosis and other clinical indices from radiographs are time consuming and prone to measurement error. Automated vertebral segmentation and Cobb angle measurements may improve accuracy and expedite clinical assessment. This study aims to accomplish this using a Convolution Neural Network (CNN) framework.

Methods
2200 AP radiographs retrospectively obtained from a large scoliosis image repository were annotated with thoracic and lumbar vertebral vertices, and resized to 512 x 512 pixels to serve as a reference dataset for CNN based segmentation. The CNN framework was trained and validated using 1760 images (80%) and 440 images (20%), respectively. AP radiographs from an additional 45 EOS patients (all etiologies) were used to test the accuracy of the automated segmentation, and automated Cobb angle measurements were compared with manual measurements.

Results
Exemplar training and testing radiographs along with the corresponding vertebral annotations and automated segmentation are shown in Figure 1. Training and validation accuracies for automated segmentation were 99% and 97%, respectively. For the 45 EOS patients, the mean absolute error between manual and automated Cobb angle measurements was 2.47 ± 1.74°.

Conclusion
A CNN framework was developed to perform automated thoracic and lumbar vertebral segmentation and Cobb angle measurements from AP radiographs with high accuracy. Such automated methods can help expedite clinical assessment and treatment of EOS, as well as other spine deformities.

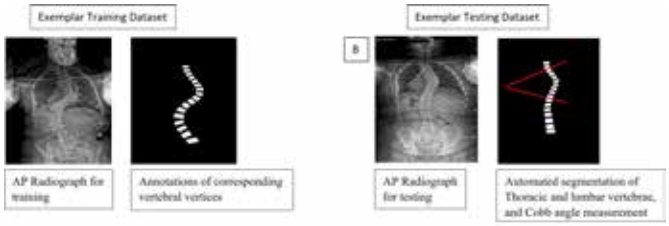


Figure 1: Exemplar datasets for (A) training, and (B) testing CNN framework for automated vertebral segmentation and Cobb angle measurements from radiographs

230. FACTORS DETERMINING T1-12 HEIGHT AFTER GROWTH FRIENDLY SURGERIES FOR EARLY ONSET SCOLIOSIS USING LOGISTIC REGRESSION MODELS

Teppei Suzuki, MD, PhD; Koki Uno, MD, PhD; Masaaki Ito, MD, PhD

Hypothesis
There might be some risk factors to obtain the acceptable thoracic spinal growth with growth friendly surgeries (GFS) for early onset scoliosis (EOS).

Design
Retrospective study

Introduction
To obtain over 20cm T1-12 height is one of the purpose of GFS. According to our previous study, final T1-12 height with Shilla growth guidance surgery (SGGS) was comparable to that with traditional growing rod (TGR). However, the factors determining the final T1-12 height is still unclear. In this study, we aimed to investigate the factors obtainingT1-12 after definitive fusion through GFS.

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Methods
Among 102 consecutive patients who had TGR or SGGS procedure by a single surgeon, there were 55 graduates after definitive fusion through GFS identified in this study (TGR:27 cases, SGGS:28 cases). The dependent variable is T1-12 height at final follow-up (less than 200mm or more than 200mm). The following potential risk factors were analyzed: GFS procedures (TGR or SGGS); an age of less than 7 years at the initial surgery; preoperative main thoracic scoliosis of 90 or more; thoracic kyphosis (TK) angle of 60 or more at the final follow-up. Logistic regression was used to evaluate the correlation between the multivariate factors and T1-12 height at final follow-up. Simple and multiple linear regressions were also used to note whether a combination of variables might better predict thoracic height.

Results
Binary logistic regression model showed that an age at the initial surgery (AOR 9.3, 95% CI 1.6-52.3, P=0.011), and magnitude of preoperative main curve (AOR 0.149, 95% CI 0.029-0.758, P=0.021) had good accuracy to predict the T1-12 thoracic height at final follow-up. The number of surgeries and GFS procedure did not affect the thoracic height. Multivariate analysis showed that the main factors influencing thoracic growth are an age at the initial surgery and TK at final follow-up, with standardized partial regression coefficients of 0.226 and -0.388, respectively.

Conclusion
Age (younger than 7 years old), severe main curve (more than 90 degrees) at the initial surgery and the magnitude of remaining thoracic kyphosis after definitive spinal fusion were identified as negative factors for affecting the thoracic height at final follow-up.

231. COMPARISON OF TRADITIONAL GROWTH RODS AND MAGNETICALLY CONTROLLED GROWING RODS IN EARLY-ONSET SCOLIOSIS: A CASE-MATCHED MID TERM FOLLOW-UP STUDY†

Abhishek Srivastava, MD; Anuj Gupta, MD; Ankur Goswami, MD; Naveen Pandita, MS; Arvind Jayaswal, MD; Govindaraja Perumal Vijayaraghavan, MBBS, MS; Bharath H. D, MBBS, MS

Hypothesis
The MCGR have results comparable to TGR in early-onset scoliosis with an option of non-invasive lengthening, hence lesser incidence of complications and lesser unplanned return to OT.

Design
Retrospective cohort study

Introduction
Early-onset scoliosis (EOS) has always been a challenging situation for spine surgeons. The aim of treatment is to control the direction of curve progression to allow for the complete development of lungs. Among all the growth constructs available, traditional growth rods (TGR) and magnetically controlled growth rods (MCGR) are most widely used. The MCGR has been introduced a few years back and there is a dearth of long-term follow-up studies. The purpose of this study is to compare the effectiveness of TGR and MCGR for the treatment of EOS.

Methods
All patients of EOS managed with either TGR or MCGR were included in the study. The patients managed with other methods or having follow-up <2-years were excluded from the study. A total of 20 patients were recruited in the MCGR group and 28 patients were recruited in the TGR group. Both groups were matched by etiology, gender, pre-operative radiological parameters, and complications including unplanned surgeries.

Results
The mean age in our study was 7.90 years in the MCGR group and 7.46 years in the TGR group. The mean duration of follow-up in the MCGR group was 50.85 months and in the TGR group 94.21 months. Pre-operative cobb's angle in the coronal plane and T1-S1 were comparable in both groups with a mean cobb's angle of 65.35 in MCGR and 70.50 in TGR. The mean T1-S1 length in the MCGR group was 36.1cms and in the TGR group was 35.2cms (p= 0.18). The average increase in T1-S1 length was 1.3cm/year in the TGR group and 1.1cm/year in the MCGR group (p>0.05). The TGR patients underwent 186 open lengthening surgeries and 11 unplanned surgeries for various complications. The MCGR group has 180 non-invasive lengthening with only 4 unplanned returns to OT for various causes.

Conclusion
The curve correction was similar in both TGR and MCGR groups. The average T1-S1 length achieved on final follow-up was similar in both groups. The MCGR patients have attained similar correction with fewer invasive procedures and lesser complications compared to the TGR group.

232. SEVERE KYPHOSCOLIOSIS PATIENTS WITH PREOPERATIVE TYPE III SPINAL CORDS ON MRI: DOES PREOPERATIVE TRACTION IMPROVE SURGICAL SAFETY?

Zezhang Zhu, MD, PhD; wanyou Liu, MS; Benlong Shi, PhD; Zhen Liu, PhD; Yong Qiu, PhD

Hypothesis
Preoperative Halo gravity traction (HGT) in the treatment of severe kyphoscoliosis patients with preoperative type III spinal cords could improve spinal deformity.

Design
A retrospective cohort study.

Introduction
HGT can improve the patient's cardiopulmonary function state, patients' tolerance of surgery, and reduce the difficulty and risk of spinal orthopaedic surgery by gradually increasing the traction force for partial preoperative

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correction. However, no literature has reported the efficacy analysis of HGT therapy in severe kyphoscoliosis patients with preoperative type III spinal cords on MRI.

Methods
A total of 47 severe thoracic kyphoscoliosis patients (18 males, 29 females, age 22.5±12.8 years) with preoperative type III spinal cords on MRI who undergoing pre-operative HGT (7.4±3.9 weeks) followed by one-stage posterior spinal instrumentation and fusion in our hospital from February 2019 to June 2021 were retrospectively analyzed. The radiographic parameters including the coronal Cobb angle and sagittal global kyphosis (GK) at pre-traction, post-traction and post-operation. Traction correction rate and surgical correction rate were also calculated. The Frankel scoring system was used for the evaluation of neurological status at at pre-traction, post-traction and post-operation.

Results
The initial coronal Cobb angle and GK before HGT was 116.0±17.5° and 110.9±22.1°. There were significantly improvement on both scoliosis and kyphosis at post-traction and post-operation (P<0.001), respectively. A total of 14 patients showed lower limbs neurological deficits at pre-traction, neurological function improvement were observed on 8 of them and after traction and 3 of them after operation. No new lower limbs neurological deficits were observed during traction, and only 1 patient were observed neurological deterioration, whose Frankel score worsened from D to C. 2 patient had transient brachial plexus palsy which resolved completely after reducing the traction weight.

Conclusion
Preoperative HGT in the treatment of severe kyphoscoliosis patients with preoperative type III spinal cords can not only improve spinal deformity, but also improve existing neurological symptoms and even reduce the risk of iatrogenic neurological injury during surgery. In addition, the safety of treatment can be carried out by closely monitoring.

233. THE STENOSIS SECONDARY TO OSSIFICATION OF LIGAMENTUM FLAVUM AT THE SEGMENTS ADJACENT TO THE KYPHOTIC APEX IN ADULT KYPHOSIS: A "NEGLECTED" ETIOLOGY FOR DURAL TEAR

Ziyang Tang, MD; Zongshan Hu, PhD; Hui Xu, MD; Yong Qiu, PhD; Zezhang Zhu, MD, PhD; Zhen Liu, PhD

Hypothesis
The incidence and morphological characteristics of ossification of ligamentum flavum (OLF) at the segments adjacent to the kyphotic apex in adult kyphosis could be different between patients with different etiologies

Design
A retrospective study

Introduction
OLF was reported as the independent risk factor of DTs, with 10%~47% incidence rate of DTs in surgery for OLF. Nowadays, several studies reported three cases with OLF at the proximal or distal segments adjacent to the kyphotic apex. Therefore, this study was aimed to investigate the incidence of OLF at the segments adjacent to the kyphotic apex in adult kyphosis, and to compare the morphological characteristics.

Methods
A total of 111 adult patients with kyphotic deformity (32 males and 79 females) were retrospectively reviewed with an average age was 59.7±14.2 years. Among these patients, 42 (31.5%) had degenerative kyphosis(DK), 17(15.3%) patients had congenital kyphosis(CK), 17(15.3%) patients had tuberculosis, 19 (17.1%) patients had old fracture and 16 (14.5%) patients had Scheuermann's kyphosis (SK). Kyphosis with a sharp angle involving less than 5 levels of vertebrae was defined as angular kyphosis. Kyphotic angle, angular/non-angular kyphosis,the occurrence of OLF at three segments adjacent to the kyphotic apex and the occurrence of DT and post-operative cerebrospinal fluid leakage were recorded.

Results
Among the 111 patients, 72 patients (64.9%) appeared OLF in three segments adjacent to the kyphotic apex. The patients with OLF were significantly older than those without OLF(P = 0.002). But kyphotic angle showed no statistically significant difference(P=0.703). Interestingly, the incidence of OLF was significantly different the patients with and without angular kyphosis(P=0.02). The patients with DS had significantly higher incidence of OLF (29/42, 69.4%) with higher age (P<0.05) and lower kyphosis angle (P<0.05) in comparation with patients with other etiologies. Likewise, the patients with OLF in segments adjacent to the kyphotic apex had a higher incidence of DT and post-operative cerebrospinal fluid leakage (27.7% vs 5.1%).

Conclusion
Among adult kyphosis, OLF may appeared in three segments adjacent to the kyphotic apex in about 64.9% of patients, and it mostly occurred in the proximal of apex and adjacent two segments.

235. MODIFIABLE RISK FACTORS FOR PERIOPERATIVE BLOOD TRANSFUSION DURING POSTERIOR SPINAL FUSION IN PATIENTS WITH CEREBRAL PALSY

Ali Asma, MD; Nicholas Gajewski, MD; Armagan C. Ulusaloglu, MD; Denver A. Burton, MD; Petya Yorgova; Paul D. Sponseller, MBA; Amit Jain, MD; Burt Yaszay, MD; Amer F. Samdani, MD; Firoz Miyanji, MD; *Suken A. Shah, MD*; Harms Study Group

Hypothesis
There are modifiable risk factors to prevent massive blood transfusion during spinal fusion in CP patients

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

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E-POSTER ABSTRACTS

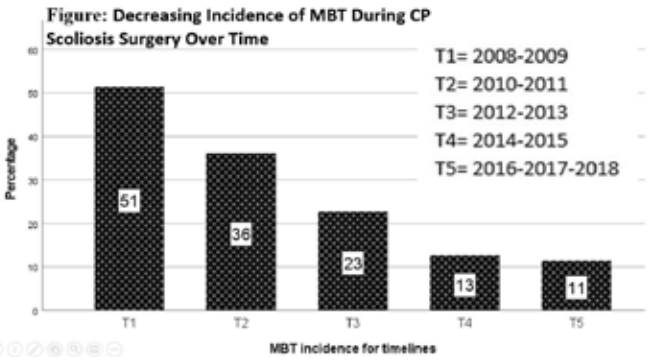
Design
Retrospective analysis of prospectively collected data

Introduction
Massive blood transfusion (MBT) is correlated to numerous complications including hypothermia and coagulopathy. Little is known regarding the risk factors for perioperative MBT in patients with CP undergoing PSF

Methods
Perioperative MBT was defined as the administration of allogenic blood products (packed red blood cells, fresh frozen plasma, platelets, cryoprecipitate) equaling at least half of the patients' preoperative blood volume(BV) during the surgical procedure. Blood products obtained from cell salvage were excluded from the analysis. Univariate and multivariate logistic regression was used for statistical analysis

Results
415 patients were included and average age at surgery was 14.3y(SD 2.8y). 87% of patients were GMFCS IV and V. The incidence of MBT was 26.7% (111/415). Mean BV was 2803 cc. Univariate analysis identified the following risk factors for perioperative MBT: intraop blood loss, number of levels fused, lack of antifibrinolytic use, use of unit rod or hybrid construct, neuromonitoring alert, low preoperative hemoglobin and albumin. Preoperative curve magnitude, perioperative curve correction, and duration of surgery were not associated with perioperative MBT. For every 1% increase in patient BV loss during surgery, the risk of requiring perioperative MBT increased by 5%. Loss of more than 60% of patient BV was the threshold for MBT(AUC= 0.84). Patients receiving MBT had increased hospital stay (p=0.02) and ICU stay(p=0.001). Patients with MBT had a higher rate of surgical site complications (p=0.03); however, the reoperation rate was not different (p=0.46). There was significant decrease in MBT incidence from 2008 (51%) to 2016 (11%)(p<0.001) with routine administration of antifibrinolytics

Conclusion
The incidence of MBT in patients with CP undergoing PSF during the study period was 26.7% and this rate has decreased over time. Lack of antifibrinolytic use, use of unit rod or hybrid constructs(perhaps due to sublaminar dissection), and low preop hemoglobin and albumin represent modifiable risk factors. Optimization of preoperative nutrition status, use of pedicle screw constructs when possible, and use of antifibrinolytics when not contraindicated is recommended to reduce the risk of MBT



236. THICKNESS OF SUBCUTANEOUS FAT AS A PROXY FOR BMI IN PREDICTING SURGICAL SITE INFECTION IN NON-AMBULATORY PATIENTS WITH NEUROMUSCULAR SCOLIOSIS†

Hamdi Sukkarieh, MD; *Chibuzo Akalonu, MD*; Steele I. Liles, BS; William H. Gillon, BS; Jaysson T. Brooks, MD

Hypothesis
Thickness of subcutaneous Fat (TSF) can provide a more reliable tool/proxy than Body mass Index (BMI) for determining obesity status and hence risk of Surgical Site Infection (SSI) in non-ambulatory patients with Neuromuscular scoliosis (NMS) undergoing scoliosis surgery.

Design
Retrospective chart review

Introduction
Higher BMI is associated with higher SSI and/or complications following surgery for NMS. However, these findings are based on BMI measurements that, at best, may be estimations in the NMS population, many of whom are non-ambulatory and suffer from significant contractures that make obtaining a true height/length measurement difficult and inaccurate. TSF is used to predict wound complications after joint arthroplasty; however, its application in spine deformity has never been explored. The purpose of this study is to identify the best location to measure TSF in the NMS population and to correlate TSF to SSIs after posterior spinal fusions (PSF).

Methods
Charts were reviewed of all non-ambulatory patients (ages 8 to 24 years) with NMS who required PSF at a single institution. Patients with inadequate radiographs were excluded along with patients treated with growing rod instrumentation. 15 radiographic measurements and 9 ratios of these measurements were chosen to best represent TSF (Figure 1). Measurements were obtained via preoperative AP pelvis and lateral spine radiographs. Intraclass correlation coefficients were calculated. BMI percentile % was calculated using the "BMI Percentile Calculator for Child and Teen" provided by the Centers for Disease Control. Data for SSI was collected.

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

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Results
One hundred and nine patients were included for the study. The average age at surgery was 13.5 ± 3.3 years with average follow-up of 22 months. Average BMI percentile was 35% with 18% of the patients in the overweight/obese OW/O categories (BMI% > 85%). The rate of SSI was 11%. OW/O status was significantly associated with SSI (23%) vs underweight and normal weight grouped (7.9%) (p=0.027). Multivariate logistic regression analysis showed TSF measures of 15,18 and 22 to be significantly associated with SSI (p-values: 0.031,0.042 and 0.028).

Conclusion
Certain radiographic measures could act as a reliable proxy for BMI in non-ambulatory patients with NMS undergoing scoliosis surgery.

Radiographic Measurements Key

237. PELVIC OSTEOTOMY IN PATIENTS WITH PREVIOUS SACRAL-ALAR-ILIAC (SAI) FIXATION

Frederick Mun, BS; Ashish Vankara, BS; Krishna Vangipuram Suresh, BS; Adam Margalit, MD; Nikitha Crasta, MBBS; Paul D. Sponseller, MBA

Hypothesis
SAI screws may complicate performance of iliac osteotomies; however, they can still be done by completing osteotomy around the screw, by using fluoroscopy to localize the tip of the screw.

Design
Retrospective Cohort

Introduction
Patients with neuromuscular disease are at high risk for developing hip dislocation and scoliosis. The purpose of this study was to investigate the technical challenges and outcomes of pelvic osteotomy in patients with prior SAI fixation.

Methods
We reviewed clinical and radiographic records of patients aged ≤18 years who underwent pelvic osteotomy after SAI fixation. Technical challenges were defined as having greater intraoperative fluoroscopy times and noted difficult osteotomy in the operative report. We also recorded time from SAI fixation to osteotomy, type of osteotomy, migration index, and distance from the SAI screw to the acetabulum. A two-sample Wilcoxon rank-sum test was used to assess the data.

Results
Ten patients were included. The average time from SAI fixation to pelvic osteotomy was 1.9 ± 1.6 years. For all 7 Chiari osteotomies, the ilium could not be laterally displaced; however medial displacement of the distal segment of the osteotomy allowed adequate coverage. All 3 Dega osteotomies were performed by cutting the cortex at the tip of the SAI screw. The screw improved proximal leverage and provided a strong buttress for bone graft. Average migration index before pelvic osteotomy was 61.7 ± 22.3%, and at most recent-follow-up was 14.7 ± 4.4%. Six patients, who had a noted complicated osteotomy, had SAI screws that were ≤ 1.87cm (p=0.01) from the acetabulum, and significantly increased intraoperative fluoroscopy time (1.68 minutes vs 1.16 minutes, p=0.0006).

Conclusion
The presence of SAI screws may cause iliac osteotomies to be technically challenging if the tip of the SAI screw is ≤ 1.87 cm to the acetabulum. When initially implanting SAI screws in neuromuscular patients, surgeons should attempt to place screw tips approximately 2 cm from the acetabulum in the event these patients require subsequent pelvic osteotomy at a later date.

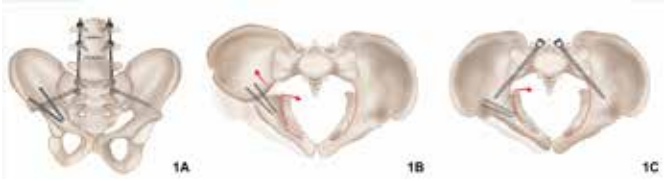

Illustration depicting AP view (1A) and axial view (1B) of Chiari iliac osteotomy in patient with prior SAI fixation. Illustration depicting axial view (1C) of Chiari iliac osteotomy in a patient without prior SAI fixation demonstrates medial displacement of the distal acetabular fragment, while the proximal iliac fragment is externally rotated (red arrows).

238. COST UTILITY ANALYSIS OF NEOADJUVANT TERIPARATIDE THERAPY IN OSTEOPENIC PATIENTS UNDERGOING ADULT SPINAL DEFORMITY SURGERY†

Micheal Raad, MD; Carlos D. Ortiz-Babilonia, BS; Hamid Hassanzadeh, MD; Varun Puvanesarajah, MD; Khaled M. Kebaish, MD; Amit Jain, MD

Hypothesis
Neoadjuvant use of teriparatide in adult patients with osteopenia undergoing adult spinal deformity (ASD) surgery is cost-effective due to lower proximal junctional failure (PJF) and pseudarthrosis rates.

Design
Cost-utility modeling

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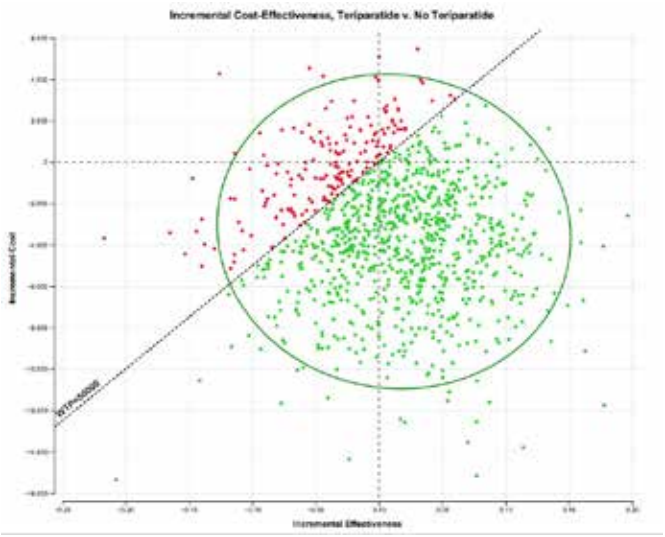
E-POSTER ABSTRACTS

Introduction
There is increasing evidence supporting preoperative use of anabolic agents such as teriparatide for ASD patients with poor bone density. However, such treatments are associated with added costs. The aim of our study was to develop a cost-utility model to evaluate the effectiveness of neoadjuvant teriparatide therapy in osteopenic patients undergoing ASD surgery.

Methods
A decision-analysis model was developed for a hypothetical 68-year old female patient with osteopenia (T-score <-1.0) undergoing a T11 to Pelvis instrumented spinal fusion for adult degenerative scoliosis. A comprehensive literature review was conducted to create estimates for event probabilities, costs, and quality-adjusted life years (QALYs) at each node. Key model assumptions were that administration of a 4-month preoperative teriparatide course reduced 2-year postoperative reoperation rates (for pseudarthrosis from 5% to 2.5% and for PJF from 15% to 5%) (Figure 1). A probabilistic sensitivity analysis through a Monte Carlo simulation of 1000 hypothetical patients was used to calculate the incremental cost effectiveness ratio (ICUR) and incremental net monetary benefits (INMB). One-way deterministic sensitivity analysis was used to estimate the contribution of individual parameters to uncertainty in the model.

Results
Teriparatide was the favored strategy in 82% of the iterations. It absolutely dominated No Teriparatide in 51% of the iterations (Figure 1). The mean ICER for the Teriparatide strategy was negative (higher net benefit, lower net cost), and lower than the willingness-to-pay threshold (WTPT) of 50,000 USD per QALY. Teriparatide use was associated with a mean INMB of 3,948 USD. One-way deterministic sensitivity analysis demonstrated that the factors with the greatest impact on the model were the incidence of PJF and the cost of reoperation.

Conclusion
Neoadjuvant teriparatide is a cost-effective strategy in adult patients undergoing ASD surgery. Preoperative teriparatide use should be considered in patients with osteopenia given protective effects against PJF and pseudarthrosis.



Cost-Utility Analysis of Teriparatide in Adult Spinal Deformity Surgery

239. COMPUTED TOMOGRAPHY AS AN ALTERNATIVE MODALITY TO CONFIRM TETHER BREAKAGE IN VERTEBRAL BODY TETHERING

Matthew Hei Yu Yeung; Hiu-Tung S. Wan; Kenny Y. Kwan, MD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Kenneth M. Cheung, MD, MBBS, FRCS

Hypothesis
Broken tethers can be clearly seen with reconstructed images on computed tomography scans

Design
Retrospective radiological analysis of case series

Introduction
Vertebral Body Tethering (VBT) is a growing surgical technique to treat adolescent idiopathic scoliosis (AIS). Tether breakage can lead to loss of correction and has been identified in up to 48% of cases in a recent study. 5° increase in inter-screw angulation is widely used as a criteria for diagnosis of tether rupture, but it has been suggested to have a low sensitivity. After analysing CT images post VBT, we found that tethers could be clearly outlined. Thus aim of the current study is to compare intactness of tether on CT image versus the current radiological diagnosis of tether rupture.

Methods
A series of 6 VBT patients with minimum 2 year follow-up and post-operative CT scans done at our institution were analysed. Parameters of CT are thickness 0.625mm, diagonal field of view 40mm, gantry rotation 0.5s. Coronal and sagittal reconstructs were created using an image viewer. The status of tether was observed on coronal reconstructed CT images, interscrew angles were measured on the PA standing radiographs immediately postop and at the time of CT scanning.

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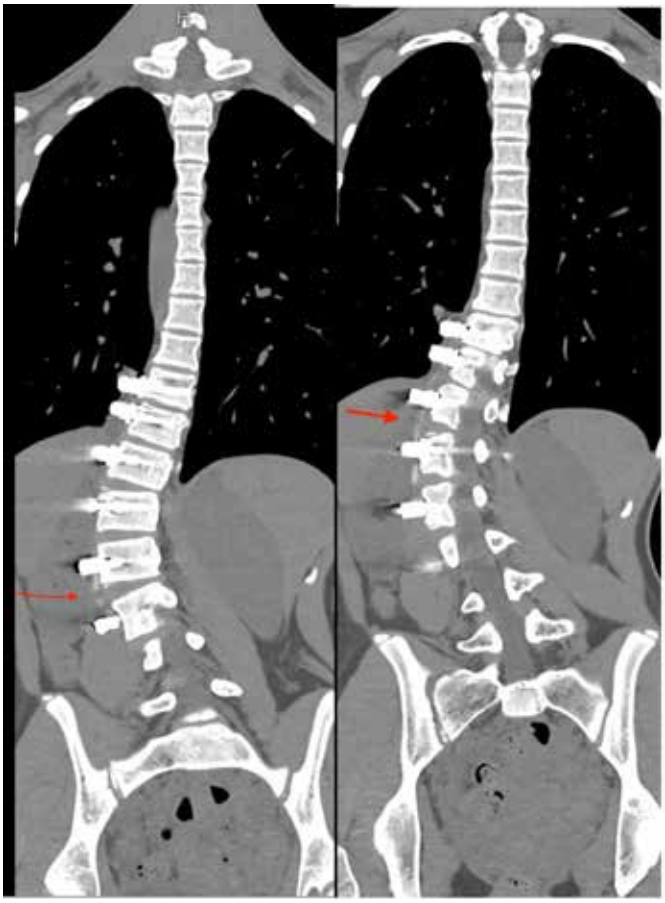
Results
Mean age at surgery was 11.3±1.3, Risser sign 0.3±0.6, with 2.3 years (2 to 2.6 years) of follow up. Number of instrumented levels were 7.2±0.69, average major Cobb's angle was 50.5° ± 7.4 pre-operative, 32.7±4.52 immediately post-operative, and 24.1±11 on last follow up. One patient showed tether breakage at 2 levels, clearly visualised on coronal reconstructed images. 5° rule predicted same levels of tether rupture, with an increase in interscrew angle of 9.4° and 11.9°. None of the other levels have an increased interscrew angle of >5°. All tethers are clearly outlined on CT reconstructed images.

Conclusion
This is the first study investigating CT as an alternative modality to assess tether integrity in VBT subjects. With CT scans, we can clearly delineate the course of each tether, demonstrating clear breakages. This can be valuable to confirm cases of suspected tether breakage predicted radiographically. We propose that CT scans with reconstruction can be used as a definite, alternative non-invasive method of diagnosing tether breakage in the future.



Reconstructed CT clearly visualising tether, with 2 points of breakage clearly identified at different slices (arrow).

240. A COMPARATIVE ANALYSIS OF RACIAL DISPARITIES IN NATIONALLY DERIVED HOSPITAL DATA AND TWO PROSPECTIVE MULTICENTER SURGICAL DATABASES OF ADULT SPINAL DEFORMITY SURGERY

Kevin C. Mo, MHA; Khaled M. Kebaish, MD; Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Vedat Deviren, MD; Kristen Roles, RN; Sarah Acselrod, BA; Brenda A. Sides, MA; Richard Hostin, MD; Jeffrey L. Gum, MD; Themistocles S. Protopsaltis, MD; Alan H. Daniels, MD; Samrat Yeramaneni, PhD; Renaud Lafage, MS; Christopher P. Ames, MD; Eric O. Klineberg, MD; D. Kojo Hamilton, FAANS; Frank J. Schwab, MD; Douglas C. Burton, MD; Alex Soroceanu, MPH; Han Jo Kim, MD; Robert A. Hart, MD; Michael P. Kelly, MD; Breton G. Line, BS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Lawrence G. Lenke, MD; Munish C. Gupta, MD; International Spine Study Group

Hypothesis
Race will not affect enrollment in prospective multi-center studies. Disparities in national databases will be different than those in prospective databases.

Design
Retrospective Review

Introduction
Purpose: 1) Assess racial disparities for enrollment in two prospective multi-center databases (ASD-DB1 and ASD-DB2). 2) Assess racial disparities in demographics, outcomes, in three databases: ASD-DB1, ASD-DB2, and the National Surgical Quality Improvement Program (NSQIP).

Methods
ASD-DB1 (2 year follow-up) included ASD patients from 2008-2019. ASD-DB2 (6 week follow-up) included ASD patients from 2019-2021. NSQIP (30 day follow-up) included ASD patients from 2012-2018. African Americans (AA), Asians (AN), and Hispanics (H) were compared to Caucasians (CA). Enrollment racial disparities were evaluated in ASD-DB1 and ASD-DB2.

Results
ASD-DB1: 1,356 patients. Compared to CA, AA and H were younger, AA had higher max Cobb and diabetes rates, H had lower SRS Activity, Mental, and Total, and AN had higher SRS Pain (all $p<0.05$). Demographics in counties was 66% CA, 18% AA, 16% H, and 11% AN. Enrolled in database (DB) was 91% CA, 5% AA, 0% H, 1% AN. ASD-DB2: 338 patients. Compared to CA, AAs were younger and more alone ($p<0.05$ all). Demographics in counties was 66% CA, 18% AA, 16% AA, and 11% AN. Enrolled in DB was 91% CA, 5% AA, 0% H, and 1% AN. On multivariable analysis (MVA), no disparity in complications, recovery in HRQOLs, surgical techniques, or correction were found in ASD-DB1 or ASD-DB2 ($p>0.05$ for all). NSQIP had 2,660 patients. AAs were younger and had higher rate of ASA Class 4, dependence, and diabetes (all $p<0.05$). On MVA,

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AAs more reoperation (OR 2.2), > 5 days length of stay (OR 1.63), septic shock (OR 10), renal failure (OR 6.5), and deep wound infection (OR 2.77) (all p<0.05).

Conclusion

All three databases found disparities in baseline patient presentation. Both prospective databases predominantly enrolled white patients. Neither of the prospective databases found racial disparities in complications, HRQOLs, radiographic correction, or techniques utilized. The national database found racial disparities in 30-day postoperative outcomes. This suggests there exist differences in patient populations and data granularity between nationally collected and prospective multi-center databases.

Disparities in Enrollment between two prospective multi-center studies

Database	% County White	% County Black	% County Hispanic	% County Asian	% DB White	% DB Black	% DB Hispanic	% DB Asian
ASD-DB1 Average	66%	18%	21%	10%	91%	6%	3%	1%
ASD-DB2 Range	43-83%	6-50%	3-69%	1-36%	67-100%	0-33%	0-17%	0-5%
ASD-DB2 Average	66%	18%	16%	11%	91%	5%	0%	1%
ASD-DB2 Range	43-83%	6-45%	3-29%	2-36%	80-100%	0-20%	0%	0-5%

Differences in presentation and outcomes between national and prospective ASD databases

	NSQIP			ASD-DB1			ASD-DB2		
	White	Black	p	White	Black	p	White	Black	p
	N=2,511	N=143		N=1,324	N=52		N=322	N=16	
Mean Age	64	57	**<0.001**	65	59	**0.013**	67	57	**0.010**
Gender	33%	36%	0.37	72%	60%	**0.054**	70%	81%	0.32
ASA Class			**0.007**			0.57			**0.007**
Grade I	3%	7%		5%	6%		4%	23%	
Grade II	41%	34%		51%	44%		50%	54%	
Grade III	55%	55%		43%	50%		46%	23%	
Grade IV	2%	4%		2%	0%		1%	0%	
Deep Wound Inf.	1%	4%	**0.012**	0%	0%	0.84	5%	0%	0.36
Sepsis	0%	4%	**<0.001**	1%	0%	0.51	1%	0%	0.70
LOS>5d	50%	60%	**0.013**	68%	65%	0.67	70%	75%	0.68
Return to OR	6%	11%	**0.005**	22%	27%	0.42	4%	6%	0.72

LOS = Length of Stay, ASA = Anesthesia Association

242. OBJECTIVE PHYSICAL FRAILTY VARIABLES AND THEIR RELATIONSHIP TO SHORT-TERM COMPLICATIONS IN ADULT SPINAL DEFORMITY SURGERY

Justin K. Scheer, MD; Munish C. Gupta, MD; Han Jo Kim, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Jeffrey L. Gum, MD; Michael P. Kelly, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Breton G. Line, BS; Themistocles S. Protopsaltis, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Lawrence G. Lenke, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group

Hypothesis

Adult spinal deformity (ASD) patients (pts) with worse frailty physical metrics have a higher postop complication rate

Design

Retrospective review of multicenter prospective ASD database

Introduction

Frailty is prevalent in ASD pts measured by the ASD-Frailty Index (ASD-FI) and is associated with a higher complication rate. Frailty defined by the Edmonton Frailty Score (EFS) in unknown in ASD pts as well as the association of EFS to objective physical metrics.

Methods

Adult spinal deformity pts were categorized by EFS and a timed up go test (TUG) measured in seconds and grip strength (GS) measured in lbs. Complications were collected by type and by severity of intervention: None, Mild, Moderate, and severe up to initial follow up. The 0-25th percentile (FAST for TUG, LOW for GS) and 75-100th percentile (SLOW for TUG, HIGH for GS) groups were compared for short-term postop complications.

Results

Total pts: 335, mean age 60.3±6.2yrs, 69% female. EFS: Not frail=274(81.8%), vulnerable=39(11.6%), mild frail=14(4.2%), Mod Frail=6(1.2%), severe frail=2(0.6%). The mean TUG time was 11.4±6.4sec (range 3-59sec) and the mean GS was 56.8±25.9lbs (range 4-198lbs). The TUG quartiles were: 0-25th(3-7s), 25-50th(7-10s), 50-75th(10-14s), 75-100th(14-59s). The GS quartiles were: 0-25th(4-39lbs), 25-50th(39-52lbs), 50-75th(52-69lbs), 75-100th(69-198lbs). Pts identified as any frail had significantly lower GS than those not frail (47.4±33.5lbs vs. 58.7 ± 43.4lbs, p=0.005). There were no significant differences in complication rates between the EF categories (p>0.05). SLOW TUG pts had significantly higher rate of mild complication (34/70, 48.6% vs. 27/84, 32.1%, p=0.03) and medical central nervous system (CNS) complications (4/70, 5.7% vs. 0/84, 0%, p=0.04). There were no significant differences in any of the complication types or severity for GS (p>0.05 for all).

Conclusion

ASD pts exhibit a wide range of objective TUG times and GS. While frailty in the ASD-FI was common, frailty defined by EFS in uncommon in ASD pts; It may not be a good metric for ASD pts. Pts with slow TUG times in the 75-100th percentile have a significantly higher complication rate for mild and medical CNS complications. Although these metrics provide additional objective insight into ASD pt function, longer complication follow-up may be needed to better evaluate the effect of these metrics on the postop complication profile.

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E-POSTER ABSTRACTS

243. PAIN AFTER VERTEBRAL BODY TETHER SURGERY: INCIDENCE, RISK FACTORS, AND TIMING

Michael Yang, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Alejandro Quinonez, BS; Maureen McGarry, BBE; Brandon J. Toll, BA; Harsh Grewal, FACS, FAAP; Joshua M. Pahys, MD

Hypothesis
Post-op pain after vertebral body tether (VBT) surgery is poorly characterized. We predict that patients with pre-op pain are more likely to develop post-op pain and that most will improve with time.

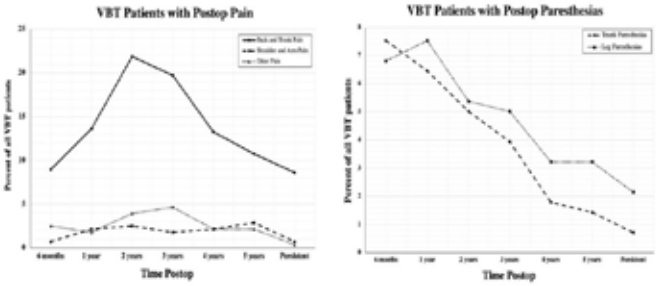
Design
Single-center retrospective

Introduction
78% of patients with adolescent idiopathic scoliosis report pre-op pain; this drops to 12% after spinal fusion. Given a paucity of data on pain after VBT, we aimed to characterize and identify risk factors for post-op pain.

Methods
We reviewed 279 patients with minimum 2-year follow-up after VBT. Demographic, radiographic, and clinical data were collected. We assessed risk factors for pain at each pre-op and post-op visit (6 weeks, 6 months, 1 year, and annually thereafter). We defined new-onset pain (NOP) as absence of pain post-op (6 weeks) with subsequent newly reported pain (6 months+), and persistent pain (PP) as contiguous pain over a year in duration and at last follow-up. Student-t tests and multivariate analysis were used to assess risk factors.

Results
The mean age was 12.7 years with 46 months follow-up; 86% were female and the mean coronal curve was 53°. 177 (63%) had reports of pre-op pain with average VAS 4.6 (range 1.5-10); 21 (12%) took analgesics pre-op. On multivariate analysis, older age (p=0.01) and larger proximal (p=0.01) and main thoracic (p=0.002) coronal curves were associated with the presence of pre-op pain. 98/279 (35%) patients reported post-op back pain. Post-op pain was associated with female gender (p=0.003), revision surgery (p=0.02), and Lenke lumbar modifier (p=0.03). Pre-op pain (p=0.07), overcorrection, adding on, and last instrumented vertebra were not associated with post-op pain. At 6 months post-op, 256/279 (92%) had pain resolution and were pain-free at last follow-up. 28/279 (10%) had NOP at 2 years which resolved within 13 months. 24/279 (9%) had PP, of which 18 had NOP that progressed to PP. The presence of a post-op complication was associated with NOP that resolved (p=0.009). 35/279 (13%) had post-op trunk and/or leg paresthesias, which decreased to 8 (3%) at last follow-up. Post-op paresthesias were more common in double vs. single tethers (52% vs. 18%, p<0.001).

Conclusion
63% of VBT patients report pre-op pain, and 35% have post-op pain. Most experience pain improvement or resolution, although small subsets develop NOP that resolves (22%) or PP (9%). Post-op paresthesias are more common with double tethers, but most resolve over time.



244. SRS PAIN DOMAIN SCORE CORRELATES TO PCS-C SCALE TOTAL SCORE IN AIS PATIENTS

Brandon A. Ramo, MD; Lydia R. Klinkerman, BS; David C. Thornberg, BS; Theresa Collins-Jones, MD

Hypothesis
Preoperatively, the SRS pain domain score correlates to the pain catastrophizing scale-children (PCS-C) total score.

Design
Prospective Cohort Study

Introduction
The SRS-22/30 is the most universally reported PRO in the literature for AIS patients. It includes several domains that can aid in the clinical decision-making process such as Pain. There is growing evidence of the effects of pain on outcomes. Measures like the PCS-C can help identify pain catastrophizing, a psychological trait which has been demonstrated in orthopedic literature to impact both nonoperative and operative patient-reported outcomes. Therefore, there may be other measures that correlate to the SRS pain domain which may increase its utility without requiring patients to complete additional PROs.

Methods
Prospective, single-center, cohort study. Data was prospectively collected between 2015-2019 for AIS Patients age≥12 who underwent PSF. Patients received the SRS-22 questionnaire and the Pain Catastrophizing Scale-Child (PCS-C) preoperatively. For the PCS, a Total Score of 30 corresponds with the 75th%tile distribution and is considered clinically significant. A Spearman's correlation was used to compare the PCS-C and the SRS pain domain. A receiver operating characteristic (ROC) curve analysis was run to identify a possible threshold value for the preop SRS Pain domain in relation to PCS-C Total Score ≥30.

Results
189 AIS patients underwent PSF with both SRS and PCS-C measures completed preoperatively. There was a strongly significant positive correlation between the PCS-C total

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

The Goldstein Award is presented to the best clinical research poster at the Annual Meeting. The Moe Award is presented to the best basic research poster at the Annual Meeting. The Program Committee selects the nominees based on abstracts and selects the winners based on the votes of attendees and the committee while at the Annual Meeting.

E-POSTER ABSTRACTS

Score and both the SRS-22 pain domain (r=-0.600, P<.05) and the SRS-22 total score (r=-0.670, p<.05). ROC curve analysis findings showed a predictive cutoff value of the preoperative SRS Pain Domain of <3.50 to identify clinically significant pain catastrophizers. The sensitivity and specificity were 0.78 and 0.95, respectively, with an area under the curve of 0.891.

Conclusion

There is a subset of the AIS patient population who experience pain catastrophizing prior to surgery. There is a strong correlation between the SRS-22 and PCS-C. Since pain catastrophizing is known to cause poorer health outcomes, accurate identification is crucial. The SRS-22 may provide a proxy for identifying these patients without increasing questionnaire fatigue/burden which could add to a surgeon's clinical decision-making tools.

245. DEVELOPMENT OF PREDICTIVE MODELS FOR PATIENT REPORTED OUTCOMES AFTER SPINAL DEFORMITY SURGERY*

Wenqi Shi, BS; Felipe Giuste, BS; Yuanda Zhu, MS; Ashley Carpenter, MS; Coleman Hilton, MS; Henry J. Iwinski, MD; John M. Wattenbarger, MD; May D. Wang, PhD

Hypothesis

Our hypothesis was that advanced machine learning techniques could be used to develop predictive models for scoliosis patient-reported outcomes (PROs) after pediatric spinal deformity surgery to facilitate precise and personalized surgical care.

Design

The purpose of this study was to develop predictive models for post-operative responses to Scoliosis Research Society-22R instrument (SRS-22R) questions with pre-operative radigoraphic measurements and PROs.

Introduction

Health-related quality of life instruments are critical in the management of pediatric diseases and the provision of individualized patient care. The SRS-22R is a disease-specific instrument composed of 22 questions classified into five categories based on their relevance to function, pain, self-image, mental health, and satisfaction. As a result, predicting post-surgical success likelihood by SRS-22R survey results is critical for patients and clinicians to make informed decisions.

Methods

Two prospective observational cohorts of patients with adolescent idiopathic scoliosis were established at Shriners Children's Hospitals in Greenville and Lexington. Pre-operative radiographic measurements and pre-operative reposnses to each of 22 questions in SRS-22R questionnaires were used in training machine learning predictive models. For each SRS-22R question, a five-class classification was performed to model the prediction ranging from best to worst. External validation was accomplished by a 70% and 30% dataset split for training and testing, respectively. The success of the predictive model was measured by accuracy to reflect the fraction of the total samples that were correctly classified.

Results

In total, 471 patients were collected from Shriners Children's Hospitals in Greenville and Lexington. The overall accuracy of 0.67 for 22 five-class classification tasks indicated the success prediction for most questions. Specifically, our model achieved most accurately prediction in patient satisfaction and function was an accuracy of 0.87 and 0.74, respectively.

Conclusion

To our knowledge, this is the first study to predict post-operative PROs to improve pedatric patient care. Predicting post-operative PROs may aid in clinical decision-making regarding spinal deformity surgery, improve pediatric patient care, and advance precision medicine.

Pre-operative prediction accuarcy for SRS-22R responses to 22 individual questions and five question groups

†Luis A. Goldstein Best Clinical Research Poster *John H. Moe Best Basic Research Poster

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INDUSTRY WORKSHOPS

The Scoliosis Research Society gratefully acknowledges
Globus Medical, Medtronic, NuVasive and ZimVie
for their support of the Annual Meeting Early Career Surgeon Session.

INDUSTRY WORKSHOPS

Annual Meeting delegates are encouraged to attend the Industry Workshops. Each workshop is programmed by a single-supporting company and will feature presentations on topics selected by the company.

*Please note: CME credits are not available for Industry Workshops.

Thursday, September 15 • 12:50 - 14:20

LOCATION	COMPANY
LEVEL 2	
Hall C1	Globus Medical
Hall C2	Medtronic
Hall C3	NuVasive
Hall C4	Stryker
LEVEL 3	
Room 38	DePuy Synthes

INDUSTRY WORKSHOP DESCRIPTIONS

DEPUY SYNTHES

Optimizing Adult and Pediatric Spinal Deformity Patient Outcomes: Case Discussions

Faculty: *Munish C. Gupta, MD (Moderator); Suken Shah, MD (Moderator); Ali A. Baaj, MD; Stephen George, MD; Sean Molloy, MD; Paul D. Sponseller, MD; Michelle C. Welborn, MD*

Description: Please join our expert surgeon panel for a workshop on Optimizing Adult and Pediatric Spinal Deformity Outcomes

GLOBUS MEDICAL, INC.

AIS Treatment: Anterior Fusion vs. Vertebral Body Tethering, benefits, limitations and potential hybrid treatments.

Faculty: *Juan C. Rodriguez-Olaverri, MD, PhD, Dr. Ahmet Alanay, MD*

Description: In this interactive panel, world recognized deformity surgeons will discuss the benefits and limitations of anterior fusion and VBT and present challenging discussion topics on hybrid options for unconventional cases.

MEDTRONIC

Accelerating the Patient-Specific Care Continuum

Faculty: *Lawrence Lenke, MD, Christopher Ames, MD & Stephen Morris, FRCS (Tr+Orth)*

Description: As the demand for customized care increases, Medtronic is driving the patient-specific care continuum through a host of complementary technologies: artificial intelligence-driven surgical planning, patient-specific spinal implants for complex constructs, and navigation and robotic-assisted surgical delivery. Together, these technologies and systems may be leveraged in a synergistic manner to drive patient-specific approaches to care. This workshop will provide a unique opportunity to discover how spine surgeons are leveraging these integrated solutions into their practice and how Medtronic is accelerating the transition to a new era of patient-specific medicine

NUVASIVE

Over a decade of MAGEC: Outcomes and efficacy through data and real-world experiences

Faculty: *Kenneth Cheung, MD, Ralf Stücker, Amer Samdani, MD, Paul Sponseller, MD, MBA Kyle Malone, MS*

Description: Join us for a case-based discussion with Professor Kenneth Cheung, Professor Ralf Stücker, Dr. Paul Sponseller and Dr. Amer Samdani on the impact that the MAGEC system has had on their early-onset scoliosis patients and on their practices over the last 10+ years. They will be discussing the clinical data supporting MAGEC, what informs their patient selection, and who they consider to be the best candidates for MAGEC. The workshop will also include a brief scientific and status update on the MAGEC system from Kyle Malone, Senior Vice President of Scientific Affairs.

STRYKER

High fidelity imaging with Airo TruCT and my journey with intraoperative guidance systems

Moderator: *Peter Newton, MD*

Faculty: *Griffin Baum, MD, Benny Dahl, MD, PhD, Rajiv Sethi, MD*

Description: Join our faculty as they discuss new preclinical data identified during a heads up comparison with Airo TruCT, 32 slice fan beam CT, when compared to O-arm 02, a cone-beam CT. We will discuss challenging cases showing how surgeons have benefited from the use of this technology and hear more about Stryker's new guidance platform that's recently been cleared for use by the FDA in the U.S.

AUTHOR INDEX

The Scoliosis Research Society gratefully acknowledges
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for their grant support of the Annual Meeting Directional Signage.

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Podium Presentations: 1-155, 1A-D, 2A-D, 3A-D; E-Posters: 200-245; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; ECCS: Early Career Surgeons Session; LTS 1: Tweeners: To Fuse or Not To Fuse? Treatment of Early Onset Scoliosis in Patients Who Are Not Yet Skeletally Mature; LTS 2: From Alignment to Balance, There is More Than One Step; LTS 3: Cervical Spine: Deformity and Instability Case Controversies; LTS 4: MIS Deformity Surgery State of the Art: How to Avoid and Manage Complications; HDC 1: Pediatric Syndromic Scoliosis: How to Safely Manage AMC to SED & Everything in Between; HDC 2: Current Updates in Understanding and Management of Intraoperative Neuromonitoring Alerts

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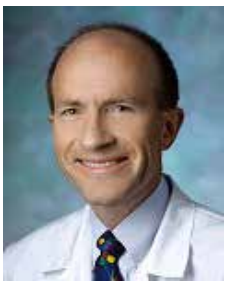

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ABOUT SRS

OVERVIEW

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 1,400 health care professionals.

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 http://www.srs.org/professionals/membership 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 http://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.

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.

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Abstract Submission Opens: August 1, 2022

Abstract Deadline: November 1, 2022

Registration Opens: December 7, 2022

SRS
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58TH ANNUAL MEETING

September 6-9, 2023

Seattle, Washington USA

Scoliosis Research Society

Abstract Submission Opens: **November 1, 2022**

Abstract Deadline: **February 1, 2023**

Registration Opens: **April 25, 2023**

www.srs.org/am23

MONDAY, SEPTEMBER 12, 2022			
08:00-14:00	SRS Board of Directors Meeting*	Room 24	Level 2
TUESDAY, SEPTEMBER 13, 2022			
07:00-17:00	Committee and Council Meetings*	Rooms 21-25	Level 2
12:00-17:00	Registration Open*	Foyer	Level 4
12:00-17:00	Speaker Ready Room Open*	Foyer	Level 5
13:00-17:00	Hibbs Society Meeting	Hall A2	Level 6
18:30-21:30	SRS Leadership Dinner (by invitation only)	Offsite	
WEDNESDAY, SEPTEMBER 14, 2022			
06:30-20:30	Registration Open*	Foyer	Level 4
06:30-19:00	Speaker Ready Room Open*	Foyer	Level 5
07:30-12:00	Pre-Meeting Course (PMC)	Hall A1	Level 5
	The Pre-Meeting Course is supported, in part, by Globus Medical, NuVasive, and ZimVie		
12:00-12:20	Lunch Pick-Up*	M1	Level 4
12:20-13:20	Lunchtime Symposia (3 Concurrent Sessions)	Halls A1, A2, A4	Levels 5 & 6
	Lunchtime Symposia are supported, in part, by Globus Medical and OrthoPediatrics		
13:20-13:40	Break*		
13:40-15:10	Abstract Session 1	Hall A1	Level 5
15:10-15:30	Refreshment Break**	M1	Level 4
15:30-17:15	Abstract Session 2	Hall A1	Level 5
17:15-17:35	Break*		
17:35-18:35	Case Discussions (3 Concurrent Sessions)	Halls A1, A2, A4	Levels 5 & 6
18:35-18:50	Break*		
18:50-20:00	Opening Ceremonies*	Hall A1	Level 5
20:00-22:00	Welcome Reception*	M1	Level 4
	The Welcome Reception is supported, in part, by Globus Medical, OrthoPediatrics and ZimVie		
THURSDAY, SEPTEMBER 15, 2022			
07:00-18:00	Registration Open*	Foyer	Level 4
07:00-18:00	Speaker Ready Room Open*	Foyer	Level 5
08:00-09:50	Abstract Session 3	Hall A1	Level 5
09:50-10:10	Refreshment Break**	M1	Level 4
10:10-12:15	Abstract Session 4	Hall A1	Level 5
12:15-12:50	Lunch Pick-Up*	M1	Level 4
12:50-14:20	Industry Workshops* (5 Concurrent Sessions)	Halls C1 - C4, Room 38	Levels 2 & 3
14:20-14:40	Refreshment Break**	M1	Level 4
14:40-17:20	Half-Day Courses (2 Concurrent Sessions)	Halls A1, A2	Levels 5 & 6
17:20-17:30	Break*		
17:30-17:45	SRS Membership Information Session	Hall C4	Level 2
17:45-17:50	Break*		
17:50-18:50	Early Career Surgeon Session	Hall C3	Level 2
	The Early Career Surgeon Session is supported, in part, by Globus Medical, Medtronic, NuVasive and ZimVie		
18:50	Early Career Surgeon Social*	C3 Foyer	Level 2
	The Early Career Surgeon Social is supported and hosted by Medtronic		
FRIDAY, SEPTEMBER 16, 2022			
07:00-17:00	Registration Open*	Foyer	Level 4
07:00-17:00	Speaker Ready Room Open*	Foyer	Level 5
07:00-08:00	Past President's Breakfast* (by invitation only)	M3	Level 2
08:00-09:50	Abstract Session 5	Hall A1	Level 5
09:50-10:10	Refreshment Break**	M1	Level 4
10:10-11:45	Abstract Session 6	Hall A1	Level 5
11:45-12:05	Lunch Pick-Up*	M1	Level 4
12:05-13:35	Member Business Meeting*	Hall A1	Level 5
12:05-13:35	Lunchtime Symposium 4	Hall A2	Level 6
	Lunchtime Symposium 4 will be live webcast and is being supported, in part, by DePuy Synthes		
13:35-13:55	Break*		
13:55-15:40	Abstract Sessions 7 and 8 (2 Concurrent Sessions)	Halls A1, A2	Levels 5 & 6
15:40-16:00	Refreshment Break**	M1	Level 4
16:00-17:45	Abstract Session 9	Hall A1	Level 5
18:30-19:30	Presidents Reception* (by invitation only)	Offsite	
19:30-22:00	Farewell Reception* (tickets required)	Offsite	
SATURDAY, SEPTEMBER 17, 2022			
07:00-08:00	SRS Board of Directors Meeting*	M3	Level 2
07:30-11:00	Registration Open*	Foyer	Level 4
07:30-11:00	Speaker Ready Room Open*	Foyer	Level 5
08:00-10:10	Abstract Session 10	Hall A1	Level 5
10:10-10:30	Break**	M1	Level 4
10:30-11:55	Abstract Session 11	Hall A1	Level 5
11:55	SRS 57th Annual Meeting Concludes		

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