58TH ANNUAL MEETING

September 6-9, 2023

Seattle, Washington, USA

Final Program

Scoliosis Research Society

www.srs.org/am23

Corporate Partners

We are pleased to acknowledge and thank those companies that **provided financial support to SRS in 2023**. 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 Outreach (REO) Fund.

Double Diamond Level Support

DePuy Synthes

Globus Medical ★

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Diamond Level Support

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★ = ASLS II Supporter

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About SRS

Annual Meeting Venue

Hyatt Regency Seattle
808 Howell Street
Seattle, WA 98101 USA

All information as of July 31, 2023.

Member's Business Meeting and Lunch

Friday, September 8 | 12:05-13:35
Regency Ballroom B | Level 7

A hot lunch will be provided.

All SRS members are invited to the 2023 Member Business Meeting. This meeting is an opportunity to hear a summary of the many activities of the Society over the last year.

The agenda will include:

- Reports from the various SRS committees presented by each Council
  - Communication
  - Education
  - Governance
  - Research
- Updates on SRS activities, programs, and financial state
- Reports from the 2021 and 2023 Traveling Fellows
- Voting for the Slate of Officers and the 2023-2024 Nominating Committee

Attendance at the Member's Business Meeting is an opportunity to not only hear updates, but actively participate in shaping the future of our Society. We encourage ALL MEMBERS to attend.

Scoliosis Research Society

Meeting Information

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

President's Message

On behalf of the Scoliosis Research Society, it is my great pleasure to welcome you to the 58th SRS Annual Meeting in Seattle, Washington.

I have been looking forward to the first fully-in person meeting in the United States since before the pandemic. We are riding positive waves from the 57th Annual Meeting in Stockholm and the recent IMAST in Dublin. We expect the mood in Seattle will prove just as uplifting and engaging.

The program this year will be among one of the best. There were more than 1,100 abstracts submitted from around the globe. Co-Chairs Amy L. McIntosh, MD and Rajiv K. Sethi, MD along with the Annual Meeting Scientific Program Committee have done outstanding work in putting together a truly great program that features an international and inclusive focus.

As always, an SRS Annual Meeting means the prestigious Hibbs Society meeting on Tuesday. The Lunchtime Symposiums on Wednesday features Bone Health Assessment and Optimization for Patients Undergoing Adult Spinal Deformity Surgery, Developing a Comprehensive Pain Management Program and Economic Outlook for Adult Spinal Deformity.

One of our "must attend" sessions is the Pre-Meeting Course on Wednesday, a Global Perspective on Spinal Deformity Care. Topics in this session include Diversity in Spinal Deformity Surgery, Impact of Scoliosis Around the World and Regional Variations in Scoliosis Surgery.

Wednesday evening will begin with the Opening Ceremonies, which includes a welcome by our local host Dr. Sethi and this year's Howard Steel Lecturer, Ann Compton. I encourage everyone to attend the ceremonies because it allows us to highlight award and research winners, thank our donors and corporate partners, and present the Walter P. Blount Humanitarian Award to this year's deserving recipient, W. Fred Hess, MD.

Thursday morning commences with sessions from the scientific program, followed by the Harrington Lecture featuring Oheneba Boachie-Adjei, MD, DSc, the President and Founder of the Foundation of Orthopedics and Complex Spine (FOCOS), and Past President of the SRS.

We will also present the 2023 Lifetime Achievement Award to a member who has exhibited long and distinguished service to SRS and to spinal deformity research and care, Douglas C. Burton, MD.

New this year, on Thursday, is the Introduction to Leadership program. This half-day session is limited to 100 participants and highlights include Introduction to Leadership in the SRS Organization, Communication with Stakeholders and Strategy. If you want to find your path to leadership within the SRS or within your associations, this course was created for you.

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 six concurrent 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 Member's Business Meeting will be held during lunch and will cover all the updates from our committees, budget, progress reports and outlook for the coming year.

We close the 58th Annual Meeting with a half-day of scientific sessions on Saturday, including the Transfer of the Presidency.

It has been an honor and a wonderful experience to be the 53rd President of the Scoliosis Research Society. Helping our members develop leadership skills, both within our society and for their home institutions, has been a rewarding part of my presidential tenure. We will continue to grow and expand our society by tapping into the experience of our current and past leaders, related societies, as well as our industry partners.

Best wishes to all for a great meeting!

Serena S. Hu, MD
SRS President, 2022-2023

Annual Meeting Committees

SRS President

Serena S. Hu, MD

Local Host

Rajiv K. Sethi, MD

SRS Education Council Chair

Munish C. Gupta, MD

Annual Meeting Scientific Program Committee

Amy L. McIntosh, MD, Co-Chair
Rajiv K. Sethi, MD, Co-Chair
Shay Bess, MD, Past Chair
Ivan Cheng, MD, Co-Chair Elect
Mitsuru Yagi, MD, PhD, Co-Chair Elect
Jennifer M. Bauer, MD, MS, Vice Chair
Joseph P. Gjolaj, MD, FACS, FAOA
Michael C. Albert, MD
David E. Lebel, MD, PhD
Mostafa H. El Dafrawy, MD
Griffin R. Baum, MD, MSc
James T. Bennet, MD
Elizabeth L. Lord, MD
Patrick J. Cahill, MD
Satoru Demura, MD
Jeffrey L. Gum, MD
Ibrahim Obeid, MD
Michael J. Heffernan, MD

Annual Meeting Education Committee

Mark A. Erickson, MD, Co-Chair
Charla R. Fischer, MD, Co-Chair
Justin S. Smith, MD, PhD Past Chair
Brian Hsu, MD, Co-Chair Elect
Javier Pizones, MD, PhD Co-Chair Elect
A. Noelle Larson, MD, Vice Chair
Amy L. McIntosh, MD
Rajiv K. Sethi, MD
Daniel J. Miller, MD
Jeffrey P. Mullin, MD, MBA
Megan Johnson, MD
Tulio Moura Rangel, MD
Eren O. Kuris, MD
Brian J. Neuman, MD
Nick Sekouris, PhD
Benjamin Daniel Elder, MD, PhD
Joseph P. Davey, MD
Marissa M. Muccio, PT
Ibrahim Obeid, MD
Luiz Müller Avila, MD
Byron F. Stephens, MD
Alpaslan Senkoylu, MD
Ali A. Baaj, MD

Program Abstract Reviewers

Md Yousuf Ali
Keith R. Bachmann, MD
Junseok Bae, MD
Paloma Bas Hermida, MD
Saumyajit Basu, MD
David B. Bumpass, MD
Michael S. Chang, MD
David B. Cohen, MD, MPH
Joseph P. Davey, MD
Romain Dayer, MD
Eugenio Dema, MD
Christopher J. DeWald, MD
Bassel G. Diebo, MD
Joseph P. Gjolaj, MD, FACS, FAOA
Judson W. Karlen, MD
David Lazarus, MD
Darren R. Lebl, MD, MBA
Jean-Christophe A. Leveque, MD
Scott J. Luhmann, MD
Hossein Mehdian, MD, FRCS(Ed)
Ahmad Nassr, MD
Karl E. Rathjen, MD
Fernando Techy, MD
Khoi D. Than, MD
Surya Prakash Rao Voleti, MS, DNB
John S. Vorhies, 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 81 E-Point Presentations will be presented on an array of topics, including adolescent idiopathic scoliosis, neuromuscular scoliosis, growing spine, kyphosis, adult deformity, minimally invasive surgery, and machine learning.

Learning Objectives

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

- Increase level of knowledge and understanding of the diversity of regional variations within Spinal deformity care and management across the globe.
- Evaluate the multidisciplinary care driven management and diagnostic decision making to increase optimization in spinal deformity surgery.
- Discuss the most recent approaches based on evidence-based research to develop pain management protocol.
- Review surgical techniques and tools available for obtaining ideal spinal deformity correction.

Target Audience

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

Registration Desk Hours

Location: Level 3, Foyer

Tuesday, September 5	12:00-17:00
Wednesday, September 6	06:30-20:00
Thursday, September 7	07:00-18:00
Friday, September 8	07:00-17:00
Saturday, September 9	07:30-11:00

Speaker Ready Room

Location: Level 3, Room 308 | Quilcene

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 5	12:00-17:00
Wednesday, September 6	06:30-19:00
Thursday, September 7	07:00-18:00
Friday, September 8	07:00-17:00
Saturday, September 9	07:30-11:00

Accreditation Statement

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

Credit Designation

SRS designates this live activity, 58th SRS Annual Meeting, for a maximum of 31 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in each activity.

Disclosure of Relevant Financial Relationships

It is the policy of SRS to ensure balance, independence, objectivity, and scientific rigor in all educational activities. In accordance with this policy, SRS identifies all financial relationships held with an ineligible company* by individuals in a position to influence or control the content of a CME activity. Relevant financial relationships are mitigated 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 can be found on page 23.

**An ineligible company is one whose primary business is producing, marketing, selling, re-selling, or distributing healthcare products used by or on patients.*

Wireless Internet

Wireless Internet access is available throughout the meeting space.

Network: SRSAM23
Password: SCOLIOSIS

Wireless internet for the SRS Annual Meeting is supported, in part, by Stryker.

SRS DEI Table

Location: Level 3, Foyer

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

The SRS DEI Table is supported, in part, by Stryker and ZimVie.

General Information

SRS Membership Desk

Location: Level 3, Columbia Ballroom Prefunction 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 Historical Display

Location: Level 3, Foyer

Explore the unique history of the SRS at the Historical Display. The SRS Historical Committee, in conjunction with SRS Archivist, Katie Dold, MLIS, has created a display highlighting the early history of the SRS and its members.

Abstract Volume

All abstracts accepted for presentation at the 58th Annual Meeting are published in the Final Program. All 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/am23/program) and in the Annual Meeting mobile app.

E-Point Presentations

There are 81 E-Point Presentations available to view on the E-Point Presentation kiosks located on Level 3.

The E-Point Presentation Kiosks are supported, in part, by ZimVie

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.

Recorded Sessions | SpineLearning

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

All registered meeting attendees will be granted access to the recorded sessions 3-4 weeks following the Annual Meeting. To access the virtual content, go to https://SpineLearning.brightspace.com, select "I have an account on the SRS website", enter your SRS username and password, click "Continue", and select 58th 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 Meeting.

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 AM23 Meeting App. Your input and comments are essential in planning future Annual Meetings.

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.

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 presentations of any kind. SRS holds the right to confiscate 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 accommodation or assistance, please notify a SRS staff member. SRS will make every effort to accommodate any special needs.

Emergency & First Aid

The Hyatt Regency Seattle is fully prepared to handle emergency requests and first aid. Contact a SRS staff person for support. Remember to note all emergency exits within the venue.

General Information

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 losses 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 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 **#SRSAM23** in your social media posts.

@srs_org

@ScoliosisResearchSociety

@ScoliosisResearchSociety

@srs_org

Session and Event Information

Hibbs Society Meeting - $50

Tuesday, September 5 | 13:00-17:00
Available to 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. The Hibbs Society Meeting is planned by the SRS Traveling Fellows and will highlight current concepts and controversies around optimization of care ranging from early onset scoliosis to idiopathic scoliosis to adult deformity surgery.

Opening Ceremonies and Welcome Reception

Wednesday, September 6
Opening Ceremonies | 18:50-20:00
Welcome Reception | 20:00-22:00
Available at no charge to meeting delegates, $100 per registered guest

The Annual Meeting will officially begin with the Opening Ceremonies and this year's Howard Steel Lecturer, Ann Compton. The Opening Ceremonies are the kick off to another wonderful meeting, giving the Society the opportunity to highlight award and research winners, thank our donors and corporate partners, and will include the presentation of the Walter P. Blount Humanitarian Award.

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

If you would like to purchase guest ticket(s), you may do so at the SRS Registration Desk.

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

Early Career Surgeon Session

Thursday, September 7 | 17:50-18:50
Available at no charge to 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 Medtronic, NuVasive, and Stryker.

Early Career Surgeon Social

Thursday, September 7 | beginning at 18:50
Available at no charge to meeting delegates

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 7 | 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 SI-BONE and ZimVie. Please see page 237 for program information.

Member's Business Meeting

Friday, September 8 | 12:05-13:35

All SRS members are invited to the Member Business Meeting. The agenda will include reports from the various SRS committees, updates on SRS activities and programs, and voting. Attendance at the Member's Business Meeting is an opportunity to not only hear updates, but actively participate in shaping the future of our Society. We encourage *ALL MEMBERS* to attend. A hot lunch will be provided.

Live Webcast

Friday, September 8 | 12:05-13:35

On Friday, September 8 from 12:05-13:35, LTS 4: Conservative Care for Adolescent Idiopathic Scoliosis: Brace and Scoliosis-specific Exercises, will be webcast live. More information about the webcast is available on the AM23 website: www.srs.org/am23.

Farewell Reception - $50

Friday, September 8 | 19:30-22:00
The Museum of Flight
Available to meeting delegates for an additional fee of $50, $150 per registered guest

Open to all registered attendees and guests of registered attendees. Registration is required and tickets 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. Tickets are $50 for registered attendees and $150 for registered guests.

Attire is business or cocktail.

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 2023.
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

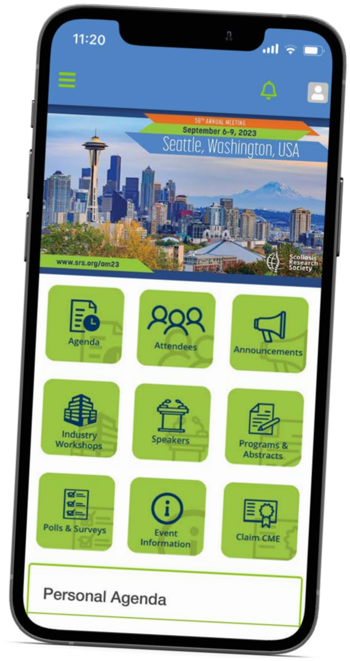
1. Open the downloaded app and enter the email address you registered with to sign up or log in.
2. If you already have an account, you will be asked to enter your password. If you do not already have an account, you will be prompted to create a password and add profile information (optional).
3. The app can also be accessed by entering the URL, www.event-mobi.com/am23 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 Registration Desk to learn more about gamification and the Annual Meeting app.

Meeting Outline

MONDAY, SEPTEMBER 4, 2023			
08:00 - 17:00	SRS Board of Directors Meeting*	302 | Beckler	Level 3
TUESDAY, SEPTEMBER 5, 2023			
07:00 - 08:00	Committee Chair Breakfast*	402 | Chiliwack	Level 4
08:00 - 17:00	Committee and Council Meetings*	301 | Ashnola 302 | Beckler 303 | Bogachiel 304 | Calawah 305 | Chelais	Level 3 Level 3 Level 3 Level 3 Level 3
12:00 - 17:00	Registration Open*	Foyer	Level 3
12:00 - 17:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
13:00 - 17:00	Hibbs Society Meeting	Regency Ballroom B	Level 7
18:30 - 21:30	SRS Leadership Dinner* *(by invitation only)*	Offsite	
WEDNESDAY, SEPTEMBER 6, 2023			
06:30 - 20:30	Registration Open*	Foyer	Level 3
06:30 - 19:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
07:30 - 12:00	Pre-Meeting Course (PMC) *The Pre-Meeting Course is supported, in part, by ZimVie.*	Columbia Ballroom	Level 3
09:35 - 10:00	Refreshment Break*	Foyer	Level 3
12:00 - 12:20	Lunch Pick-Up*	Foyer	Level 3
12:20 - 13:20	Lunchtime Symposia (LTS) *(3 Concurrent Sessions)*	Columbia Ballroom Regency Ballroom A Regency Ballroom B	Level 3 Level 7 Level 7
13:20 - 13:40	Break*		
13:40 - 15:10	Abstract Session 1 | Adult Spinal Deformity	Columbia Ballroom	Level 3
15:10 - 15:30	Refreshment Break*	Foyer	Level 3
15:30 - 17:15	Abstract Session 2 | Adolescent Idiopathic Scoliosis	Columbia Ballroom	Level 3
17:15 - 17:35	Break*		
17:35 - 18:35	Case Discussions *(3 Concurrent Sessions)*	Columbia Ballroom Regency Ballroom A Regency Ballroom B	Level 3 Level 7 Level 7
18:35 - 18:50	Break*		
18:50 - 20:00	Opening Ceremonies*	Columbia Ballroom	Level 3
20:00 - 22:00	Welcome Reception* *The Welcome Reception is supported, in part, by Globus Medical and ZimVie.*	Foyer	Level 3
THURSDAY, SEPTEMBER 7, 2023			
07:00 - 18:00	Registration Open*	Foyer	Level 3
07:00 - 18:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
08:00 - 09:50	Abstract Session 3 | Quality/Safety/Value/Complications	Columbia Ballroom	Level 3
09:50 - 10:10	Refreshment Break*	Foyer	Level 3
10:10 - 12:15	Abstract Session 4 | Adolescent Idiopathic Scoliosis and Harrington Lecture	Columbia Ballroom	Level 3
12:15 - 12:50	Lunch Pick-Up*	Foyer	Level 3
12:50 - 14:20	Industry Workshops* *(6 Concurrent Sessions)*	301 | Ashnola 302 | Beckler 305 | Chelais 401 | Chelan 402 | Chiliwack 405 | Kachess	Level 3 Level 3 Level 3 Level 4 Level 4 Level 4

*Denotes non-CME Session/Activity

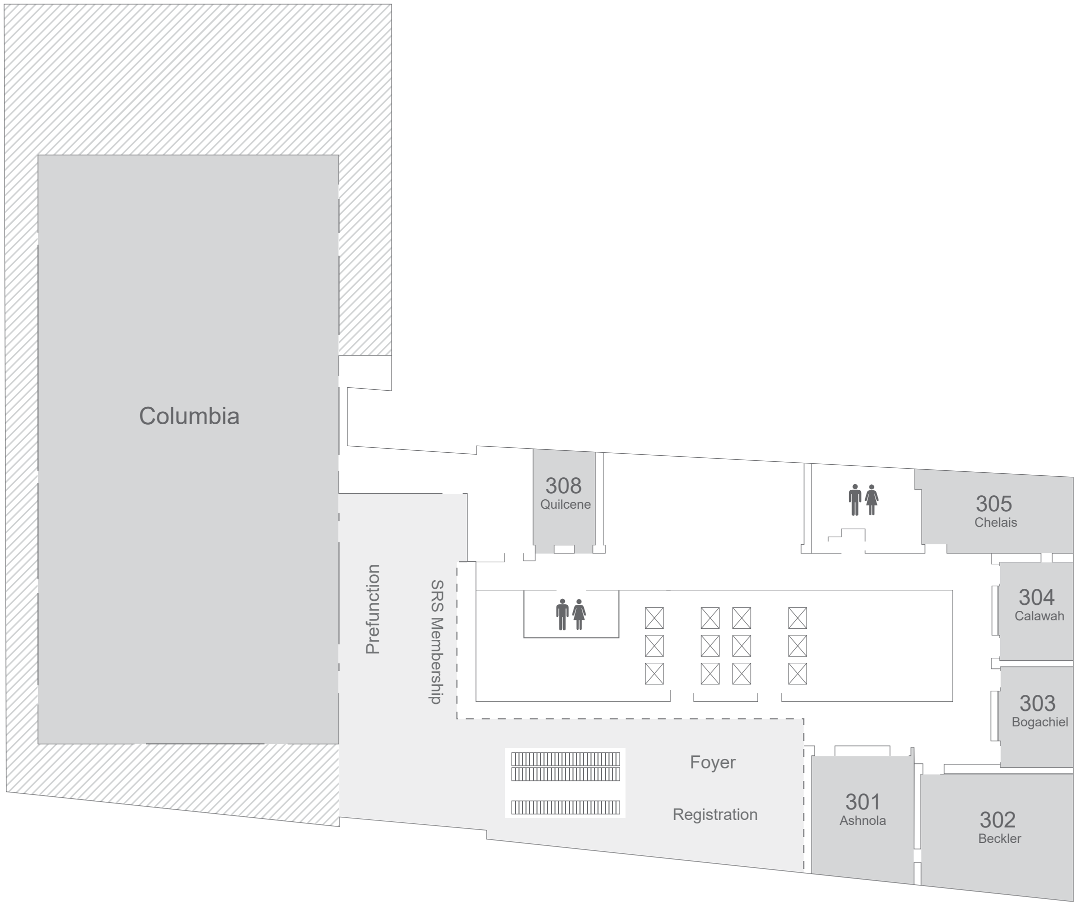
Meeting Outline

THURSDAY, SEPTEMBER 7, 2023, continued.			
14:20 - 14:40	Refreshment Break*	Foyer	Level 3
14:40 - 17:20	Half-Day Courses (HDC) *(3 Concurrent Sessions)*	Columbia Ballroom Regency Ballroom A Regency Ballroom B	Level 3 Level 7 Level 7
17:20 - 17:30	Break*		
17:30 - 17:45	SRS Membership Information Session*	401 | Chelan	Level 4
17:45 - 17:50	Break*		
17:50 - 18:50	Early Career Surgeon Session* *The Early Career Surgeon Session is supported, in part, by Medtronic, NuVasive and Stryker.*	Regency Ballroom A	Level 7
18:50	Early Career Surgeon Social* *The Early Career Surgeon Social is hosted by Medtronic.*	Regency Ballroom Foyer	Level 7
FRIDAY, SEPTEMBER 8, 2023			
07:00 - 17:00	Registration Open*	Foyer	Level 3
07:00 - 17:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
07:00 - 08:00	Past Presidents' Breakfast* *(by invitation only)*	402 | Chiliwack	Level 4
08:00 - 09:50	Abstract Session 5 | Hibbs Award-Nominated Papers	Columbia Ballroom	Level 3
09:50 - 10:10	Refreshment Break*	Foyer	Level 3
10:10 - 11:45	Abstract Session 6 | Cervical Deformity and Presidential Address	Columbia Ballroom	Level 3
11:45 - 12:05	Lunch Pick-Up*	Foyer	Level 3
12:05 - 13:35	Member Business Meeting and Lunch*	Regency Ballroom B	Level 7
12:05 - 13:35	Lunchtime Symposium 4 | Conservative Care for Adolescent Idiopathic Scoliosis: Brace and Scoliosis-specific Exercises *Lunchtime Symposium 4 will be live webcast.*	Columbia Ballroom	Level 3
13:35 - 13:55	Break*		
13:55 - 15:40	Abstract Session 7A | Adult Spinal Deformity II Abstract Session 7B | Adolescent Idiopathic Scoliosis and Adult Spinal Deformity Controversies	Regency Ballroom B Columbia Ballroom	Level 7 Level 3
15:40 - 16:00	Refreshment Break*	Foyer	Level 3
16:00 - 17:45	Abstract Session 8 | Early Onset Scoliosis, Kyphosis, Basic Science	Columbia Ballroom	Level 3
18:30 - 19:30	President's Reception* *(by invitation only)*	Offsite	
19:30 - 22:00	Farewell Reception* *(tickets required)*	Offsite	
SATURDAY, SEPTEMBER 9, 2023			
07:00 - 08:00	SRS Board of Directors Meeting*	402 | Chiliwack	Level 4
07:30 - 11:00	Registration Open*	Foyer	Level 3
07:30 - 11:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
08:00 - 10:10	Abstract Session 9 | Miscellaneous, Hibbs Award Presentation, and Transfer of Presidency	Columbia Ballroom	Level 3
10:10 - 10:30	Refreshment Break*	Foyer	Level 3
10:30 - 11:55	Abstract Session 10 | Neuromuscular and Miscellaneous	Columbia Ballroom	Level 3
11:55	SRS 58th Annual Meeting Concludes		

**Denotes non-CME Session/Activity*

Meeting Space Floorplans

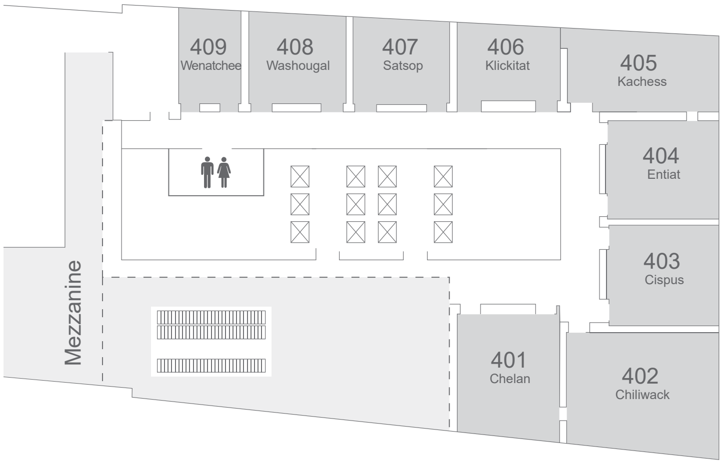
LEVEL 3



Meeting Room	Function
Columbia Ballroom	Opening Ceremonies | Wednesday General Session | Wednesday-Saturday Concurrent Sessions | Wednesday-Friday
Foyer & Prefunction	Registration Refreshment Breaks; SRS Membership; DEI Table; Historical Display Welcome Reception | Wednesday
301 | Ashnola	SRS Committee & Council Meetings | Tuesday Industry Workshop | Thursday
302 | Beckler	SRS Board of Directors Meeting | Monday SRS Committee & Council Meetings | Tuesday Industry Workshop | Thursday
303 | Bogachiel	SRS Committee & Council Meetings | Tuesday SRS Meeting Room | Wednesday-Saturday
304 | Calawah	SRS Committee & Council Meetings | Tuesday SRS Meeting Room | Wednesday-Saturday
305 | Chelais	SRS Committee & Council Meetings | Tuesday Industry Workshop | Thursday
308 | Quilcene	Speaker Ready Room

Meeting Space Floorplans

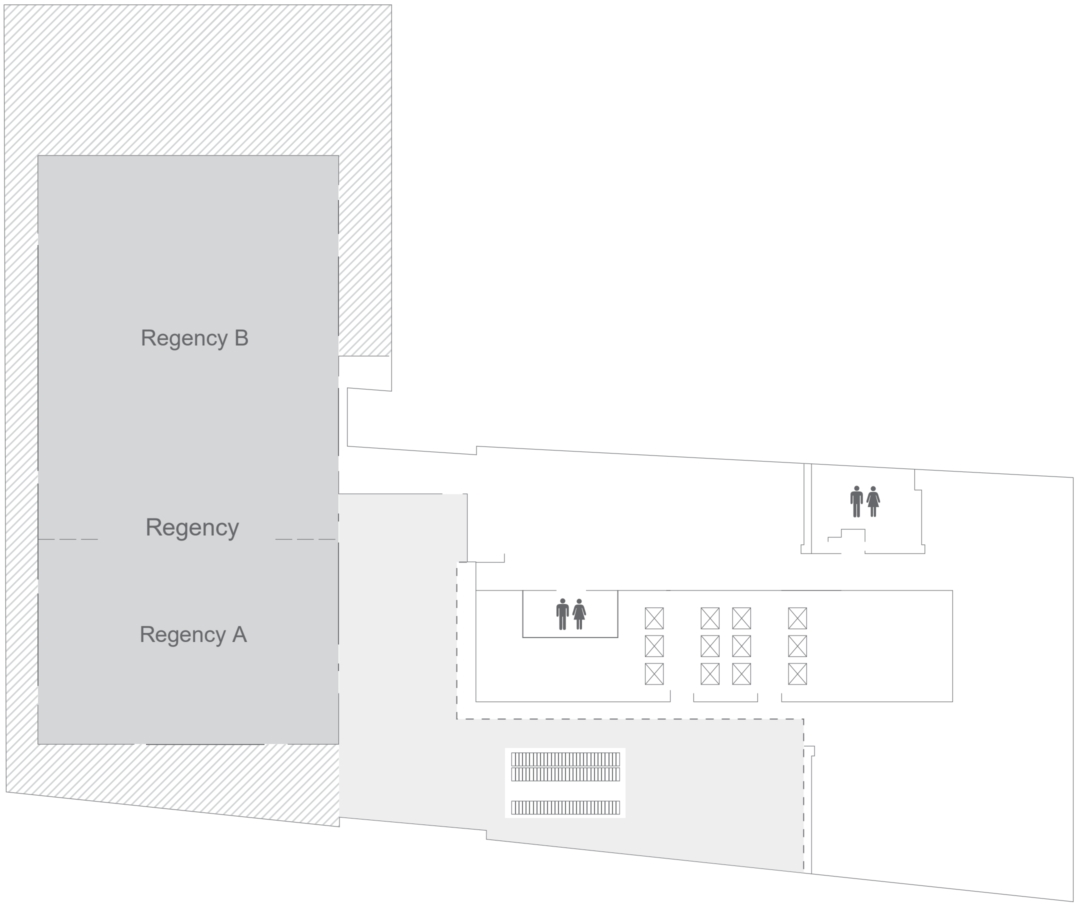
LEVEL 4



Meeting Room	Function
401 | Chelan	Industry Workshop | Thursday SRS Member Info Session | Thursday
402 | Chiliwack	Committee Chair Breakfast | Tuesday Industry Workshop | Thursday SRS Past Presidents' Breakfast | Friday SRS Board of Directors Meeting | Saturday
403 | Cispus	Double Diamond Hospitality Suite: NuVasive | Wednesday-Saturday
404 | Entiat	Double Diamond Hospitality Suite: Globus Medical | Wednesday-Saturday
405 | Kachess	Industry Workshop | Thursday
406 | Klickitat	Double Diamond Hospitality Suite: ZimVie | Wednesday-Saturday
407 | Satsop	Double Diamond Hospitality Suite: DePuy Synthes | Wednesday-Saturday
408 | Washougal	Double Diamond Hospitality Suite: Medtronic | Wednesday-Saturday
409 | Wenatchee	Diamond Hospitality Suite: Stryker | Wednesday-Saturday

Meeting Space Floorplans

LEVEL 7



Meeting Room	Function
Regency A Ballroom	Concurrent Sessions | Wednesday-Thursday Early Career Surgeon Session | Thursday
Regency B Ballroom	Hibbs Society Meeting | Tuesday Concurrent Sessions | Wednesday-Friday SRS Member Business Meeting | Friday

Guest Lectures

Wednesday, September 6

Howard Steel Lecture: The White House - Journeys through Chaos and Hope

Ann Compton

Ann Compton has always been a pioneer.

As the first woman assigned to cover the White House on network television and with 41 years on the air for ABC News, her longevity and impact are unparalleled. Compton's career spanned seven presidents and 10 presidential campaigns. President Barack Obama announced her retirement when calling on her at a West Wing news conference saying, "Ann Compton, everybody here knows, is not only the consummate professional but is also just a pleasure to get to know."

Traveling with President George W. Bush on September 11, 2001, Ann was the only broadcast reporter allowed to remain on Air Force One to report on behalf of all the press during the chaotic hours following the terrorist attacks when the President was unable to return directly to Washington. For that coverage Compton received special recognition in the awards bestowed on ABC's coverage, including an Emmy, a Peabody, and the Silver Baton from the DuPont awards at Columbia University.

Her colleagues elected Compton as president of the White House Correspondents' Association for 2007-2008 and chair of the Radio- Television Correspondents' on Capitol Hill in 1987-1988. The Commission on Presidential Debates selected Compton to serve as a debate panelist in 1988 and 1992.

After retiring from daily coverage in 2014, Compton reignited her legendary career by returning to ABC to cover the 2016 political conventions, as well as accepting a fellowship at Harvard's Kennedy School of Government Institute of Politics focusing on media coverage of the 2016 election.

She has been inducted into six halls of fame and has received five honorary university degrees. Ann is married to Dr. William Hughes, a physician in Washington,D.C., and they are the parents of three sons and a daughter and the proud grandparents of nine.

Compton says her most valued award is a golden statuette bestowed by the National Mothers' Day committee naming her a "Mother of the Year" in 1988.

Thursday, September 7

Harrington Lecture: Optimizing Complex Spine Deformity Treatment in Underserved Regions - My Odyssey

Oheneba Boachie-Adjei, MD, DSc

Prof. Oheneba Boachie-Adjei is the President and Founder of the Foundation of Orthopedics and Complex Spine (FOCOS). He completed his Secondary school education at Opoku Ware School in Kumasi and received a Bachelor of Science from Brooklyn college in NYC in 1976. He completed his medical education at Columbia University in 1980, an Orthopedic residency at the Hospital for Special Surgery (HSS) in New York in 1986 and a Spine fellowship at the Twin Cities Scoliosis Center in 1987.

Prof. Boachie-Adjei is an Emeritus Prof. of Orthopaedic Surgery at Weill Cornell Medical an emeritus chief of the Scoliosis Service at (HSS).

He received the Scoliosis Research Society (SRS) Russell Hibbs award for Best Clinical Paper in 1989, 2002 & 2013 and the Louis Goldstein Award for Best Clinical Poster in 1999 and 2002. He was named the HSS Philip D. Wilson Outstanding Teacher in 1998. He received the Distinguished Alumnus award in 2003 by Brooklyn College, the AAOS Humanitarian award in 2004, the SRS Blount Service Award in 2006 and the HSS Lifetime Achievement Award in 2013. He served as President of the SRS in 2008-2009. In 2015, he received an honorary doctorate by Brooklyn College. He was featured in the Discovery channel documentary "Surgery Saved My Life." and CNN's African Voices as the Surgeon transforming Spine Surgery in Ghana. In 2016 the University Of Toledo, Ohio inducted him into their Global Medical Mission Hall of Fame. In 2017-2021 he won eight more international awards.

Prof. Boachie-Adjei has published extensively on Spine surgery and is an inventor with several patents.

On the 19th November 2020 Nana Prof. was sworn in as Otumfuo Hiahene at the Manhyia palace in Kumasi. He is married to Hilda and they have 3 sons Kwadwo, Yaw and Kwame.

2023 SRS Awards

2023 Walter P. Blount Humanitarian Award

Presented for outstanding service to those with spinal deformity and for generosity to the profession and Society. The 2023 Blount award will be presented on Wednesday, September 6.

W. Fred Hess, MD

Dr. W. Fred Hess is currently emeritus Chief of Spine at the Janet Weis Childrens Hospital/Geisinger Medical Center in Danville, PA. He joined the Department of Orthopaedic Surgery in August 1990, following the completion of the Rae R. Jacobs Memorial Spine Fellowship at the Kansas University Medical Center.

Dr. Hess was born in York, PA and raised with a strong faith instilled by his parents. His interest in science was sparked by one of his college professors who opened a world of neuroanatomy to him. It was also in college where he met his wife Heather, who encouraged him to become a Young Life leader working with high school students.

Marriage and a move to University of South Florida College of Medicine in Tampa, FL led him to a career in orthopaedics. He was then appointed Surgical General Medical Officer with the US Public Health Service from 1982-85, where he served the Native Americans of the Navajo Area IHS. When he returned to USF, he completed his Orthopaedic Residency and his Fellowship at KUMC.

Upon arriving at GMC, Dr. Hess became highly involved in the community, serving as team doctor for the High School, teaching Sunday school, and covering several Pennsylvania Crippled Childrens Clinics (Sunbury, Bloomsburg, and Danville). When one of the local orthopaedic surgeons asked him to assist with a scoliosis fusion, this prompted his first mission trip to Cuenca, Ecuador in February 1994, where he performed a complex spine reconstruction on a young woman with Marfan's Syndrome. This led to Dr. Hess accepting 1-2 children per year from Ecuador and other Latin American countries for Spine Deformity Care at GMC. Additionally, through Families for Missions, he and his family (Heather, Ashley, and Andy) made numerous trips to Haiti and Jamaica.

Accompanying daughter Ashley to Accra, Ghana in April 2002, Dr. Hess connected with his friend Dr. Boachie-Adjei, FOCOS, and the indomitable Bettye Wright, solidifying his commitment to providing care to those with severe spinal deformities. This resulted in him taking 1-4 trips per year to Ghana (2002-2017), Barbados, and most recently Jamaica through the Ken Paonessa and Duncan Tree Foundation. Heather has also made several trips independently over the years, offering nursing care and staff education. The pleasure of these trips comes not only from caring for the patients, but also from teaching the local staff and other surgeons who are willing to help.

He has been an active member of several prestigious organizations, including the SRS, AAOS, ACS, ATLS Instructor, ABOS, AMA, PAMED, EOA, Hanlon Society, ISOLA Study Group, CSSG, and the Christian Medical and Dental Association. In 2002, he was honored with the Albright College Distinguished Alumni Award for his exemplary community service and medical mission work.

2023 Lifetime Achievement Award

Presented to a member who has exhibited long and distinguished service to SRS and to spinal deformity research and care. The 2023 Lifetime Achievement award will be presented on Thursday, September 7.

Douglas C. Burton, MD

Douglas Burton, M.D. is the past Peltier/Reckling Professor and Chair and current Marc and Elinor Asher Spine Professor in the Department of Orthopedic Surgery at the University of Kansas Health System. He received his undergraduate degree from Kansas State University in Manhattan, KS and his MD from the University of Texas Southwestern in Dallas, TX. He completed his orthopedic residency at the University of Kansas Medical Center and completed spine fellowships at The Texas Back Institute in Plano, TX and at Thomas Jefferson University in Philadelphia, PA. He joined the KU School of Medicine faculty in 2000.

Dr. Burton has been an active fellow in the SRS since 2004 and currently serves as the Research Council Chair and member of the Executive Committee. He has previously served as an At-Large member of the Board of Directors and has chaired the Fellowship, Outcomes & Benchmarking (formerly M&M), and Evidence Based Outcomes Committees and the Evidence Based Medicine Task Force. He served as the SRS FOSA representative and on the Research and Fellowship Taskforces. At the SRS Annual Meeting and IMAST, he has been honored with the Hibbs (2), Goldstein (2), Moe, and Whitecloud (2) Awards.

He is a member of the American Academy of Orthopaedic Surgeons, the American Orthopaedic Association, the Interurban Orthopaedic Society, and the North American Spine Society. He served as the co-chair of the Data Use Committee for the American Spine Registry. He was President of the Federation of Spine Associations from 2018 to 2019.

His research interests include the development of disease specific health related quality of life instruments and the study of complications and outcomes associated with spinal deformity surgery. He has authored or co-authored over 300 peer reviewed publications and serves as a Deputy Editor of *Spine Deformity*, the official journal of the Scoliosis Research Society.

In 2006 he helped found and remains on the Executive Council of the International Spine Study Group. This is consortium of spinal deformity surgeons and researchers at over 15 top academic centers in the United States and Canada with collaborators in Europe and Japan. They have been performing prospective and retrospective studies on surgical and non-surgical adult spinal deformity patients since their inception.

SRS Annual Meeting Awards

The 2023 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-Point Presentations (John H. Moe and Louis A. Goldstein Awards) at the 58th Annual Meeting will be presented on Saturday, September 9.

57th Annual Meeting Russell A. Hibbs Awards

Presented to the best basic science and clinical research papers at the 57th Annual Meeting.

2022 Hibbs Award for Best Basic Science/Translational Research Paper

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 Koike, 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

2022 Hibbs Awards for Best Clinical Research Paper

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 Gehrch¬en, MD, PhD; Benny T. Dahl, DMSc

57th Annual Meeting John H. Moe and Louis A. Goldstein Awards

Presented to the best basic science and clinical research E-Point Presentations at the 57th Annual Meeting.

2022 John H. Moe Award for Best Basic Science/Translational Research Poster

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

2022 Louis A. Goldstein Award for Best Clinical Research Poster

Pre-Operative Carbohydrate Drink for Early Recovery in Pediat¬ric Spine Fusion: Randomized Control Trial

Jennifer M. Bauer, MD; Kathryn B. Anderson, BS; Eliot B. Grigg, MD

Relevant Financial Relationship Disclosures

The Scoliosis Research Society gratefully acknowledges ZimVie for their support of the Pre-Meeting Course.

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Relevant Financial Relationship Disclosures

Full Name	Country	Disclosure(s)
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Full Name	Country	Disclosure(s)
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Relevant Financial Relationship Disclosures

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Relevant Financial Relationship Disclosures

Full Name	Country	Disclosure(s)
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Richard G. Fessler, MD	United States	DePuy Synthes (b); Spinal Elements (b); InQ Innovations (g); Orthofix (b)

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Full Name	Country	Disclosure(s)
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Charla R. Fischer, MD	United States	Globus Medical (b); NuVasive (b); Zimmer Biomet (b)
Jeffrey Fischgrund, MD	Italy	Stryker Spine (b); Relievant (b); FzioMed (b); Asahi (b)
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Sumeet Garg, MD	United States	Medtronic (b)
Kelly Gassie, MD	United States	No Relationships
David Ge, MD	United States	No Relationships
Zhaohui Ge, MD	China	No Relationships
Eric Geng, BA	United States	No Relationships
Stephen G. George, MD	United States	No Relationships
Paul Gerdhem, MD, PhD	Sweden	DePuy Synthes (g); Philips Healtcare (a); Brainlab AG (a)
Ismat Ghanem, MD, MS	Lebanon	No Relationships
Michelle Gilbert, PA-C	United States	No Relationships
Mika Gissler, PhD	Finland	No Relationships
Edina Gjonbalaj, BS	United States	No Relationships
Halil Gok, MD	Turkey	No Relationships

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Relevant Financial Relationship Disclosures

Full Name	Country	Disclosure(s)
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Alejandro Gomez-Rice, MD, PhD	Spain	Stryker Spine (b)
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Christine Goodbody, MD	United States	No Relationships
Prakash Gorroochurn, PhD	United States	No Relationships
Randolph Gray, MD	Australia	No Relationships
Benjamin Groisser, MS	Israel	No Relationships
Brian E. Grottkau, MD	United States	3D Biotherapeutics Inc (c)
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Nina Grundlingh, MS	United States	No Relationships
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Tenner Guillaume, MD	United States	Zimmer Biomet (b); NuVasive (b)
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Purnendu Gupta, MD	United States	No Relationships
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Abdelrahman Hamouda, BS	United States	No Relationships
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Full Name	Country	Disclosure(s)
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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.)

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Eric O. Klineberg, MD	United States	DePuy Synthes (b); Stryker Spine (b); Medtronic (b); AOSpine (a, e); SI Bone (b); Agnovos (b); Seaspine (b); MMI (c); Relatable (c)

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.)

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Full Name	Country	Disclosure(s)
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Relevant Financial Relationship Disclosures

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Meeting Agenda

The Scoliosis Research Society gratefully acknowledges NuVasive, Shriners Children's and Stryker for their Educational Grant support of the Annual Meeting.

Meeting Agenda

Tuesday, September 5, 2023

Program (topics, timing, and faculty) is subject to change.

13:00 - 17:00 Regency Ballroom B | Level 7

Hibbs Society Meeting

Chairs: Steven W. Hwang, MD, Michelle C. Welborn, MD, Hamid Hassanzadeh, MD & Robert W. Gaines, MD

13:00 - 14:15 Regency Ballroom B | Level 7

Hibbs Society 1 | Early Onset Scoliosis

Moderator: Michelle C. Welborn, MD

13:00 - 13:05 **Welcome and Background on Hibb's Society**
Robert W. Gaines, MD

13:05 - 13:07 **Introduction**
Michelle C. Welborn, MD

13:07 - 13:15 **Bracing vs. Casting Can We Cure Patients with Infantile Scoliosis**
Stuart L. Weinstein, MD

13:15 - 13:23 **Orthosis as a Temporizing Measure vs. a Primary Treatment**
Craig M. Birch, MD

13:23 - 13:31 **Casting and Bracing 2.0 How to Modify for Alternative Populations**
G. Ying Li, MD

13:31 - 13:41 **Case Discussion**

13:41 - 13:49 **Ideal Age of Index Surgical Treatment Is Anytime a Good Time?**
Jason Pui Yin Cheung, MD, MBBS, MS, FRCS

13:49 - 13:57 **Growth Guidance vs Distraction Based vs Other Picking the Right Construct for the Right Kiddo**
Patrick J. Cahill, MD

13:57 - 14:05 **When Is Good Enough, Good Enough Pulling the Trigger on Fusion**
Suken A. Shah, MD

14:05 - 14:15 **Case Discussion**

14:15 - 15:25 Regency Ballroom B | Level 7

Hibbs Society 2 | Adolescent Idiopathic Scoliosis

Moderator: Steven W. Hwang, MD

14:15 - 14:17 **Introduction**
Steven W. Hwang, MD

14:17 - 14:19 **Case Presentation: VBT vs Fusion: When Is Each Option Better?**
Steven W. Hwang, MD

14:19 - 14:25 **When is VBT Best?**
Amer F. Samdani, MD

14:25 - 14:31 **When is Fusion Best?**
Daniel J. Sucato, MD, MS

14:31 - 14:37 **When to do Both or Hybrid?**
Ahmet Alanay, MD

14:37 - 14:50 **Case Discussion**

14:50 - 14:52 **Case Presentation: Have We Made Any Progress in AIS Surgery?**
Steven W. Hwang, MD

14:52 - 14:57 **Have Indications for Selective Thoracic Fusions Changed?**
Meric Enercan, MD

14:57 - 15:02 **Should We Avoid Selective Fusions**
Muharrem Yazici, MD

Meeting Agenda

Tuesday, September 5, 2023

Program (topics, timing, and faculty) is subject to change.

15:02 - 15:07 **Ponte's and Apical Discectomies Are Enough**
Suken A. Shah, MD

15:07 - 15:12 **There Is Still a Role for 3 Column Osteotomies in AIS**
Lawrence G. Lenke, MD

15:12 - 15:25 **Case Discussion**

15:25 - 15:45 Foyer | Level 7

Refreshment Break

15:45 - 17:00 Regency Ballroom B | Level 7

Hibbs Society 3 | Adult Spinal Deformity

Moderator: Hamid Hassanzadeh, MD

15:45 - 15:47 **Introduction**
Hamid Hassanzadeh, MD

15:47 - 15:54 **Adult Spinal Deformity Patient; Should We Always Fuse to the Pelvis?**
Khaled M. Kebaish, MD

15:54 - 16:01 **Adult on Idiopathic vs. Degenerative Scoliosis: How Different Are They?**
Lawrence G. Lenke, MD

16:01 - 16:08 **Adult Patients With Prior AIS Surgery**
Michael P. Kelly, MD

16:08 - 16:18 **Case Discussion**

16:18 - 16:25 **Risk Stratification in Elderly Deformity Patients, When to Say No**
Christopher I. Shaffrey, MD

16:25 - 16:32 **How to Measure Success and Failure in Adult Spine Deformity Surgery**
Shay Bess, MD

16:32 - 16:39 **Best Approach: Is There a Role for Anterior Surgery?**
Munish C. Gupta, MD

16:39 - 16:46 **High Grade Spondy**
Robert W. Gaines, MD

16:46 - 16:56 **Case Discussion**

16:56 - 17:00 **Concluding Remarks**
Robert W. Gaines, MD

18:30 - 21:30

Leadership Dinner (by invitation only)

Meeting Agenda

Wednesday, September 6, 2023

Program (topics, timing, and faculty) is subject to change.

07:30 - 12:00 Columbia Ballroom | Level 3

Pre-Meeting Course
A Global Perspective on Spinal Deformity Care

Chairs: Mark A. Erickson, MD & Charla R. Fischer, MD

07:30 - 07:35 **Course Welcome**
Mark A. Erickson, MD & Charla R. Fischer, MD

07:35 - 08:13 Columbia Ballroom | Level 3

Part 1 | Diversity in Spinal Deformity Surgery

Moderators: Ali A. Baaj, MD & Benjamin D. Elder, MD, PhD

07:35 - 07:50 **Diversity in Spine Surgery I**
Qusai Hammouri, MD, MBBS

07:50 - 08:05 **Diversity in Spine Surgery II**
Megan E. Johnson, MD

08:05 - 08:13 **Discussion**

08:13 - 09:35 Columbia Ballroom | Level 3

Part 2 | Impact of Scoliosis Around the World

Moderators: Luiz Müller Avila, MD & Eren O. Kuris, MD

08:13 - 08:15 **Transition to Part 2**
Luiz Müller Avila, MD & Eren O. Kuris, MD

08:15 - 08:27 **Scoliosis in Latin America**
Karen A. Weissmann, MD, PhD

08:27 - 08:39 **Impact of Scoliosis in India**
Sajan K. Hegde, MD

08:39 - 08:51 **EPOS Spine Study Group: Consensus on Idiopathic EOS Management**
Brice Ilharreborde, MD, PhD

08:51 - 09:01 **Discussion**

09:01 - 09:13 **Effect of Scoliosis in Turkey**
Ahmet Alanay, MD

09:13 - 09:25 **EPOS Spine Study Group: Consensus on Non-idiopathic EOS Management**
Ilkka J. Helenius, MD, PhD

09:25 - 09:35 **Discussion**

09:35 - 10:00 Foyer | Level 3

Refreshment Break

10:00 - 10:58 Columbia Ballroom | Level 3

Part 3 | Regional Variations in Scoliosis Surgery

Moderators: A. Noelle Larson, MD & Brian J. Neuman, MD

10:00 - 10:02 **Transition to Part 3**
A. Noelle Larson, MD & Brian J. Neuman, MD

10:02 - 10:12 **Scoliosis Treatment in Brazil**
Alexandre Fogaca Cristante, FRCS(C)

10:12 - 10:22 **Treatment of Spinal Deformity in South Korea**
Yongjung J. Kim, MD

10:22 - 10:30 **Discussion**

Meeting Agenda

Wednesday, September 6, 2023

Program (topics, timing, and faculty) is subject to change.

10:30 - 10:40 **Spinal Defrmity Surgery in Japan**
Mitsuru Yagi, MD, PhD

10:40 - 10:50 **Addressing Spinal Deformity in Political Conflict (Palestine)**
Alaaeldin Azmi Ahmad, MD

10:50 - 10:58 **Discussion**

10:58 - 12:00 Columbia Ballroom | Level 3

Part 4 | Effect of SRS and Mission Work Around The World

Moderators: Alpaslan Senkoylu, MD & Túlio A. Rangel, MD

10:58 - 10:59 **Transition to Part 4**
Alpaslan Senkoylu, MD & Túlio A. Rangel, MD

10:59 - 11:09 **Impact of SRS Global Courses**
Andre Luis Andujar, MD

11:09 - 11:19 **Impact of SRS Hands on Course**
Kenny Y. Kwan, MD

11:19 - 11:27 **Discussion**

11:27 - 11:37 **Developing Medical Missions**
Emmanuel N. Menga, MD

11:37 - 11:47 **Long Term Perspectives on Medical Mission Work**
Gregory M. Mundis Jr., MD

11:47 - 11:55 **Discussion**

11:55 - 12:00 **Closing Comments**
Mark A. Erickson, MD & Charla R. Fischer, MD

12:00 - 12:20 Foyer | Level 3

Lunch Pickup

12:20 - 13:20

Lunchtime Symposia (LTS) (three concurrent sessions)

12:20 - 13:20 Columbia Ballroom | Level 3

LTS 1 | Bone Health Assessment and Optimization for Patients Undergoing Adult Spinal Deformity Surgery

Moderators: Venu M. Nemani, MD, PhD & John R. Dimar, II, MD

12:20 - 12:23 **Introduction**
Venu M. Nemani, MD, PhD

12:23 - 12:28 **Case Presentation: My Patient is Scheduled for an Adult Spinal Deformity Reconstruction and has a T-Score of -2.6, Now What?**
Jean-Christophe A. Leveque, MD

12:28 - 12:38 **What Does a Comprehensive Bone Health Assessment Look Like and What are the Treatment Options? The Endocrinology Perspective**
Susan Ott, MD
**This speaker is sponsored, in part, by the Sponseller Interdisciplinary Fund*

12:38 - 12:53 **Panel Discussion 1: Pre-Operative Bone Health Evaluation and Optimization**
Benny T. Dahl, MD, PhD, DMSc; Paul C. Celestre, MD; Jean-Christophe A. Leveque, MD; Susan Ott, MD

12:53 - 13:03 **The Impact of Poor Bone Quality on Outcomes Following ASD Surgery**
Mitsuru Yagi, MD, PhD

13:03 - 13:18 **Panel Discussion 2: Operating on a Patient with Poor Bone Health - Pearls and Pitfalls**
Dominique A. Rothenfluh, MD, PhD; Zeeshan Sardar, MD; Brandon B. Carlson, MD; Mitsuru Yagi, MD, PhD

13:18 - 13:20 **Conclusion**
John R. Dimar, II, MD

12:20 - 13:20 Regency Ballroom B | Level 7

LTS 2 | Developing a Comprehensive Pain Management Program: The Before, During and After

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

12:20 - 12:23 **Introduction**
Michelle C. Welborn, MD

12:23 - 12:28 **Starting Early, Building Resilience in our Brace Patients**
Catherine McClellan, PhD
**This speaker is sponsored, in part, by the Sponseller Interdisciplinary Fund*

12:28 - 12:33 **SurgeryPal Program and Optimizing Patients Preoperatively**
Jennifer Rabbitts, MD

12:33 - 12:38 **PROMIS Scores and their Ability to Predict Outcomes**
Daniel Bouton, MD

12:38 - 12:43 **Prognostication in the Adult Risk Factors for Poor Outcomes and How to Modify Them**
Jeffrey L. Gum, MD

12:43 - 12:49 **Discussion**

12:49 - 12:54 **Intraoperative Adjuncts to Pain Management**
Amy L. McIntosh, MD

12:54 - 12:59 **The Road to Recovery in Less Than Ideal Patients Intraoperative and Postoperative Optimization Strategies**
Serena S. Hu, MD

12:59 - 13:04 **ERAS Program, Building a Multimodal Pain Management**
Nicholas D. Fletcher, MD

13:04 - 13:09 **The Role of Preoperative and Postoperative Physical Therapy**
Michelle C. Welborn, MD

13:09 - 13:14 **Minimizing Long-term Use of Pain Medications in Pediatric and Adult Patients**
Michael P. Kelly, MD

13:14 - 13:20 **Discussion**

12:20 - 13:20 Regency Ballroom A | Level 7

LTS 3 | Economic Outlook for Adult Spinal Deformity: The Past, Present and Future

Moderators: Rajiv K. Sethi, MD & Marinus de Kleuver, MD, PhD

12:20 - 12:25 **Introduction**
Rajiv K. Sethi, MD

12:25 - 12:29 **Mechanics of Basic Health Economics in View of Adut Spinal Deformity**
Philip K. Louie, MD

12:29 - 12:33 **Advocacy to Government and Stakeholders in Spine Surgery: Why Surgeons Should be Involved in Government and Reimbursement**
David W. Polly Jr., MD

12:33 - 12:37 **Global Perspectives: What Can we Learn from European Health Economics**
Ferran Pellisé, MD, PhD

12:37 - 12:41 **Team Strategies: Multidisciplinary Strategies and how to Build the Economic Model**
Lawrence G. Lenke, MD

12:41 - 12:45 **Centers of Excellence for ASD Surgery and Preferred Reimbursement**
Jesse Shen, MD, PhD

12:45 - 12:49 **Predictive Analytics and AI in Spine: Is this just an Academic Topic or an Actual Gamechanger?**
Vijay Yanamadala, MD, MS, MBA

Meeting Agenda

Program (topics, timing, and faculty) is subject to change.

12:49 - 12:57 **Discussion**

12:57 - 13:17 **Panel Discussion: Adult Spinal Deformity Across Generations of Surgeons, What has Changed and what Challenges Remain. Will Cost Preclude Progress?**
Ahmet Alanay, MD; Evalina L. Burger, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Kota Watanabe, MD, PhD

13:17 - 13:20 **Conclusion**
Rajiv K. Sethi, MD

13:20 - 13:40

Break

13:40 - 15:10 Regency Ballroom A | Level 7

Abstract Session 1 | Adult Spinal Deformity

Moderators: Eric O. Klineberg, MD & Kota Watanabe, MD, PhD

13:40 - 13:45 **Introduction**

13:45 - 13:49 **Paper #1: Twenty-year Follow-up after Single Level Lumbar Fusion, a Retrospective Analysis**
José Spirig, MD; Shayan Golshani, MD; Mazda Farshad, MPH; Michael Betz, MD

13:49 - 13:53 **Paper #2: Change in Spinal Bone Mineral Density as Estimated by Hounsfield Units following Osteoporosis Treatment with Romosozumab, Teriparatide, Denosumab, and Alendronate: An Analysis of 318 Patients**
Anthony Mikula, MD; Nikita Lakomkin, MD; Abdelrahman Hamouda, BS; Megan C. Everson, MD; Zach Pennington, MD; Rahul Kumar, MD, PhD; Zachariah W. Pinter, MD; Michael Martini, PhD; Kurt A. Kennel, MD; Francis Baffour, MD; Ahmad Nassr, MD; Arjun Sebastian, MD; Kingsley Abode-Iyamah, MD; Mohamad Bydon, MD; Paul A. Anderson, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD

13:53 - 13:57 **Paper #3: ASD with High PT have Decreased Hamstring Lengths Both in Standing Position and During Walking**
Guillaume Rebeyrat, MS; Ayman Assi, PhD; Rami Rachkidi, MD, MS; Abir Massaad, PhD; Mohammad I. Karam, PhD; Ismat Ghanem, MD, MS; Helene Pillet, PhD; Wafa Skalli, PhD

13:57 - 14:06 **Discussion**

14:06 - 14:10 **Paper #4: Osteoporotic Patients on Teriparatide Have Lower Pseudoarthrosis Rate Compared to Patients with Osteopenia**
Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Erik Lewerenz, BS; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

14:10 - 14:14 **Paper #5: Measuring Acetabular Orientation in the Lewinnek Plane is Not Suitable for ASD Patients with High Pelvic Retroversion**
Elena Jaber, MS; Rami Rachkidi, MD, MS; Ali Rteil, MS; Elma Ayoub, MS; Maria Saadé, MS; Celine Chaaya, MS; Rami Rhayem, BS; Elio Mekhael, BS; Nabil Nassim, BS; Mohammad I. Karam, PhD; Abir Massaad, PhD; Ismat Ghanem, MD, MS; Virginie Lafage, PhD; Wafa Skalli, PhD; Ayman Assi, PhD

14:14 - 14:18 **Paper #6: Are NIH and Industry Payments Related to the Type of Attention Articles Receive?**
Daniel Farivar, BS; Kenneth D. Illingworth, MD; Amar Vadhera, BS; David L. Skaggs, MD, MMM

14:18 - 14:22 **Discussion**

14:22 - 14:31 **Paper #7: Comparison of Radiographic and Clinical Outcomes of Adult vs Adolescent Scheuermann Kyphosis Patients: A Matched Cohort Analysis after Surgery**
Caglar Yilgor, MD; Altug Yucekul, MD; Tais Zulemyan, MSc; Yasemin Yavuz, PhD; Baron S. Lonner, MD; Ibrahim Obeid, MD; Burt Yaszay, MD; Frank S. Kleinstueck, MD; Suken A. Shah, MD; Javier Pizones, MD, PhD; Harry L. Shufflebarger, MD; Francisco Javier S. Perez-Grueso, MD; Peter O. Newton, MD; Ferran Pellisé, MD, PhD; Ahmet Alanay, MD; Harms Study Group ; European Spine Study Group

14:31 - 14:35 **Paper #8: Long Term Mechanical Failure In Well Aligned ASD Patients**
Sleiman Haddad, MD, PhD, FRCS; Susana Núñez Pereira, MD; Javier Pizones, MD, PhD; Manuel Ramirez Valencia, MD; Caglar Yilgor, MD; Ahmet Alanay, MD; Frank S. Kleinstueck, MD; Ibrahim Obeid, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; European Spine Study Group

14:35 - 14:39 **Paper #9: Validation of Lordosis Distribution Index for Predicting Mechanical Complications After Long Level Fusion Surgery: A Comparison of GAP Score and Roussouly Classification**
Myung-Hoon Shin, MD, PhD

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

14:48 - 14:52 **Paper #10: Comparing the Upper Instrumented Vertebrae Tilt Angle Versus Screw Angle in the Development of Proximal Junction Kyphosis after Adult Spinal Deformity Surgery: Which Matters More?**
Keyan Peterson, MD, MS; Hani Chanbour, MD; Jeffrey W. Chen, BS; Michael Longo, MD; Soren Jonzzon, MD; Steven G. Roth, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MPH

14:52 - 14:56 **Paper #11: Self-Image Is Underestimated as a Primary Driver for Patient Treatment and Surgical Satisfaction In Adult Spinal Deformity (ASD)**
Douglas C. Burton, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Stephen J. Lewis, MD, FRCS(C); Breton G. Line, BS; Lawrence G. Lenke, MD; Eric O. Klineberg, MD; Christopher P. Ames, MD; Robert K. Eastlack, MD; Gregory M. Mundis, MD; Jeffrey L. Gum, MD; D.Kojo Hamilton, FAANS; Virginie Lafage, PhD; Renaud Lafage, MS; Alan H. Daniels, MD; Munish C. Gupta, MD; Michael P. Kelly, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Justin S. Smith, MD, PhD; International Spine Study Group

14:56 - 15:00 **Paper #12: Adult Spinal Deformity Patients Revised for Pseudarthrosis have Comparable 2Yr Outcomes to those not undergoing any Revision Surgery**
Sarthak Mohanty, BS; Andrew Platt, MD; Fthimnir Hassan, MPH; Erik Lewerenz, BS; Christopher Mikhail, MD; Stephen Stephan, MD; Joshua Baksheshian, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

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

15:10 - 15:30 Foyer | Level 3

Refreshment Break

15:30 - 17:15 Columbia Ballroom | Level 3

Abstract Session 2 | Adolescent Idiopathic Scoliosis

Moderators: Jennifer M. Bauer, MD, MS & Peter O. Newton, MD

15:30 - 15:34 **Paper #13: Natural History of Low-Grade Isthmic Spondylolisthesis Found Incidentally in Asymptomatic Children. A Longitudinal Cohort Study of 151 Patients with Minimum 2-Year Follow-Up.**
Antoine Dionne, BS; Abdulmajeed Alzakri, MD; Hubert Labelle, MD; Julie Joncas, RN; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

15:34 - 15:38 **Paper #14: Development of Pelvic Incidence, Sacral Slope and Pelvic Tilt and the Effect of Age, Sex, and BMI: An Automated 3D-CT Study of 882 Children and Adolescents**
Grant D. Hogue, MD; Eduardo Novais, MD; Mallika Singh, MS; Mohammadreza Movahhedi, BS; Ata Kiapour, PhD

15:38 - 15:42 **Paper #15: Functional Motion and Balance Improve after Posterior Spinal Fusion in AIS**
Tori Kinamon, BA; Anthony A. Catanzano, MD; Mary Jackson, PT; Elizabeth Sachs, Research Coordinator; Robert K. Lark, MD

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

15:51 - 15:55 **Paper #16: Surface Topographic Chest Volume Measurements Strongly Correlate with Pulmonary Function Volume Measurements in Pediatric Spinal Deformity Patients**
Jessica H. Heyer, MD; Jenna L. Wisch, BS; Kiranpreet K. Nagra, BA; Ankush Thakur, MS; Howard Hillstrom, PhD; Colson P. Zucker, BA; Benjamin Groisser, MS; Matthew E. Cunningham, MD, PhD; M. Timothy Hresko, MD; Ram Haddas, PhD; John S. Blanco, MD; Mary F. Di Maio, MD; Roger F. Widmann, MD

15:55 - 15:59 **Paper #17: The Impact of Mental Health on Post-Operative Outcomes for Adolescents Undergoing Posterior Spinal Fusion for Idiopathic Scoliosis at a Tertiary Care Children's Hospital in an Underserved Region**
Leila Mehraban Alvandi, PhD; Kathryn Segal, BS; Jorden Xavier, BS; Alexandria Debasitis, BS; Edina Gjonbalaj, BS; David Ge, MD; Jacob F. Schulz, MD; Jaime A. Gomez, MD; Eric Fornari, MD

15:59 - 16:03 **Paper #18: Have We Improved Anterior Vertebral Body Tethering Outcomes Over Time? An Examination of Survivorship Trends**
Joshua Tadlock, MD; Peter O. Newton, MD; Tracey P. Bastrom, MA; Stefan Parent, MD, PhD; Ahmet Alanay, MD; Dan Hoernschemeyer, MD; Firoz Miyanji, MD; Harms Non-Fusion C. Study Group

Meeting Agenda

Wednesday, September 6, 2023

Program (topics, timing, and faculty) is subject to change.

16:03 - 16:12 **Discussion**

16:12 - 16:16 **Paper #19: Outcomes of Anterior Vertebral Body Tethering in Lenke 1AR vs. 1AL Curve Types**
Joshua Pahys, MD; Steven W. Hwang, MD; Terrence G. Ishmael, MBBS; Alejandro Quinonez, BS; Jason Woloff, BS; Maureen McGarry, BBE; Kaitlin Kirk, BS; Emily Nice, BS; Amer F. Samdani, MD

16:16 - 16:20 **Paper #20: Does Screw Density Influence Transverse Plane Correction in AIS Instrumentation: A Comprehensive 3D Biomechanical Study Complementary to the MIMO Clinical Trial?**
Carl-Eric Aubin, PhD; Xiaoyu Wang, PhD; Mathieu Chayer; David W. Polly, MD; Christian Bellefleur, MS, Eng; Christiane Caouette, PhD; Stefan Parent, MD, PhD; A. Noelle Larson, MD
** Partially funded by an SRS Grant*

16:20 - 16:24 **Paper #21: Epidemiology of Surgical Management for Pediatric Spondylolysis and Spondylolisthesis**
Wesley M. Durand, MD; Miguel A. Cartagena-Reyes, BS; Paul D. Sponseller, MD, MBA; Amit Jain, MD

16:24 - 16:33 **Discussion**

16:33 - 16:37 **Paper #22: Thoracic Kyphosis Maintenance in Lenke 1 AIS: Vertebral Body Tethering Versus Posterior Spinal Fusion**
Baron S. Lonner, MD; Ashley Wilczek, BS; Peter O. Newton, MD; Dan Hoernschemeyer, MD; Amer F. Samdani, MD; Stefan Parent, MD, PhD; Firoz Miyanji, MD; Ahmet Alanay, MD; Burt Yaszay, MD; Suken A. Shah, MD; Harms Study Group

16:37 - 16:41 **Paper #23: Prediction of Curve Progression in Adolescent Idiopathic Scoliosis with Bone Microarchitecture Phenotyping by an Unsupervised Machine Learning Protocol**
Kenneth GP Yang, PhD, MBBS; Wayne YW Lee, PhD; Lik Hang Alec Hung, MBBS, MS, FRCS; Jack C. Cheng, MD, FRCS; Tsz-Ping Lam, MBBS, FRCS

16:41 - 16:45 **Paper #24: Predicting Outcomes of Thoraco-Lumbo-Sacral Orthosis Treatment in Adolescent Idiopathic Scoliosis**
Kristin J. Smith, CO; Brian M. Benish, CO; Elizabeth A. Nelson, MPH; Meghan E. Munger, MPH; Joseph H. Perra, MD; John E. Lonstein, MD; Tom F. Novacheck, MD; Carol J. Hentges, CO; Jennifer E. Fawcett, CO; Michael H. Schwartz, PhD

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

16:54 - 16:58 **Paper #25: Chronic Nerve Root Injury in Pediatric Patients with Chronic Lumbar Stress Fractures**
Cole D. Tessendorf, MS3; Kyle Haddick; John McClellan, MD

16:58 - 17:02 **Paper #26: The Kids Are Not Alright: The Decline of Pre-Operative SRS Scores over Time in Patients with Adolescent Idiopathic Scoliosis**
Adam Jamnik, BA; David C. Thornberg, BS; Chan-hee Jo, PhD; Jaysson T. Brooks, MD; Amy L. McIntosh, MD; Brandon Ramo, MD

17:02 - 17:06 **Paper #27: The Oswestry Disability Index is Valid in Children**
Karina A. Zapata, PhD, PT, DPT; Chan-Hee Jo, PhD; Brandon A. Ramo, MD; Jaysson T. Brooks, MD

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

17:15 - 17:35
Break

Program (topics, timing, and faculty) is subject to change.

17:35 - 18:35

Case Discussions (three concurrent sessions)

17:35 - 18:35 Regency Ballroom A | Level 7

Case Discussion 1 | Cervical & IONM

Moderators: Amer F. Samdani, MD & Han Jo Kim, MD

17:35 - 17:50 **Paper #CD-1: Gout-Induced Cervical Deformity and Progressive Myelopathy Mimicking Infection Requiring Cervical Reconstruction**
Philip K. Louie, MD; Hannah Boudreaux, PA-C; Jesse Shen, MSc; Devon Lefever, MD; Venu M. Nemani, MD, PhD

17:50 - 18:05 **Paper #CD-2: Aborted AIS Spinal Fusion Due To Persistent Loss of IONM: Which Patients Are At Greatest Risk?**
Amy L. McIntosh, MD; Lydia Klinkerman, BS; Megan E. Johnson, MD

18:05 - 18:20 **Paper #CD-3: Severe Cervical Kyphosis of Neurofibromatosis Type 1 with Intradural Tumor in a Pediatric Patient with 2-year Follow-up**
Siyi Cai, MD; Ye Tian, MD; Xin Chen, MD

18:20 - 18:35 **Paper #CD-4: Craniovertebral Angle (CVA) and Head Position Should be Considered in Autistic AIS Patients**
Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Aravind Patil, MD; Terry D. Amaral, MD

17:35 - 18:35 Columbia Ballroom | Level 3

Case Discussion 2 | Early Onset Scoliosis

Moderators: Lindsay M. Andras, MD & Michael G. Vitale, MD, MPH

17:35 - 17:50 **Paper #CD-5: Paralysis and Repeated Rod Fractures During Traditional Dual Growing Rods Treatment in a Patient With Marfanoid-Progeroid-Lipodystrophy Syndrome: More than 9-year Follow-up**
Yang Yang, MD; Nan Wu, MD; Shengru Wang, MD, PhD; Terry Jianguo Zhang, MD

17:50 - 18:05 **Paper #CD-6: Rib Fracture and Pneumothorax during Intraoperative Magnetic Rod Distraction**
Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Aravind Patil, MD; Terry D. Amaral, MD

18:05 - 18:20 **Paper #CD-7: Time and Distance: The Temporal and Travel Burden Associated with Growth-Friendly Surgical Treatment of Early Onset Scoliosis**
Ryan McFadden, BS; Lucas Hauth, BS; Jason Brett Anari, MD; Jaysson T. Brooks, MD; Jeffrey R. Sawyer, MD; Maxwell D. Marshall, BM; Pediatric Spine Study Group; Robert F. Murphy, MD

18:20 - 18:35 **Discussion**

17:35 - 18:35 Regency Ballroom B | Level 7

Case Discussion 3 | Rare Cases

Moderators: Ron El-Hawary, MD & John S. Vorhies, MD

17:35 - 17:50 **Paper #CD-9: Posterior Temporary Internal Distraction with Anterior Release and Subsequent Spinal Fusion for the Treatment of Severe Scoliosis**
Daisuke Yamabe, MD, PhD; Hideki Murakami, MD, PhD; Hirooki Endo, MD, PhD; Yusuke Chiba, MD, PhD; Hirotaka Yan, MD; Minoru Doita, MD, PhD

17:50 - 18:05 **Paper #CD-10: Outcomes after Completing Growth-Friendly Surgical Treatment for Early Onset Scoliosis in Patients with Skeletal Dysplasia**
Antti J. Saarinen, MD; Paul D. Sponseller, MD, MBA; George H. Thompson, MD; John B. Emans, MD; Patrick J. Cahill, MD; Steven W. Hwang, MD; Lindsay M. Andras, MD; Klane K. White, MD; Amer F. Samdani, MD; Pediatric Spine Study Group; Ilkka J. Helenius, MD, PhD

18:05 - 18:20 **Paper #CD-11: Congenital Dislocation Spine: A Rare Case Report with Diagnostic Dilemma**
Shah Waliullah, PhD, MBBS, MS

18:20 - 18:35 **Paper #CD-12: The Case for Posterior Spinal Fusion Surgery in Severe Thoracolumbar Neuromuscular Scoliosis with Chronic Hip Dislocation**
Paige Miller, BA; Lauren Lamont, MD

Meeting Agenda

Wednesday, September 6, 2023

Program (topics, timing, and faculty) is subject to change.

18:35 - 18:50

Break

18:50 - 20:00 Columbia Ballroom | Level 3

Opening Ceremonies

18:50 - 18:53 **Welcome to Seattle**
Rajiv K. Sethi, MD

18:53 - 18:56 **Presidential Message**
Serena S. Hu, MD

18:56 - 18:59 **Acknowledgement of 2023 Research Grant Recipients**
Michelle C. Welborn, MD

18:59 - 19:02 **Acknowledgement of 2023 Biedermann Innovation Award Recipient**
Markku Biedermann, MD

19:02 - 19:05 **Acknowledgement of 2023 SRS-Cotrel Foundation Basic Science Research Grant Recipient**
Nicolas Plais, MD

19:05 - 19:08 **Acknowledgement of 2023 Awards & Scholarship Winners**
Paul C. Celestre, MD

19:08 - 19:15 **Presentation of Blount Humanitarian Award**
Paul C. Celestre, MD

19:15 - 19:33 **Acknowledgement of Corporate Supporters**
Christopher I. Shaffrey, MD

19:33 - 19:38 **Introduction of Howard Steel Lecturer**
Serena S. Hu, MD

19:38 - 19:58 **Howard Steel Lecture**
Ann Compton

19:58 - 20:00 **Closing Remarks**
Serena S. Hu, MD

20:00 - 22:00 Foyer | Level 3

Welcome Reception

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

Meeting Agenda

Thursday, September 7, 2023

Program (topics, timing, and faculty) is subject to change.

08:00 - 09:50 Columbia Ballroom | Level 3

Abstract Session 3 | Quality/Safety/Value/Complications

Moderators: Shay Bess, MD & Suken A. Shah, MD

08:00 - 08:05 **Introduction**

08:05 - 08:09 **Paper #40: Does Weight Loss Reduce the Risk of Obesity-Related Complications in Spine Fusion Surgery?**
Camryn Myers, BS; Abel De Varona-Cocero, BS; Fares Ani, MD; Constance Maglaras, PhD; Themistocles Protopsaltis, MD

08:09 - 08:13 **Paper #41: Intra-Abdominal Content Movement In Prone Versus Lateral Decubitus Position Lateral Lumbar Interbody Fusion (LLIF.)**
Cristiano Menezes, MD, PhD; Luciene M. Andrade, MD, PhD; Gabriel C. Lacerda, MD; Marlus M. Salomão, MD; Mark T. Freeborn, MD; J A. Thomas, MD

08:13 - 08:17 **Paper #42: Surgeons Beware! Defining the "No Surgery Recommended" (NSR) Patient Who Should Not Undergo ASD Surgery**
Jeffrey L. Gum, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Jeffrey P Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MPH; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D.Kojo Hamilton, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

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

08:26 - 08:30 **Paper #43: Achievement and Maintenance of Optimal Alignment Following Adult Spinal Deformity Corrective Surgery: A 5 Year Outcome Analysis**
Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Renaud Lafage, MS; Virginie Lafage, PhD; D. Kojo Hamilton, MD, FAANS; Peter G. Passias, MD

08:30 - 08:34 **Paper #44: Neuro-monitoring can be Safely Stopped 20 minutes after Pediatric Spine Deformity Correction. The 20-minute Rule.**
John T. Smith, MD; Nancy Campbell, DO; Jonathon Umina, BS; Joshua Klatt, MD; John A. A. Heflin, MD; Jayden Brennan, BS

08:34 - 08:38 **Paper #45: Metal Hypersensitivity Prevalence in Pediatric Spine Surgery**
Alvin C. Jones, MD; Nichole S. Leitsinger, BS; Lindsay R. Schultz, CCRP; Viral V. Jain, MD

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

08:47 - 08:51 **Paper #46: Intrawound Vancomycin Powder Reduces Delayed Deep Surgical Site Infections in Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis Patients**
Kensuke Shinohara, MD; Peter O. Newton, MD; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Harms Study Group

08:51 - 08:55 **Paper #47: Monthly Multidisciplinary Adult Spinal Deformity Conference is Cost-Effective: Cost-Analysis Utilizing Lean Methodology and Time-Driven Activity-Based Costing**
Devon Lefever, MD; Philip K. Louie, MD; Caroline E. Drolet, PhD; Michelle Gilbert, PA-C; Andrew Friedman, MD; Joseph Strunk, MD; Brooks Ohlson, MD; Richard Kronfol, MD; Venu M. Nemani, MD, PhD; Jean-Christophe A. Leveque, MD; Rajiv K. Sethi, MD

08:55 - 08:59 **Paper #48: "Too Much of a Good Thing": High Cell Saver Autotransfusion is Associated with Perioperative Medical Complications**
Sarthak Mohanty, BS; Lawrence G. Lenke, MD; Josephine R. Coury, MD; Fthimnir Hassan, MPH; Justin Reyes, MS; Ronald A. Lehman, MD; Zeeshan M. Sardar, MD

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

09:08 - 09:12 **Paper #49: The Evolution of ERAS: Assessing the Clinical Benefits of Developments within Enhanced Recovery After Surgery Protocols in Adult Cervical Deformity Surgery**
Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Andrew Chen, BS; Neel Vallurupalli, BA; Neel Anand, MD; Peter G. Passias, MD

Meeting Agenda

Thursday, September 7, 2023

Program (topics, timing, and faculty) is subject to change.

09:12 - 09:16 **Paper #50: Clinical and Patient-Reported Outcomes of Adult Spinal Deformity Surgery with Ten-Year Follow-Up**
Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Stephane Owusu-Sarpong, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD

09:16 - 09:20 **Paper #51: A Ten Year Review of Pediatric Posterior Deformity Cases Utilizing Tranexamic Acid (TXA) Infusions with New Onset Central Diabetes Insipidus (CDI)**
Kyle Hardacker, MD; Pierce Hardacker, BS; Doris M. Hardacker, MD

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

09:29 - 09:33 **Paper #52: Cost-Value of the Spine At Risk Program**
Madeleine E. Jackson, MD; Amanda K. Galambas, BS; Walter F. Krengel III, MD; Samuel R. Browd, MD, PhD; Klane K. White, MD; Burt Yaszay, MD; Jennifer M. Bauer, MD, MS

09:33 - 09:37 **Paper #53: Apical Region Correction and Global Balance Surgical Strategy Can Improve Pulmonary Function in Patients with Severe Thoracic Scoliosis at 2-year Follow-up**
Yang Jiao, MD; Junduo Zhao, MBBS; Zhen Wang, MD; Haoyu Cai, MD; Jianxiong Shen, MD; Xin Chen, MD

09:37 - 09:41 **Paper #54: Thoracolumbar Fusions for Adult Lumbar Deformity Show Superior QALY Gain and Lower Costs Compared to Upper Thoracic Fusions**
Richard A. Hostin, Jr., MD; Samrat Yeramaneni, PhD; Jeffrey L. Gum, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Jeffrey P Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MPH; Gregory M. Mundis, MD; Themistocles S. Protopsaltis, MD; D.Kojo Hamilton, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

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

09:50 - 10:10 Foyer | Level 3

Refreshment Break

10:10 - 12:15 Columbia Ballroom | Level 3

Abstract Session 4 | Adolescent Idiopathic Scoliosis and Harrington Lecture

Moderators: Munish C. Gupta, MD & A. Noelle Larson, MD

10:10 - 10:14 **Paper #55: Neck and Shoulder Pain 10 Years After Posterior Spinal Fusion for Thoracic Adolescent Idiopathic Scoliosis**
Masayuki Ohashi, MD, PhD; Kei Watanabe, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Toru Hirano, MD, PhD

10:14 - 10:18 **Paper #56: The Modified Proximal Humerus Ossification System Predicts Surgical Curve Progression in Unbraced Patients with Adolescent Idiopathic Scoliosis**
Tristen N. Taylor, BS; Callie Bridges, BS; Tiffany Lee, BS; Brian G. Smith, MD

10:18 - 10:22 **Paper #57: Five-year Longitudinal Outcomes Following Selective vs Non-selective Fusion for Adolescent Idiopathic Scoliosis: Is Lumbar Fixation Warranted**
Richard E. Campbell, MD; Monica Arney, MD; Alexander Hafey; Theodore Rudic; Elizabeth Driskill, MS; Peter O. Newton, MD; Harms Study Group; Keith R. Bachmann, MD

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

10:31 - 10:35 **Paper #58: The Impact of Closed Suction Wound Drain on Immediate And Persistent Pain in Adolescents Undergoing Posterior Spinal Fusion For Idiopathic Scoliosis**
Linda Helenius, MD, PhD; Paul Gerdhem, MD, PhD; Matti Ahonen, MD, PhD; Johanna Syvänen, MD, PhD; Ilkka J. Helenius, MD, PhD

10:35 - 10:39 **Paper #59: Subclassification of Sanders Maturation Stage 3: Differences in Spine and Total Height Velocity Between 3A and 3B in Patients with Idiopathic Scoliosis**
*Yusuke Hori, MD, PhD; Burak Kaymaz, MD; Luiz Silva, MD; Kenneth J. Rogers, PhD; Petya Yorgova, MS; Irene Li, MS; Peter G. Gabos, MD; Suken A. Shah, MD_*

Program (topics, timing, and faculty) is subject to change.

10:39 - 10:43 **Paper #60: Should We Adopt Gradual or Immediate Brace Weaning for AIS? - A Randomized Controlled Trial**
Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Prudence Wing Hang Cheung, PhD, BDSc (Hons)

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

10:52 - 10:56 **Paper #61: LncAIS: A Novel and Significant Long Non-coding RNA Identified by Microarray Analysis and Implicated in the Pathogenesis of AIS and Associated Osteopenia**
Qianyu Zhuang, MD; Jianguo Zhang, MD

10:56 - 11:00 **Paper #62: Asymmetry Index Derived from Mobile Device 3D Scanning Accurately Detects Idiopathic Scoliosis: A Pilot Study**
Jack B. Michaud, BS; Christopher A. Jin, BS; Yousi A. Oquendo, MSE; Xochitl M. Bryson, BA; Michael Gardner, MD; Kali R. Tileston, MD; John S. Vorhies, MD

11:00 - 11:04 **Paper #63: Anterior Vertebral Body Tethering: A Single Center Cohort with 5+ Years of Follow-Up**
Dan Hoernschemeyer, MD; Nicole Tweedy, PNP; Melanie Boeyer, PhD

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

11:13 - 11:17 **Paper #64: Should the C7-T1 Junction Be Feared? The Effect of a T1 UIV on PJK Risk in AIS Patients at Long-Term Follow-Up**
Jaysson T. Brooks, MD; Jennifer M. Bauer, MD, MS; Amit Jain, MD; Firoz Miyanji, MD; Stefan Parent, MD, PhD; Peter O. Newton, MD; Vidyadhar V. Upasani, MD; Patrick J. Cahill, MD; Daniel J. Sucato, MD, MS; Paul D. Sponseller, MD, MBA; Amer F. Samdani, MD; Harms Study Group ; Jayden Brennan, BS

11:17 - 11:21 **Paper #65: What is the Incidence and Course of Lumbar Vertebral Body Tethering Breakage?**
Steven W. Hwang, MD; Amer F. Samdani, MD; Terrence G. Ishmael, MBBS; Maureen McGarry, BBE; Alejandro Quinonez, BS; Jason Woloff, BS; Kaitlin Kirk, BS; Emily Nice, BS; Joshua M. Pahys, MD

11:21 - 11:25 **Paper #66: Core Muscle Strengths, Lumbar Flexibility and Quality of Life in AIS Patients Treated with either Long Fusion or Hybrid Technique Compared to Healthy Individuals**
Celaleddin Bildik, MD; Selmin E. Arsoy, PT ; Selen Saygılı, Exercise Specialist; Hamisi M. Mraja, MD; Cem Sever, MD; Ali T. Evren, MD; Meric Enercan, MD; Selhan Karadereler, MD; Tunay Sanli, MA; Azmi Hamzaoglu, MD

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

11:34 - 11:39 **Harrington Lecture Introduction**
Serena S. Hu, MD

11:39 - 11:59 **Harrington Lecture**
Oheneba Boachie-Adjei, MD

11:59 - 12:15 **Presentation of the Lifetime Achievement Award**
Marinus de Kleuver, MD, PhD

12:15 - 12:50 Foyer | Level 3

Lunch Pickup & Break

12:50 - 14:20

Industry Workshops (Refer to page 237)

14:20 - 14:40 Foyer | Level 3

Refreshment Break

Meeting Agenda

Thursday, September 7, 2023

Program (topics, timing, and faculty) is subject to change.

14:40 - 17:20

Half-Day Courses (HDC) (three concurrent sessions)

14:40 - 17:20 Columbia Ballroom | Level 3

HDC 1 | Neuromuscular Scoliosis From Head to Toe and Everything in Between

Moderators: Selina C. Poon, MD, Michelle C. Welborn, MD & Steven W. Hwang, MD

Session 1: Pre-op Non-Surgical Consideration

14:40 - 14:42 **Introduction**
Selina C. Poon, MD

14:42 - 14:47 **Pulmonary**
Gregory J. Redding, MD

14:47 - 14:52 **Cardiology**
Katheryn Holmes, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

14:52 - 14:57 **Endocrinology**
Lindsey E. Nicol, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

14:57 - 15:02 **Neurosurgery**
Rajiv Iyer, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

15:02 - 15:07 **Spacity and Scoliosis**
David F. Bauer, MD

15:07 - 15:12 **Anesthesiology**
Lydia Andras, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

15:12 - 15:20 **Discussion**

Session 2: Surgical Considerations

15:20 - 15:25 **Go Long and Include the Pelvis**
Ilkka J. Helenius, MD, PhD

15:25 - 15:30 **Stop Short**
Lindsay M. Andras, MD

15:30 - 15:35 **Forget Fusion, VBT is The Way**
Amer F. Samdani, MD

15:35 - 15:40 **Anterior/Posterior/VCR**
Lawrence G. Lenke, MD

15:40 - 15:45 **Less is Better- Balanced Residual**
Muharrem Yazici, MD

15:45 - 15:50 **Classic Detethering is Best and Stage It**
Mari L. Groves, MD

15:50 - 15:55 **Concurrent Vertebral Column Shortening is the Way**
Andrew H. Jea, MD

15:55 - 16:00 **Discussion**

Session 3: Complication Avoidance and Post-Op Considerations

16:00 - 16:06 **Complication Avoidance**
Michael G. Vitale, MD, MPH

16:06 - 16:12 **Ethics: Should We Be Doing This?**
A. Noelle Larson, MD

Program (topics, timing, and faculty) is subject to change.

16:12 - 16:18 **Outreach: What Should we be Doing in Limited Resource Areas?**
Kenneth M. Cheung, MD, MBBS, FRCS

16:18 - 16:24 **Functional Considerations and Implications After PSF**
Glendaliz Bosques, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

16:24 - 16:30 **General Pediatric Considerations and Changes After PSF**
Alexander Van Speybroeck, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

16:30 - 16:37 **Discussion**

16:37 - 16:40 **Conclusion**
Michelle C. Welborn, MD

16:40 - 16:44 **Paper #67: Intrathecal Baclofen Pumps Do Not Increase the Risk of Complications in Cerebral Palsy Patients Undergoing Spinal Fusion**
Kenneth H. Levy, BS; Burt Yaszay, MD; Suken A. Shah, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Paul D. Sponseller, MD, MBA

16:44 - 16:48 **Paper #68: Does the Availability of Baseline Intraoperative Neuromonitoring Data Affect Outcomes in Patients with Cerebral Palsy Undergoing PSF?**
Daniel Cherian, MD; Terrence G. Ishmael, MBBS; Alan Stein, MD; Joshua M. Pahys, MD; Steven W. Hwang, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Harms Study Group

16:48 - 16:52 **Paper #69: Effects of Conversion from Gastrostomy to Gastrojejunostomy Tube Before Spinal Fusion for Children with Neuromuscular Scoliosis**
Candice Legister, BS; chrystina james, MD; Walter H. Truong, FAOA; Tenner Guillaume, MD; Danielle Harding, PA-C; Casey Palmer, BS; Sara Morgan, PhD; Eduardo C. Beauchamp, MD; Joseph H. Perra, MD; Daniel Miller, MD

16:52 - 17:02 **Discussion**

17:02 - 17:06 **Paper #70: Does Tone Affect Outcomes in Cerebral Palsy Patients Undergoing Posterior Spinal Fusion?**
Daniel Cherian, MD; Amer F. Samdani, MD; Joshua M. Pahys, MD; Terrence G. Ishmael, MBBS; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Harms Study Group ; Steven W. Hwang, MD

17:06 - 17:10 **Paper #71: Pelvic Asymmetry in Children with Neuromuscular Scoliosis. 3D Tomographic Analysis**
Juan P. Arispe, MD; Mariano A. Noel, MD; Carlos A. Tello, MD, PhD; Lucas Piantoni, MD; Rodrigo G. Remondino, MD; Julian Calcagni, MD; Eduardo Galaretto, MD

17:10- 17:20 **Discussion**

14:40 - 17:20 Regency Ballroom B | Level 7

HDC 2 | I Understand the Numbers, but How Do I Actually Perform the Surgery to Obtain Optimal Results: Step by Step Correction of Spinal Deformity

Moderators: Ronald A. Lehman, MD & D. Kojo Hamilton, MD, FAANS

14:40 - 14:43 **Introduction**
Ronald A. Lehman, MD

14:43 - 14:55 **Correcting the Adult Deformity Patient with Severe Coronal Malalignment**
Ronald A. Lehman, MD

14:55 - 15:07 **Severe Sagittal Malalginment: When to do Three Column Osteotomy and How to Perform it to Accomplish your Goals**
D. Kojo Hamilton MD, FAANS

15:07 - 15:19 **How to Address Severe Kyphosising Scoliosis While Avoiding Severe Complications**
Lawrence G. Lenke, MD

15:19 - 15:27 **Discussion**

15:27 - 15:40 **Panel Discussion: Bringing it All Together: Revision CT and LS Malalignment**
D. Kojo Hamilton MD, FAANS; Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Joseph A. Osorio, MD, PhD

Meeting Agenda

Thursday, September 7, 2023

Program (topics, timing, and faculty) is subject to change.

15:40 - 15:52 **Using Artifical Intelligence to Map out the Case, and Employing Real Time Dynamic Feedback to Perform the Surgery**
Joseph A. Osorio, MD, PhD

15:52 - 16:04 **Correction of a CervicoThoracic Deformity: When is it at the Junction and When is it a Combined CT and LS Issue?**
Christopher P. Ames, MD

16:04 - 16:16 **Use of Anterior, Lateral and Oblique Approaches to Correct Spinal Deformity: It Does work and this is how I do it**
Nitin Agarwal, MD

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

16:24 - 16:37 **Case Panel Discussion: Bringing it All Together: Revision CT and LS Malalignment**
D. Kojo Hamilton, MD, FAANS; Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Joseph A. Osorio, MD, PhD

16:37 - 16:40 **Conclusion**
D. Kojo Hamilton, MD, FAANS

16:40- 16:45 **Transition**

16:45 - 16:49 **Paper #72: Risk Factors for Reoperation for Mechanical Complications after Adult Spinal Deformity Surgery, Minimum 2 Year Follow Up**
Karnmanee Srisanguan, BS; Themistocles S. Protopsaltis, MD; Thomas Errico, MD; Tina Raman, MD; Stephane Owusu-Sarpong, MD

16:49 - 16:53 **Paper #73: Radiographic Outcomes Following Surgical Correction for Lumbar Degenerative Kyphosis: The Impact of Supine Pelvic Tilt**
Jae-Koo Lee, MD; Seung-Jae Hyun, MD, PhD; Seung Heon Yang, MD; Ki-Jeong Kim, MD, PhD

16:53 - 16:57 **Paper #74: Incidence and Risk Factors for Rod Fractures Occurring Greater than Two Years after Adult Spinal Deformity Surgery**
Karnmanee Srisanguan, BS; Thomas Errico, MD; Tina Raman, MD

16:57 - 17:04 **Discussion**

17:04 - 17:08 **Paper #75: Examining Malalignment: Persistent Compensatory Mechanisms Versus Normal Alignment in High Pelvic Incidence Patients**
Julio Jauregui, MD; Thamrong Lertudomphonwanit, MD; Alekos A. Theologis, MD; Munish C. Gupta, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Michael P. Kelly, MD

17:08 - 17:12 **Paper #76: Upper Instrumented Vertebral Fracture in Adult Spinal Deformity Surgery can be Reduced by Increasing Occupancy Rate of Pedicle Screw in Vertebral Body over 80%**
Shin Oe, MD; Yu Yamato, MD, PhD; Tomohiko Hasegawa, MD, PhD; Go Yoshida, MD, PhD; Tomohiro Banno, MD, PhD; Hideyuki Arima, MD, PhD; Koichiro Ide, MD; Tomohiro Yamada, MD; Yukihiro Matsuyama, MD, PhD

17:12 - 17:20 **Discussion**

14:40 - 17:22 Regency Ballroom A | Level 7

HDC 3 | Introduction to Leadership

Attendance at this Half Day Course is limited to 100 participants, please inquire about space at the Registration Desk if interested in attending.
Moderators: Serena S. Hu, MD & Todd J. Albert, MD

14:40 - 14:45 **Welcome and Introduction**
Serena S. Hu, MD

Introduction to Leadership, Healthcare Leadership

14:45 - 15:05 **Leadership in The Modern World- Relationship to History and Stoicism**
Todd J. Albert, MD

Part 1: Leadership in the SRS Organization

15:05 - 15:15 **Structure of The SRS- Table of Organization and Program Goals**
Serena S. Hu, MD

15:15 - 15:25 **My Journey to the Presidential Line**
Marinus de Kleuver, MD, PhD

Program (topics, timing, and faculty) is subject to change.

15:25 - 15:35 **My Journey to the Presidential Line**
Peter O. Newton, MD

15:35 - 15:45 **Discussion**

Part 2: Communication with Stakeholders

15:45 - 16:00 **Basic Communication Tools (Pathos, Logos, Ethos, etc.)**
David L. Skaggs, MD, MMM

16:00 - 16:05 **Discussion**

Part 3: Strategy

16:05 - 16:20 **Is a Mission and Vision Statement Important?- How to Create**
Paul T. Rubery Jr., MD

16:20 - 16:35 **Importance of 1, 3, 5, and 10 Year Plans - How to Create**
Daniel J. Sucato, MD, MS

16:35 - 16:50 **Kaizen- Should You Embrace It and What Can It Do For Your Organization**
Rajiv K. Sethi, MD

16:50 - 16:55 **Discussion**

16:55 - 17:20 **Group Exercise/Activity on Leadership**

17:20 - 17:22 **Closing Remark, Reminder to Apply for L.E.A.D SRS, and Adjourn**
Serena S. Hu, MD

17:20 - 17:30

Break

17:30 - 17:45 401 | Chelan | Level 4

Membership Information Session

17:45 - 17:50

Break

17:50 - 18:50 Regency Ballroom A | Level 7

Early Career Surgeon Session

The Early Career Surgeon Session is supported, in part, by Medtronic, NuVasive, and Stryker.

Building a Spine Deformity Practice: Tips and Tricks to Avoid Pitfalls

Moderators: Nitin Agarwal, MD & D. Kojo Hamilton, MD, FAANS

17:50 - 17:52 **Introduction**
Nitin Agarwal, MD & D. Kojo Hamilton, MD, FAANS

Part 1: Transitioning to Practice

17:52 - 17:56 **Navigating the Job Market**
Lindsay M. Andras, MD

17:56 - 18:00 **Contract Negotiation**
Shay Bess, MD

18:00 - 18:06 **Discussion**

Part 2: Practice Expansion

18:06 - 18:10 **Augmenting Referral Networks**
Teresa Bas, MD, PhD

18:10 - 18:14 **Achieving Balance in a Fast-Paced Practice**
Eric O. Klineberg, MD

18:14 - 18:20 **Discussion**

Meeting Agenda

Thursday, September 7, 2023

Program (topics, timing, and faculty) is subject to change.

Part 3: Practice Management

18:20 - 18:24 **Learning a New Language: Coding for Deformity**
Jaysson T. Brooks, MD

18:24 - 18:28 **Medicolegal Mitigation**
Serena S. Hu, MD

18:28 - 18:34 **Discussion**

Part 4: Team Building and Research

18:34 - 18:38 **Building a Team**
Abigail K. Allen, MD

18:38 - 18:42 **Integrating Research into Your Practice**
Thomas J. Buell, MD
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

18:42 - 18:48 **Discussion**

18:48 - 18:50 **Conclusion**
Kariman Abelin Genevois, MD

18:50 Regency Ballroom A Foyer | Level 7

Early Career Surgeon Social

The Early Career Surgeon Social is hosted by Medtronic.

Program (topics, timing, and faculty) is subject to change.

08:00 - 09:50 Columbia Ballroom | Level 3

Abstract Session 5 | Hibbs Award-Nominated Papers

Moderators: Amy L. McIntosh, MD & Rajiv K. Sethi, MD

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

08:05 - 08:11 **Paper #77: Comparison of Disc and Facet Joint Degeneration and Quality of Life in Stopping Fusion at L3 versus L4 in AIS: An MRI Study with Mean 17 (15-21) years Follow-up†**
Hamisi M. Mraja, MD; Ayhan Mutlu, MD; Onur Levent Ulusoy, MD; Celaleddin Bildik, MD; Baris Peker, MD; Inas M. Daadour, MD; Tunay Sanli, MA; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

08:11 - 08:17 **Paper #78: The Reunion with my Patients. Their Journey and Experience 30 Years after Their Intervention for Adolescent Idiopathic Scoliosis (AIS) via CD Instrumentation†**
Francisco Javier Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Javier Pizones, MD, PhD

08:17 - 08:23 **Paper #79: Radiographic Motion Before and After Anterior Vertebral Body Tethering Compared to Posterior Spinal Fusion for Thoracic Scoliosis†**
Michelle Claire Marks, PT; Maty Petcharaporn, BS; Tracey P. Bastrom, MA; Firoz Miyanji, MD; Patrick J. Cahill, MD; John (Jack) M. Flynn, MD; Baron S. Lonner, MD; Harms Study Group ; Peter O. Newton, MD

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

08:37 - 08:43 **Paper #80: Natural History of Adult Spinal Deformity: How do patients with Suboptimal Surgical Outcomes Fare Relative to Non-Operative Counterparts?†**
Peter G. Passias, MD; Rachel Joujon-Roche, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS

08:43 - 08:49 **Paper #81: Importance of Self-Image in Adult Spinal Deformity: Results from the Prospective Evaluation of Elderly Deformity Surgery (PEEDS)†**
Christopher J. Nielsen, MD; Lauren Lewis ; Kristen Arnold ; Thorsten Jentzsch, MSc; Colby Oitment, MD, FRCS(C)

08:49 - 08:55 **Paper #82: A Prospective, Observational, Multicenter Study Assessing Functional Improvements After Multilevel Fusion for Adult Spinal Deformity (ASD): 5-Year Follow-Up Results†**
Aditya Raj, MS; Stephen J. Lewis, MD, FRCS(C); Christopher J. Nielsen, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Kenneth M. Cheung, MD, MBBS, FRCS; David W. Polly, MD; Yong Qiu, PhD; Yukihiro Matsuyama, MD, PhD; Ferran Pellisé, MD, PhD; Jonathan N. Sembrano, MD; Benny T. Dahl, DMSc; Michael P. Kelly, MD; Marinus de Kleuver, MD, PhD; Ahmet Alanay, MD; Maarten Spruit, MD; Justin S. Smith, MD, PhD; Sigurd H. Berven, MD

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

09:09 - 09:15 **Paper #83: Hierarchical Evaluation of Mechanically Induced Growth Modulation of the Spine in a Growing Pig Model***
Madeline Boyes, DVM; Axel C. Moore, PhD; Julie Engiles, VMD, DACVP; Benjamin Sinder, PhD; Rachel Hilliard ; Jason B. Anari, MD; Sriram Balasubramanian, PhD; Edward Vresilovic, MD, PhD; Thomas P. Schaer, VMD; Dawn M. Elliott, PhD; Brian D. Snyder, MD, PhD; Patrick J. Cahill, MD

09:15 - 09:21 **Paper #84: Core Planar Cell Polarity Genes VANGL1 and VANGL2 in Predisposition to Congenital Scoliosis***
Yongyu Ye, MD; Xin Feng, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Terry Jianguo Zhang, MD; Bo Gao, PhD; Nan Wu, MD

09:21 - 09:27 **Paper #85: Impaired Glycine Neurotransmission Causes Adolescent Idiopathic Scoliosis***
Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Xiaolu Wang, PhD; Ming Yue, PhD; Prudence Wing Hang Cheung, BDSc (Hons); Yanhui Fan, PhD; Meicheng Wu, PhD; Xiaojun Wang, PhD; Sen Zhao, BS; Anas M. Khanshour, PhD; Zheyi Chen, MPhil; Danny Chan, PhD; Qiuju Yuan, PhD; Guixing Qiu, PhD; Zhihong Wu, MD; Jianguo Zhang, MD; Shiro Ikegawa, MD, PhD; Nan Wu, MD; Carol A. Wise, PhD; Yong Hu, PhD; Keith Dip Kei Luk, MCh(Orth); You-Qiang Song, PhD; Bo Gao, PhD

09:27 - 09:33 **Paper #86: Uncovering the Role of a Genetic Variant in Adolescent Idiopathic Scoliosis: Enhanced UNCX Expression Leads to Axial Deformations in Zebrafish***
Yoshiro Yonezawa, MD; Guo Long, MD, PhD; Nao Otomo, MD; Soichiro Yoshino, MD; Kazuki Takeda, MD, PhD; Yoshinao Koike, MD; Mitsuru Yagi, MD, PhD; Chikashi Terao, MD, PhD; Masaya Nakamura, MD, PhD; Morio Matsumoto, MD, PhD; Shiro Ikegawa, MD, PhD; Kota Watanabe, MD, PhD

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

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

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

Meeting Agenda

Friday, September 8, 2023

Program (topics, timing, and faculty) is subject to change.

09:50 - 10:10 Foyer | Level 3

Refreshment Break

10:10 - 11:45 Columbia Ballroom | Level 3

Abstract Session 6 | Cervical Deformity and Presidential Address

Moderators: Han Jo Kim, MD & Christopher I. Shaffrey, MD

10:10 - 10:14 **Paper #87: Development of a Hierarchical Approach to Surgical Planning in ACD Surgery**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Lee A. Tan, MD

10:14 - 10:18 **Paper #88: Are we Getting Better at Treating Adult Cervical Deformity? Complication Rate Trends Analysis in Adult Cervical Deformity Over 10 Years**
Jamshaid Mir, MD; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; Claudia Bennett-Caso, BA; Peter Tretiakov, BS; Daniel M. Sciubba, MD; Peter G. Passias, MD

10:18 - 10:22 **Paper #89: Assessing the Synergistic Impacts of Frailty, Sarcopenia, and Osteoporosis on Morbidity and Mortality in the Adult Cervical Deformity Population**
Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; M. Burhan Janjua, MD; Han Jo Kim, MD; Peter G. Passias, MD

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

10:31 - 10:35 **Paper #90: Analysis of Cost Utility of Distal Junctional Kyphosis Occurrence after Adult Cervical Deformity Surgery: The Benefit of Prophylaxis and Preoperative Optimization**
Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Tobi Onafowokan, MBBS; Bassel G. Diebo, MD; Peter G. Passias, MD

10:35 - 10:39 **Paper #91: Lower Hounsfield Units at the Lowest Instrumented Vertebra is an Independent Risk Factor for Distal Junctional Kyphosis After Adult Cervical Deformity Surgery**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Robert K. Eastlack, MD

10:39 - 10:43 **Paper #92: Despite a Multifactorial Etiology, Rates of Distal Junctional Kyphosis after Adult Cervical Deformity Corrective Surgery Can be Dramatically Diminished by Optimizing Age Specific Radiographic Improvement**
Peter G. Passias, MD; Oscar Krol, BS; Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Pawel P. Jankowski, MD

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

10:52 - 10:56 **Paper #93: Preventing Distal Junctional Kyphosis: Choosing a Stable End for the Lowest-Instrumented Vertebra is Protective Following Adult Cervical Deformity Surgery**
Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Peter G. Passias, MD; D. Kojo Hamilton MD, FAANS

10:56 - 11:00 **Paper #94: Optimizing Mental Health Conditions Prior to Adult Spinal Deformity Surgery: Does Preoperative Optimization Improve Surgical Outcomes?**
Pooja Dave, BS; Peter Tretiakov, BS; Jamshaid Mir, MD; Dean Chou, MD; Peter G. Passias, MD; Justin S. Smith MD, PhD

11:00 - 11:04 **Paper #95: 20-year Clinical Outcomes of Cervical Disc Arthroplasty vs ACDF: A Prospective, Randomized, Controlled Trial**
Willa Sasso, BS; Jason Ye, MBA; Rick C. Sasso, MD

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

11:13 - 11:15 **2024 IMAST Preview**
Eric O. Klineberg, MD

11:15 - 11:17 **2024 Annual Meeting Preview**
Ferran Pellisé, MD, PhD

11:17 - 11:20 **2024 Regional Courses Preview**
Saumyajit Basu, MS(orth), DNB(orth), FRCSEd

Program (topics, timing, and faculty) is subject to change.

11:20 - 11:25 **Introduction of the President**
Marinus de Kleuver, MD, PhD

11:25 - 11:45 **Presidential Address**
Serena S. Hu, MD

11:45 - 12:05 Foyer | Level 3

Lunch Pick-up (Non-members)

12:05 - 13:35 Regency Ballroom B | Level 7

Member Business Meeting and Lunch (Lunch will be served inside Regency Ballroom B. Runs concurrently to Lunchtime Symposium 4)

12:05 - 13:35 Columbia Ballroom | Level 3

LTS 4 | Conservative Care for Adolescent Idiopathic Scoliosis: Brace and Scoliosis-specific Exercises

Moderators: Brian G. Smith, MD, Sabrina Donzelli, MD, Msc, Nikos Karavidas, PT, Eric C. Parent, PhD & James Wynne, CPO, FAAOP

12:05 - 12:11 **Introduction by Chair**
Brian G. Smith, MD

12:11 - 12:15 **Prognostic Models for Bracing Outcomes**
Lori A. Dolan, PhD

12:15 - 12:19 **Prognostic Calculators in Clinical Practice**
Stuart L. Weinstein, MD

12:19 - 12:27 **Brace Types and their Biomechanics, Brace Classification**
James Wynne CPO, FAAOP
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

12:27 - 12:35 **Brace Indications, Protocols and Management**
Caglar Yilgor, MD

12:35 - 12:45 **Discussion**

12:45 - 12:53 **Scientific Evidence for PSSE and Brace: What We Have and What is Missing**
Eric C. Parent, PhD

12:53 - 13:01 **PSSE Indications, Protocols and Program Characteristics**
Nikos Karavidas, Physiotherapist

13:01 - 13:09 **PSSE – A Common EBM Approach**
Schreiber Sanja, Physiotherapist, PhD

13:09 - 13:19 **Discussion**

13:19 - 13:29 **Wrap Up**
Michael J. Mendelow, MD

13:29 - 13:35 **Closing**
James Wynne, CPO, FAAOP
**This speaker was sponsored, in part, by the Sponseller Interdisciplinary Fund*

13:35 - 13:55

Break

Meeting Agenda

Program (topics, timing, and faculty) is subject to change.

13:55 - 15:40

Abstract Sessions 7A & 7B (two concurrent sessions)

13:55 - 15:40 Regency Ballroom B | Level 7

Abstract Session 7A | Adult Spinal Deformity II

Moderators: Ferran Pellisé, MD, PhD & Lawrence G. Lenke, MD

13:55 - 13:59 **Paper #96: A Parameter Fixed to Poor Outcomes? A Detailed Analysis of High Pelvic Incidence in Adult Spinal Deformity Surgery**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Han Jo Kim, MD

13:59 - 14:03 **Paper #97: Pseudarthrosis and Instrumentation Failure at the Pedicle Subtraction Osteotomy Site: Is a Multiple Rod Construct Necessary?**
Karnmanee Srisanguan, BS; Tina Raman, MD

14:03 - 14:07 **Paper #98: A Machine-Learned Quantitative Classification of Asymptomatic Adult Spinal Sagittal Curvature: Comparison to Roussouly Types**
Saba Pasha, PhD; Kazuhiro Hasegawa, MD, PhD; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD; Hee-Kit Wong, FRCS; Jeffrey M. Hills, MD; Stephane Bourret, PhD; Dennis Hey, MD, MBBS, FRCS; Jean-Charles Le Huec, MD, PhD; Michael P. Kelly, MD; Nicholas Pallotta, MD, MS

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

14:16 - 14:20 **Paper #99: 5-Year Outcomes of Prospective Evaluation of Elderly Deformity Surgery: A Multicenter International Study on Patients over 60 Years of Age**
Stephen J. Lewis, MD, FRCS(C); Sigurd H. Berven, MD; Christopher J. Nielsen, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Marinus de Kleuver, MD, PhD; David W. Polly, MD; Ferran Pellisé, MD, PhD; Yong Qiu, PhD; Jonathan N. Sembrano, MD; Michael P. Kelly, MD; Benny T. Dahl, DMSc; Maarten Spruit, MD; Ahmet Alanay, MD; Kenneth M. Cheung, MD, MBBS, FRCS; Yukihiro Matsuyama, MD, PhD; Justin S. Smith, MD, PhD

14:20 - 14:24 **Paper #100: Urinary N-Telopeptide is Associated with Rod Fracture after Corrective Adult Spinal Deformity Surgery**
Jerry Y. Du, MD; Francis C. Lovecchio, MD; Gregory Kazarian, MD; David Kim, BS; Bo Zhang, MD; Robert Merrill, MD; John Clohisy, MD; Anthony Pajak, BS; Austin Kaidi, MD; Rachel L. Knopp, MPH; Izzet Akosman, BS; Mitchell Johnson, MD; Hiroyuki Nakarai, MD; Alex Dash, BS; Matthew E. Cunningham, MD, PhD; Han Jo Kim, MD

14:24 - 14:28 **Paper #101: Improvement of Pulmonary Function and Reconstructed 3D Lung Volume After Halo-Pelvic Traction Combined with Posterior Correction for Severe Rigid Spinal Deformity: A Multicenter Study**
Zhenhai Zhou, MD, PhD; Zhiming Liu, MD; Shengbiao Ma, MD; Zhongren Huang, MBBS; Wenbing Wan, MD, PhD; Zongmiao Wan, MD, PhD; Cao Yang, MD, PhD; Yingsong Wang, MD; Zhaohui Ge, MD; Kai Cao, MD, PhD

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

14:37 - 14:41 **Paper #102: Development of AI Algorithm for Automatic Cobb Angle Measurement in Adolescent and Adult Spinal Deformities**
Shuzo Kato, MD; Takeo Nagura, MD, PhD; Yoshihiro Maeda, MD; Mitsuru Yagi, MD, PhD; Satoshi Suzuki, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

14:41 - 14:45 **Paper #103: Spinopelvic Mismatch after Short Segment Lumbar Fusions Results in Increased Disability at Two Years Following Surgery**
Devon Lefever, MD; Caroline E. Drolet, PhD; Philip K. Louie, MD; Venu M. Nemani, MD, PhD; Rajiv K. Sethi, MD; Jean-Christophe A. Leveque, MD

14:45 - 14:49 **Paper #104: Pseudarthrosis and Rod Fracture at the Distal Levels of a Long Construct are Associated with Proximal Junctional Kyphosis after ASD Surgery**
Karnmanee Srisanguan, BS; Themistocles S. Protopsaltis, MD; Thomas Errico, MD; Tina Raman, MD

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

14:58 - 15:02 **Paper #105: Decreased Bone Mineral Density is Associated with a Higher Rate of Pseudarthrosis and Unplanned Revision after Adult Spinal Deformity Surgery at Three Year Follow Up**
Karnmanee Srisanguan, BS; Stephane Owusu-Sarpong, MD; Tina Raman, MD

15:02 - 15:06 **Paper #106: Patients Undergoing Adult Spinal Deformity Surgery Report More Improvement with Standing than Sitting**
Michael Longo, MD; Hani Chanbour, MD; Jeffrey W. Chen, BS; Iyan Younus, MD; Steven G. Roth, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MPH

15:06 - 15:10 **Paper #107: Combined Anterior-Posterior vs. All-Posterior Approach in Adult Spinal Deformity Surgery: Which Strategy Is Superior?**
Jeffrey Chen, BS; Hani Chanbour, MD; Graham W. Johnson, BA; Tyler D. Metcalf, BS; Alexander Lyons, BS; Soren Jonzzon, MD; Steven G. Roth, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MPH

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

15:19 - 15:23 **Paper #108: The Ability of ChatGPT to Address Patient Concerns Regarding Adult Degenerative Scoliosis and the Possibility of AI-assisted Resources for Patient Education**
Justin Tang, BS; Ula Isleem, MD; Eric Geng, BA; Jun S. Kim, MD; Samuel K. Cho, MD

15:23 - 15:27 **Paper #109: Overcorrection in Sagittal Alignment Effect on Optimal Outcomes in Adult Spinal Deformity Patients**
Alan H. Daniels, MD; Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Renaud Lafage, MS; Virginie Lafage, PhD; Tyler K. Williamson, MS, BS; Claudia Bennett-Caso, BA; Peter G. Passias, MD

15:27 - 15:31 **Paper #110: Association Between Elevated C-Reactive Protein and Operative Complications in Adult Spinal Deformity Surgery: An International Multicenter Study**
Mitsuru Yagi, MD, PhD; Christopher P. Ames, MD; Naobumi Hosogane, MD, PhD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Masaya Nakamura, MD, PhD; Shay Bess, MD; Kota Watanabe, MD, PhD; International Spine Study Group

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

13:55 - 15:40 Columbia Ballroom | Level 3

Abstract Session 7B | Adolescent Idiopathic Scoliosis and Adult Spinal Deformity Controversies

Moderators: Michael P. Kelly, MD & Marinus de Kleuver, MD, PhD

13:55 - 13:59 **Paper #111: The Effect of Traction and Spinal Cord Morphology on Intraoperative Neuromonitoring Alerts**
Evan Fene, MD; Lydia Klinkerman, BS; Charles E. Johnston, MD; Jaysson T. Brooks, MD; Megan E. Johnson, MD

13:59 - 14:03 **Paper #112: Vertebral Body Tethering for Lenke 1A Curves: The L4 Modifier Predicts Less Optimal Outcomes**
Kenneth A. Shaw, DO; Firoz Miyanji, MD; Tracey P. Bastrom, MA; Stefan Parent, MD, PhD; Peter O. Newton, MD; Harms Study Group ; Joshua S. Murphy, MD

14:03 - 14:07 **Paper #113: Radiation Exposure in Navigated Techniques for AIS: Is There a Difference for Pre-operative CT vs. Intraoperative CT?**
Mikaela Sullivan, MD; Lifeng Yu, PhD; Beth Schueler, PhD; Ahmad Nassr, MD; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD

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

14:16 - 14:20 **Paper #114: Can Use of a Stiffer Rod Obviate the Need for Posterior Column Oosteotomy in Lenke I and II Curves? Prospective, Multi-center**
Luke Mugge, MD; Matthew E. Cunningham, MD, PhD; Dennis R. Knapp, Jr, MD; Shyam Kishan, MD; Mark Rahm, MD; Randolph Gray, MD; Laurel C. Blakemore, MD

14:20 - 14:24 **Paper #115: Mental Health Components in Adolescents are Associated with Onset of Back Pain during Adulthood: A Cohort of Non-operative Idiopathic Scoliosis with a Mean Follow-up of 9.8 years**
Kenney Ki-Lee Lau; Kenny Y. Kwan, MD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Karlen Law, OT; Kenneth M. Cheung, MD, MBBS, FRCS

14:24 - 14:28 **Paper #116: Vitamin D and Adolescent Idiopathic Scoliosis (AIS), Should we Stop the Hype? A Cross-sectional Observational Prospective Study Based on a Geometric Morphometrics Approach**
Jose María González-Ruiz, MS; Markus Bastir, PhD; Javier Pizones, MD, PhD; Carlos Palancar, MS; Viviana Toro-Ibacache, PhD; María Dolores García-Alfaro, MD, PhD; Lucía Moreno-Manzanaro, BS; Jose Miguel Sánchez-Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; María Isabel Perez-Nuñez, MD, PhD

Meeting Agenda

Friday, September 8, 2023

Program (topics, timing, and faculty) is subject to change.

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

14:37 - 14:41 **Paper #117: Can an Immediate Increase of Standing Height, When Wearing a Corrective Scoliosis Brace, be Predictive of In-Brace Skeletal Correction?**
Anna Courtney, BSc (Hons); Sam Walmsley, BSc (Hons); Darren F. Lui, FRCS; Tim Bishop, FRCS; Jason Bernard, MD, FRCS

14:41 - 14:45 **Paper #118: Starting Young: Differences in Brace Compliance Between Juvenile and Adolescent Idiopathic Scoliosis**
Julianna Lee, BA; Kevin Orellana, BS; Lucas Hauth, BS; Wudbhav N. Sankar, MD; Jason B. Anari, MD; Patrick J. Cahill, MD; John (Jack) Flynn, MD

14:45 - 14:49 **Paper #119: Long-Term (>2yr) Complications after Adult Spinal Deformity Surgery: Survivor Analysis Focused on Patients without Early- or Mid-Term Complications**
Thomas J. Buell, MD; Andrew Legarreta, MD; Justin S. Smith, MD, PhD; Bassel G. Diebo, MD; Peter G. Passias, MD; Jeffrey L. Gum, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Nitin Agarwal, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Robert K. Eastlack, MD; Michael P. Kelly, MD; Alan H. Daniels, MD; Justin K. Scheer, MD; Alex Soroceanu, MPH; Richard Hostin, MD; Khaled M. Kebaish, MD; Robert A. Hart, MD; Stephen J. Lewis, MD, FRCS(C); Frank J. Schwab, MD; Christopher P. Ames, MD; Munish C. Gupta, MD; David O. Okonkwo, MD, PhD; D.Kojo Hamilton, FAANS; Douglas C. Burton, MD; International Spine Study Group

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

14:58 - 15:02 **Paper #120: Comparison of Multi-Level Low-Grade Techniques versus Three-Column Osteotomies in Adult Spinal Deformity Surgery: Does Harmonious Correction Matter?**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Jamshaid Mir, MD; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; Peter Tretiakov, BS; Jordan Lebovic, BA; Daniel M. Sciubba, MD

15:02 - 15:06 **Paper #121: Corner Osteotomy: The More Efficient Technique for Deformity Correction of Adult Spinal Deformity in Comparison to Pedicle Subtraction Osteotomy**
Jung-Hee Lee, MD, PhD; Kyung-Chung Kang, MD; Ki-Young Lee, MD, PhD; Jaeho Kim, MD; Tae-Su Jang, MD; Won Young Lee, MD; Seong Jin Cho, MD; Cheol-Hyun Jung, MD; Gil Han, MD; Min-Jeong Park, PA

15:06 - 15:10 **Paper #122: Open Deformity Correction Has Greater Improvements in Spinopelvic Parameters and Lower Rates of Hardware Failure than Minimally Invasive Techniques**
Elliot Pressman, MD; Kelly Gassie, MD; Molly Monsour, BS; Deborah Liaw, BS; Puya Alikhani, MD

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

15:19 - 15:23 **Paper #123: Correct Now or Wait? An Analysis of Comorbidity Burden and Optimization Thresholds in Surgical Adult Spinal Deformity Patients**
Peter Tretiakov, BS; Kimberly McFarland, BS; Pooja Dave, BS; Jamshaid Mir, MD; Andrew Chen, BS; Giorgos Michalopoulos, MD; Jordan Lebovic, BA; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD; Robert K. Eastlack, MD

15:23 - 15:27 **Paper #124: Crossing the Bridge from Degeneration to Deformity: When Good Outcomes Necessitate Sagittal Correction in Adult Spinal Deformity Surgery**
Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Jamshaid Mir, MD; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Peter Tretiakov, BS; Jordan Lebovic, BA; Pawel P. Jankowski, MD

15:27 - 15:31 **Paper #125: Pelvic Non-Response is Associated with Failure to Restore Low Lumbar Lordosis and a Higher Rate of Mechanical Complications in Adult Spinal Deformity Patients**
Tyler D. Metcalf, BS; Hani Chanbour, MD; Jeffrey W. Chen, BS; Graham W. Johnson, BA; Mason Young, MD; Mitchell Bowers, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Scott Zuckerman, MPH; Byron F. Stephens, MD

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

15:40 - 16:00 Foyer | Level 3

Refreshment Break

Program (topics, timing, and faculty) is subject to change.

16:00 - 17:45 Columbia Ballroom | Level 3

Abstract Session 8 | Early Onset Scoliosis, Kyphosis, Basic Science

Moderators: Mitsuru Yagi, MD, PhD & Kenneth M. Cheung, MD, MBBS, FRCS

16:00 - 16:04 **Paper #126: Serum Titanium Levels Remain Elevated but Urine Titanium is Undetectable in Children with Early Onset Scoliosis (EOS) Undergoing Growth-Friendly Surgical Treatment: A Prospective Study**
Kameron Shams, MD; Sahil Jha, BS; Jennylee Swallow, MS; Michelle S. Caird, MD; Frances A. Farley, MD; Matthew Stepanovich, MD; Noelle Whyte, MD; G. Ying Li, MD
**Funded by an SRS Grant*

16:04 - 16:08 **Paper #127: Screening MRI in Congenital EOS; Is it Safe to Delay Advanced Imaging to Decrease Early Anesthesia?**
Evan Mostafa, MD; Leila Mehraban Alvandi, PhD; Edina Gjonbalaj, BS; John B. Emans, MD; Paul D. Sponseller, MD, MBA; A. Noelle Larson, MD; Purnendu Gupta, MD; Jaime A. Gomez, MD; Pediatric Spine Study Group

16:08 - 16:12 **Paper #128: Smaller Curves in Juvenile Idiopathic Scoliosis Improve with Part-Time Bracing**
Christina C. Rymond, BA; Afrain Z. Boby, MS, BS; Jacob Ball, MD; Alondra Concepción-González, BA; Kevin Lu, MS; Rishi Sinha, BA; Michael G. Vitale, MD; Benjamin D. Roye, MD

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

16:21 - 16:25 **Paper #129: The Spring Distraction System for Growth-Friendly Surgical Treatment of Early Onset Scoliosis: Performance After >2 Years Follow-Up in a Prospective Clinical Trial.**
Casper S. Tabeling, MD; Justin V. Lemans, MD; Anouk Top, MD; Pauline Scholten ; Hilde W. Stempels ; Tom P. Schlösser, MD, PhD; René M. Castelein, MD, PhD; Moyo C. Kruyt, MD, PhD; Keita Ito, MD, PhD

16:25 - 16:29 **Paper #130: The Optimal Surgical Timing for Posterior-only Hemivertebra Resection in Children Younger than 10-years**
Ziming Yao, PhD; Xue Jun Zhang, MD

16:29 - 16:33 **Paper #131: Risk Severity Score (RSS) for Surgical Site Infection (SSI) is Associated with Length of Hospital Stay in Growth Friendly Index Surgeries for Early Onset Scoliosis (EOS)**
Alondra Concepción-González, BA; Rishi Sinha, BA; Christina C. Rymond, BA; Kevin Lu, MS; Afrain Z. Boby, MS, BS; Hannah Lin ; Peter F. Sturm, MD; Scott J. Luhmann, MD; Paul D. Sponseller, MD, MBA; John T. Smith, MD; Lindsay M. Andras, MD; Mark A. Erickson, MD; Benjamin D. Roye, MD; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group

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

16:42 - 16:46 **Paper #132: Traditional Growing Rod Lengthening Without Intraoperative Neuromonitoring: 20-year Experience with no Neurologic Deficits**
Tyler D. Metcalf, BS; Gregory A. Mencio, MD; Jeffrey E. Martus, MD; Craig R. Louer, MD

16:46 - 16:50 **Paper #133: Outcomes of Growth-Friendly Instrumentation in Osteogenesis Imperfecta**
Daniel Badin, MD; Frederick Mun, BS; Behrooz A. Akbarnia, MD; Francisco Javier S. Perez-Grueso, MD; Paul D. Sponseller, MD, MBA; Pediatric Spine Study Group

16:50 - 16:54 **Paper #134: Outcomes from Surgical Treatment in Idiopathic Early-Onset Scoliosis: A Minimum 25-year Follow-up**
Patrick McCabe, MD; Martin Kelly, FRCS (Tr & Orth); Flavia Alberghina, MD, FEBOT; Patrick J. Kiely, FRCS (Tr & Orth); Patrick O'Toole, FRCS (Tr & Orth); Jacques Noel, FRCS (Tr & Orth); David P. Moore, FRCSI MCh; Caroline Goldberg, MD; Esmond E. Fogarty, FRCSI FRACS; Frank E. Dowling, FRCSI BSc; James F. Kennedy, MD, FRCS

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

17:03 - 17:07 **Paper #135: What has Changed in the Last Ten Years for Spine Surgery Training? Residency and Spine Fellowship Program Directors Response to A Nationwide Survey 2013 vs 2023**
Alan H. Daniels, MD; Daniel Alsoof, MBBS; Bassel G. Diebo, MD; Christopher L. McDonald, MD; Andrew S. Zhang, MD; Craig P. Eberson, MD; Carl B. Paulino, MD; Eren Kuris, MD; William F. Lavelle, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Robert A. Hart, MD

Meeting Agenda

Friday, September 8, 2023

Program (topics, timing, and faculty) is subject to change.

17:07 - 17:11	**Paper #136: The Surgical Correction of Severe Scoliosis (SS) with Asymptomatic Syringomyelia (AS): with Traction-assistance without Neurosurgical Intervention** *Zhi Zhao, MD; Yingsong Wang, MD; Jingming Xie, MD; Tao Li, MD; Quan Li, MD; Zhibo Song, MD; Tingbiao Zhu, MD; Ying Zhang, MD*
17:11 - 17:15	**Paper #137: Experimental Study of the Asymmetric Growth of Vertebral NCS Modulated with MWA under CT-guided in Immature Porcine** *Tingbiao Zhu, MD; Jingming Xie, MD; Yingsong Wang, MD; Tao Li, MD; Zhiyue Shi, MD; Ying Zhang, MD; Zhi Zhao, MD; Ni Bi, MD; Quan Li, MD*
17:15 - 17:24	**Discussion**
17:24 - 17:28	**Paper #138: Selecting "SSV-1" as Lower Instrumented Vertebra in Scheuermann's Kyphosis: A Prospective Study with a Minimum of 2-year Follow-up** *Dongyue Li; Zezhang Zhu, PhD; Yong Qiu, PhD; Zhen Liu, PhD*
17:28 - 17:32	**Paper #139: Adding Satellite Rods to Standard Two-rod Construct in Posterior Correction of Scheuermann Kyphosis: Can it Promote Vertebral Remodeling?** *Xu Sun, MD; Yong Qiu, PhD; Zezhang Zhu, PhD; Sinian Wang, MD*
17:32 - 17:36	**Paper #140: Independent Variables Determining The Outcome Of Halo Gravity Traction (Hgt) In Rigid Severe Spinal Deformities - A Multi Centric Study Of 65 Patients** *Saumyajit Basu, MS(orth),DNB(orth), FRCSEd; Dheeraj M. Manikanta, M.S.,(Orthopaedics); Ajoy Prasad Shetty, MS Orth; S. Rajasekaran, MCh; Mainak Palit, PhD*
17:36 - 17:45	**Discussion**

18:30 - 19:30

Presidential Reception (by invitation only)

19:30 - 22:00

Farewell Reception (ticket required) Transportation will be provided from and return to the Hyatt Regency Hotel.

08:00 - 10:10 Columbia Ballroom | Level 3

Abstract Session 9 | Miscellaneous, Hibbs Award Presentation and Transfer of Presidency

Moderators: Serena S. Hu, MD & Laurel C. Blakemore, MD

08:00 - 08:04 **Paper #141: Chronic Absenteeism in Scoliosis Care: an Analysis of Missed Work and School**
Christina M. Regan, BS; Charles P. Nolte, -; Todd A. Milbrandt, MD, MS; Anthony A. A. Stans, MD; William Shaughnessy, MD; A. Noelle Larson, MD

08:04 - 08:08 **Paper #142: Assessing the Economic Benefit of Enhanced Recovery After Surgery (ERAS) Protocols in Adult Cervical Deformity Patients: Is the Initial Additive Cost of Protocols Offset by Clinical Gains**
Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Jordan Lebovic, BA; Pawel P. Jankowski, MD; Peter G. Passias, MD; Thomas J. Buell, MD

08:08 - 08:12 **Paper #143: Learning Curve for Navigated Screw Placement for Vertebral Body Tethering: 3D Imaging Analysis**
Chun-ho Chen, MD; A. Noelle Larson, MD; Todd A. Milbrandt, MD, MS; William J. Shaughnessy, MD; Anthony A. A. Stans, MD

08:12 – 08:21 **Discussion**

08:21 - 08:25 **Paper #144: Delayed Onset Neurologic Deficit Following Spinal Fusion for Pediatric Spinal Deformity**
Nicholas D. Fletcher, MD; Hilary Harris, BS; John S. Vorhies, MD; Sumeet Garg, MD; Jorge Fabregas, MD; Stephen G. George, MD; John Lovejoy, MD; Baron S. Lonner, MD; Brandon A. Ramo, MD; Viral V. Jain, MD; Jennifer M. Bauer, MD, MS

08:25 - 08:29 **Paper #145: Does Custom Instrumentation Reduce the Risk of Implant Failure in Adult Cervical, Spinal Deformity, or Degenerative Lumbar Pathology Patients?: A Multi-Center Predictive Analysis**
Peter G. Passias, MD; Peter Tretiakov, BS; Christopher J. Kleck, MD; David C. Ou-Yang, MD; Evalina L. Burger, MD; Afshin Aminian, MD; Meagan D. Fernandez, DO; Andrew G. King, MD; Dennis P. Devito, MD; Aubrie Nuccio, BS; Personalized Spine Study Group

08:29 - 08:33 **Paper #146: Patient Financial Burden in Surgical Treatment of Adolescent and Adult Spinal Deformity**
Wesley Durand, MD; Alekos A. Theologis, MD; Miguel A. Cartagena-Reyes, BS; Hamid Hassanzadeh, MD; Khaled M. Kebaish, MD; Paul D. Sponseller, MD, MBA; Amit Jain, MD

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

08:42 - 08:46 **Paper #147: Compliance with the Best Practice Guidelines for Preventing Surgical Site Infections (SSI) in High-risk Pediatric Spine Surgery**
Alondra Concepción-González, BA; J. Manuel Sarmiento, MD; Benjamin D. Roye, MD; Christina C. Rymond, BA; Chinenye Ezeh, MPH; Hannah Lin ; Kevin Lu, MS; Afrain Z. Boby, MS, BS; Prakash Gorroochurn, PhD; Brice Ilharreborde, MD, PhD; Michael G. Vitale, MD

08:46 - 08:50 **Paper #148: Selection of the Lowest Instrumented Vertebra and Odds Ratio of Distal Complications for Lenke Type 5 Curves in Adolescent Idiopathic Scoliosis using a posterior approach: A Systematic Review and Meta-analysis**
Esteban Quiceno Restrepo, MD; Amna Hussein, MD; Michael Prim, MD; Ali A Baaj, MD

08:50 - 08:54 **Paper #149: Spinopelvic Failure After Adult Spinal Deformity Surgery: Incidence and Predictors**
Graham W. Johnson, BA; Hani Chanbour, MD; Jeffrey W. Chen, BS; Tyler D. Metcalf, BS; Steven G. Roth, MD; Soren Jonzzon, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH

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

09:03 - 09:07 **Paper #150: Outcomes for Nighttime Bracing in Adolescent Idiopathic Scoliosis Based on Brace Wear Compliance**
Karina A. Zapata, PhD, PT, DPT; Megan E. Johnson, MD; Donald Virostek, LPO/CPO; Anne-Marie Datcu, BS; Chan-Hee Jo, PhD; McKenzie Gunselman, CPO; John A Herring, MD

09:07 - 09:11 **Paper #151: The Addition of Daytime Schroth-based Physical Therapy to AIS Nighttime Bracing Reduces Curve Progression**
Karina A. Zapata, PhD, PT, DPT; Chan-Hee Jo, PhD; Donald Virostek, LPO/CPO; Amy L. McIntosh, MD

Meeting Agenda

Program (topics, timing, and faculty) is subject to change.

09:11 - 09:15 **Paper #152: Femoral Neck Version in the Spinopelvic and Lower Limb 3D Alignment. A Full-body EOS® Study in 400 Healthy Subjects.**
Marc Khalifé, MD, MS; Claudio Vergari, PhD; Guillaume Rebeyrat, MS; Emmanuelle Ferrero, MD, PhD; Pierre Guigui, MD; Ayman Assi, PhD; Wafa Skalli, PhD

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

09:24- 09:28 **Paper #153: Lumbar Lordosis Redistribution and Segmental Correction in Adult Spinal Deformity (ASD): Does it Matter?**
Bassel G. Diebo, MD; Alan H. Daniels, MD; Renaud Lafage, MS; Mariah Balmaceno-Criss, BS; D.Kojo Hamilton, FAANS; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Richard G. Fessler, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Stephen J. Lewis, MD, FRCS(C); Breton G. Line, BS; Pierce D. Nunley, MD; Gregory M. Mundis, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Jeffrey P Mullin, MD; Alex Soroceanu, MPH; Christopher P. Ames, MD; Lawrence G. Lenke, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Douglas C. Burton, MD; International Spine Study Group

09:28 - 09:32 **Paper #154: Three-Column Osteotomy for The Surgical Treatment of Dropped Head Syndrome Due to the Cervicothoracic-Upper Thoracic Proximal Junctional Failures Following Adult Spinal Deformity Surgery: Radiologic and Clinical Outcomes**
Baris Peker, MD; Ali T. Evren, MD; Hamisi M. Mraja, MD; Halil Gok, MD; Cem Sever, MD; Tunay Sanli, MA; Meric Enercan, MD; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

09:32 - 09:36 **Paper #155: Does Preoperative Optimization of Psychiatric Conditions Improve Perioperative Outcomes in Adult Cervical Deformity Patients?**
Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Lee A. Tan, MD; Peter G. Passias, MD

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

09:45 - 09:55 **Presentation of the Hibbs Award(s)**
Rajiv K. Sethi, MD & Amy L. McIntosh, MD

09:55 - 10:05 **Transfer of the Presidency Introduction**
Serena S. Hu, MD

10:05 - 10:10 **Transfer of the Presidency Speech**
Marinus de Kleuver, MD, PhD

10:10 - 10:30 Foyer | Level 3

Refreshment Break

10:30 - 11:55 Columbia Ballroom | Level 3

Abstract Session 10 | Neuromuscular and Miscellaneous

Moderators: Ahmet Alanay, MD & John S. Vorhies, MD

10:30 - 10:34 **Paper #156: Surgery for Neuromuscular Scoliosis Is Associated with Reduced Pulmonary Mortality in Children with Cerebral Palsy**
Matti Ahonen, MD, PhD; Ilkka J. Helenius, MD, PhD; Mika Gissler, PhD; Ira Jeglinsky-Kankainen, PhD

10:34 - 10:38 **Paper #157: Risk for Reoperation 10 years Following Spinal Fusion for Neuromuscular Scoliosis Associated with Cerebral Palsy**
Christopher Seaver, BS; Candice Legister, BS; Sara Morgan, PhD; Casey Palmer, BS; Eduardo C. Beauchamp, MD; Tenner Guillaume, MD; Walter H. Truong, FAOA; Steven E. Koop, MD; Joseph H. Perra, MD; Daniel Miller, MD

10:38 - 10:42 **Paper #158: 15 Years of Spinal Fusion Outcomes in Children with Cerebral Palsy: How Are We Doing?**
Daniel Badin, MD; Majd Marrache, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Burt Yaszay, MD; Patrick J. Cahill, MD; Joann Hunsberger, MD; Paul D. Sponseller, MD, MBA; Harms Study Group

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

10:51 - 10:55 **Paper #159: Spinal Fusion in Patients with Classic Amyoplasia and General Arthrogryposis**
Dietrich Riepen, MD; Emily Lachmann, BS; Brian Wahlig, MD; Karl E. Rathjen, MD

10:55 - 10:59 **Paper #160: Prospective Natural History Study of Idiopathic-like Scoliosis in Patients with 22q11.2 Deletion Syndrome, Starting Before its Pathological Onset**
Peter Lafranca, MD; Steven de Reuver, MD; Abdiqani Abdi, BS; Moyo C. Kruyt, MD, PhD; Keita Ito, MD, PhD; René M. Castelein, MD, PhD; Tom P. Schlösser, MD, PhD

10:59 - 11:03 **Paper #161: Defect in Extrinsic Pathway Impacts Clotting Efficiency in Neuromuscular Scoliosis**
Gregory Benes, BS; William G. Elnemer, BS; Amit Jain, MD; Dolores Njoku, MD; Paul D. Sponseller, MBA

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

11:12 - 11:16 **Paper #162: Greater Implant Density Does Not Improve Pelvic Obliquity and Major Curve Correction in Neuromuscular Scoliosis**
Patrick Thornley, MD; Arlene Maheu, MD; Kenneth J. Rogers, PhD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Burt Yaszay, MD; A. Noelle Larson, MD; Joshua M. Pahys, MD; Peter G. Gabos, MD; M. Wade Shrader, MD; Suken A. Shah, MD

11:16 - 11:20 **Paper #163: What is the Optimal Curve Correction for Cerebral Palsy Patients Undergoing Posterior Spinal Fusion?**
Joshua M. Pahys, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Terrence G. Ishmael, MBBS; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Harms Study Group ; Suken A. Shah, MD

11:20 - 11:24 **Paper #164: Why are we Giving Additional Parenteral Antibiotics to Non-ambulatory Cerebral Palsy Patients with Isolated Acute Post-operative Fevers Following Posterior Spinal Fusion?**
Joshua S. Murphy, MD; Ryan Koehler, MD; Kenneth A. Shaw, DO; Daniel Raftis ; Dennis P. Devito, MD; Robert W. Bruce Jr., MD; Michael L. Schmitz, MD; Numera Sachwani, BS; Jorge Fabregas, MD; Nicholas D. Fletcher, MD

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

11:33 - 11:37 **Paper #165: Is Long-Term Follow-Up Required for Low-Grade Spondylolisthesis? A Prospective Study of 247 Children Followed until Skeletal Maturity**
Antoine Dionne, BS; Abdulmajeed Alzakri, MD; Hubert Labelle, MD; Julie Joncas, RN; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

11:37 - 11:41 **Paper #166: The Effect of Antibiotic-Impregnated Calcium Sulfate Beads and Medical Optimization Clinic Attendance on Surgical Site Infection Rate in High-Risk Scoliosis Patients**
Yashas C. Reddy, BS; Adam Jamnik, BA; David C. Thornberg, BS; Anne-Marie Datcu, BS; Emily Lachmann, BS; Megan E. Johnson, MD; Brandon A. Ramo, MD; Amy L. McIntosh, MD

11:41 - 11:45 **Paper #167: Does Laminectomy Adjacent to Instrumented Fusion Increase the Risk of Adjacent Segment Disease?**
Brandon Simonetta, MD; Biodun Adeniyi, MD, MS; Andrew Corbett, DO; Dennis G. Crandall, MD; Michael S. Chang, MD

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

11:55 **Adjournment**

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Case Discussion Abstracts

CD-1. Gout-Induced Cervical Deformity and Progressive Myelopathy Mimicking Infection Requiring Cervical Reconstruction

Philip K. Louie, MD; Hannah Boudreaux, PA-C; Jesse Shen, MSc; Devon Lefever, MD; Venu M. Nemani, MD, PhD

Hypothesis
N/A

Design
Case Report

Introduction
Although various gout-induced spinal pathologies have been described, it is rare to observe this presentation as an initial gout diagnosis, leading to a spinal deformity, with a concomitant infection in neighboring anatomy. We present a unique case of a previously healthy patient presenting with progressively worsening myelopathy, neck pain and severe jaw pain in the setting of a dental abscess and severe focal cervical spinal deformity.

Methods
A 56-year-old female with 1 week of severe jaw pain and 1-2 days of worsening swelling of her jaw as well as worsening balance and tingling in her hands. On exam, had several upper motor neuron findings. Imaging showed bony erosion of the C3-C6 vertebral bodies with focal kyphosis as well as a grade 2 spondylolisthesis at C3-4. Severe spinal cord compression in the region of the focal kyphotic deformity with spinal cord signal change. Elevated inflammatory markers and white blood cell count were documented. She initially underwent a laminectomy from C3-7, bilateral facetectomies at C3-4, with placement of C2, T1, and T2 pedicle screws. Then placed in Halo Traction with 16 pounds of traction. For the next 4 days, 10 pounds were added each day. On POD5, she underwent a C4-6 corpectomy and completion of the of C2-T2 posterior spinal fusion. There were no intra-operative complications. She was started on Daptomycin and Ertepenam by the Infectious Disease Team.

Results
The patient tolerated surgery very well and stopped taking opioid medications on post-operative day 2. Her jaw pain and swelling had significantly improved with the antibiotics. She was continued on antibiotics until post-operative day 7, when pathology demonstrated infiltration by collections of macrophages responding to deposition of urate crystals in a pattern typical of a gouty tophus. At 6 months after surgery, she is doing well overall. Her hand tingling has resolved, and her balance has significantly improved. She denies neck pain and has returned to all activities without limitation.

Conclusion
We present a unique case of a previously healthy patient presenting with progressively worsening myelopathy, neck pain and severe jaw pain in the setting of a dental abscess and severe focal cervical spinal deformity, found to be gout following an extensive cervical deformity reconstruction surgery.

CD-2. Aborted AIS Spinal Fusion Due To Persistent Loss of IONM: Which Patients Are At Greatest Risk?

Amy L. McIntosh, MD; Lydia Klinkerman, BS; Megan E. Johnson, MD

Hypothesis
Male sex is a risk factor for case abortion due to persistent loss of IONM in AIS patients undergoing fusion surgery.

Design
retrospective review of prospectively collected data.

Introduction
The use of intraoperative neurophysiologic monitoring (IONM) in adolescent idiopathic scoliosis (AIS) surgery is critical for detecting potential neurologic injury. Aborting surgery occurs when abnormal IONM persists despite performance of a well-accepted checklist. The purpose of this study was to determine perioperative risk factors predicting the need for prematurely stopping surgery.

Methods
This is an IRB approved review at a single institution from 2007-2022 for AIS patients that underwent spinal fusion with curves greater than 70°. Aborted cases due to persistent loss of IONM were compared to completed AIS cases. Demographics, curve type, cobb angle, EBL, surgical time, time to return to the OR, IONM reports, advanced imaging and post-operative neurologic exam were obtained.

Results
Nine (9/453: (2%)) AIS patients with pre-operative Cobb angles ≥ 70° were aborted due to persistent loss of IONM. The 9 aborted cases were compared to 444 completed cases. Pre-operative risk factors associated with case abortion were older age (15.3 vs. 13.8 yrs.; p= 0.02) male sex (66.7% vs. 20.3%, p = 0.004) and larger pre-operative cobb angles (87.6° vs. 79.2°; p= 0.01). Male sex increased the risk of case abortion by 7.9X. Intraoperative risk factors associated with case abortion were combined anterior/posterior

Case Discussion Abstracts

approach (ASF/PSF) (44.4% vs. 7.2%; p=0.003), higher EBL (1625 vs. 755 mL; p = 0.006) and longer surgical time (505 vs. 290 min.; p = 0.001). ASF/PSF increased the risk by 10.3X Four (4/9;44%) of the aborted cases awoke with a neurologic deficit. Their motor strength returned to 4+/5 or 5/5 at 2.6 days (0-18). The mean time to return to the OR for aborted cases was 12.6±7.0 days (1-23) and was directly related to time to regain motor strength.

Conclusion

Pre-operative risk factors for AIS case abortion due to persistent loss of IOMN are older age, males, with larger pre-operative Cobb angles. Intraoperative risk factors are combined ASF/PSF, longer surgical times, and higher EBL. Independent risk factors were male sex and ASF/PSF which increased the risk 7.9X and 10.3X, respectively.

CD-3. Severe Cervical Kyphosis of Neurofibromatosis Type 1 with Intradural Tumor in a Pediatric Patient with 2-year Follow-up

Siyi Cai, MD; Ye Tian, MD; *Xin Chen, MD*

Hypothesis

N/A

Design

Case Report

Introduction

Cervical kyphosis is rarely seen in the pediatric population. Neurofibromatosis type 1 (NF1) is a commonly reported hereditary disease which can affect multiple systems. However, few reports have been found regarding to its manifestations regarding to severe dystrophic changes leading to cervical kyphosis together with intradural tumor growth at the same level in pediatric patients.

Methods

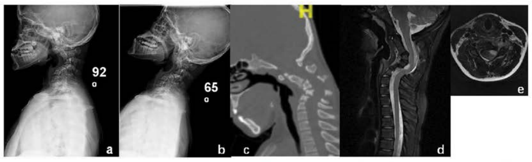
We herein report a case of a 11-year old female patient with NF1 who presented with severe (>90º) cervical kyphosis and intradural tumor growth at the same region. A one-stage tumor resection and deformity corrections was performed. The kyphotic angle was eventually corrected to -5º through combined anterior and posterior approach. There was no correction loss or tumor relapse observed at the two-year follow-up visit. We also reviewed literature on the topic of osteopathy in NF1 to summarize the current understanding of the biology of NF1 related to spinal deformities and potential intervention algorithm concerning cervical deformity.

Results

A total of 22 patients from 7 reports concerning surgical treatment of NF1 related cervical kyphosis have been identified. Among which, 10 patients were below the age of 16. All patients underwent fusion with different surgical approaches. However, combined anteroposterior approach was mostly performed. In addition, pre-operative traction has been suggested to achieve better results.

Conclusion

Based on our case and previous case reports and series, we recommend preoperative traction for patients with severe cervical kyphosis for the best correction. As to surgical corrections of kyphotic deformity, anteroposterior approach should be considered as the first-line choice. In addition, due to distinctive feature of a dilated spinal canal, the intradural tumor may not hinder the correction and can be resected during the correction under spinal cord electrophysiological monitoring.



11yr,femle,cervical kyphosis with neurofibromatosis-1. X-ray(Lateral film) showed cervical kyphosis of 92º between C2 and C5, subluxation between C2 and C3 and 65º at extension radiographs (Figure 1a and 1b) .Vertebrates dysplasia and spinal canal enlargement were seen in CT scan(Figure 1c). An intra dura mass was located prone to the spinal cord at C4 level and extent to the left foramina of C4 was shown in MRI T2 (Figure 1d and 1e).

6 months follow-up, the C2-C5 were seen fused from the CT .(Figure 2a) There was no sign of loss of correction (Figure 2b) and no tumor at the 2 years follow-up(Figure 2C)

Comparison between before pre- and post-operative images

CD-4. Craniovertebral Angle (CVA) and Head Position Should Be Considered in Autistic AIS Patients

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

Hypothesis

Head position and craniovertebral angle (CVA) should be considered for optimal cranial-sagittal alignment in any patient exhibiting degrees of autism, behavioral or neuromuscular diseases to prevent proximal-junctional kyphosis (PJK).

Design

Case Report

Introduction

A 15 year old female with adolescent idiopathic scoliosis (AIS) and a chromosome anomaly with tetrasomy 9p. Patient exhibited proximal-junctional kyphosis (PJK) as well.

Methods

At presentation, patient had a 75° preoperative curve from T11 – L4. The coronal decompensation was 29.6 mm. Lateral xrays revealed an 83° kyphotic curve and a sagittal decompensation 36.6 mm. Given that the shoulders and pelvis were balanced, touched vertebrae (TV) on the xray was used for the T4 – L4 construct. Posterior spinal fusion surgery was conducted without complication. Estimated blood loss was approximately 1 L with 2 units of PRBC used. The Cobb angle was 21° with a coronal decompensation of 42.9 mm. Lateral xrays showed improvement in kyphosis with a thoracic curve of 30° and a sagittal decompensation of 53.5 mm. She began to demonstrate PJK once again with a lateral thoracic curve progressing from 30° to 58°. Objective comparisons of all pre- and post-operative parameters and we discovered that patient was recreating her initial cranial-sagittal alignment. In her initial preoperative lateral xray, the patient had displayed a 19.7 mm C1 – C7 balance. When compared with the sagittal balance, this revealed the C1 – S1 decompensation to be 56.3 mm. The patient also had an initial craniovertebral angle (CVA) of 67° and indicated a forward cranial position. At immediate postoperative lateral xray, the C1-C7 balance was 31.0 mm and a total C1-S1 decompensation of 84.5mm and a craniovertebral angle (CVA) of 70°. The latest follow-up postoperative lateral xray saw a 22.8 mm C1 – C7 balance, a 52.2 mm sagittal balance and a 75.0 mm C1 –S1 decompensation. The craniovertebral angle (CVA) was 57°.

Results

Upon noticing this forward cranial translation, patients with these types of behavioral/neuromuscular disorders may have a propensity to return to their potentially normal physiological cranial-sagittal alignment.

Conclusion

Surgeons should consider optimal kyphosis correction and head position with measures such as the craniovertebral angle (CVA) and cranial position for desired cranial-sagittal alignment.

CD-5. Paralysis and Repeated Rod Fractures During Traditional Dual Growing Rods Treatment in a Patient With Marfanoid-Progeroid-Lipodystrophy Syndrome: More than 9-year Follow-up

Yang Yang, MD; Nan Wu, MD; Shengru Wang, MD, PhD; Terry Jianguo Zhang, MD

Hypothesis

Treatment for patients with syndromic early onset scoliosis (EOS) is chanllging. More complications may occur compared with patients with other types of scoliosis.

Design

Case report.

Introduction

Marfanoid-progeroid-lipodystrophy syndrome (MPLS), caused by a rare mutation of FBN1, is a complicated fibrillinopathy, characterized by accelerated aging and postnatal lipodystrophy, poor postnatal weight gain, and characteristic dysmorphic facial features. Treatment for patients with MPLS and EOS is difficult and challenging.

Methods

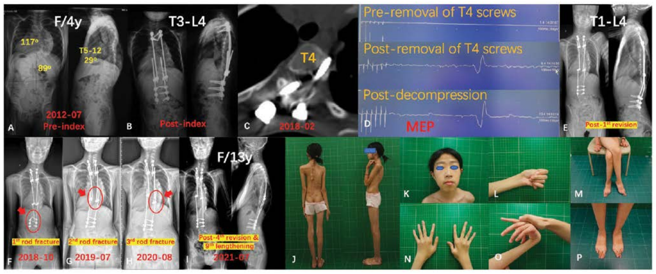
A 4-year old girl, who was the first reported Chinese subject with MPLS, had severe scoliosis (117 degree and 89 degree) and hyphokyphosis (T5-12: 29 degree). She was treated with traditional dual growing rods (TDGRs).

Results

During her 9-year treatment, she had suffered several severe complications, including paralysis caused by T4(R) screw dislodgement into spinal canal after an accidental falling down and 3 repeated rod fractures. After removal of proximal pedicle screws and spinal canal decompression, her motor ability totally recovered. Proximal anchors were extended to T1-2 using four hooks. Until now, this young girl had underwent 4 revision surgeries and 9 lengthening procedures. The deformity correction and spinal growth were satisfied. She enjoys a normal life and comes back to our hospital regularly.

Conclusion

For patients with MPLS and EOS, TDGRs technique could provide satisfying results, though much more complications may occur compared with other types of EOS. Both surgeons and patients/parents should be aware of this condition.



Radiographs and Clinical Appearance of a Young Girl with MPLS and EOS.

CD-6. Rib Fracture and Pneumothorax during Intraoperative Magnetic Rod Distraction

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

Hypothesis

Due to the relatively low-strength of rib-based fixation points increased vigilance is necessary to prevent compromised fixation during initial correction

Design

Case Report

Introduction

Patient is a 7 year old female with juvenile scoliosis curve of 62° from T7 to L1. The patient has failed conservative management and was indicated for a growth friendly construct to maintain correction of the deformity, prevent further curve progression, and allow for growth.

Methods

A 2 incision approach was taken. One incision from L2-L3. Screws were placed freehand in the lumbar spine first. To allow for fusion, the L2-L3 facet joint was incised. A second incision was made from T2-T5. The paraspinal muscles were exposed and the ribs were identified. Subperiosteal dissection was performed at T2, T3, and T4 and hooks were placed on the left side. Hooks were also placed on the right side. No pleural compromise was found on either side, confirmed with the Valsalva test. A 70 mm x 5 mm magnetically controlled growing rod was contoured and placed. Distraction was successfully performed on the right side rod first. During the left side distraction, the T4 rib fractured, resulting in a small pneumothorax. This was confirmed on XR. Pediatric general surgery was called to repair the hole in the pleura. The lung was able to be inflated and a chest tube was not needed. XR confirmed lung inflation and a Valsalva test was done to further confirm.

Case Discussion Abstracts

Results
Patient was released from PICU on POD 2. Estimated blood loss was 200mL and total operative time was 610min. She was transitioned from PCA to oral pain medication on POD 2. Patient had right side pain due to the fractured ribs. Hospital course was otherwise uneventful and patient was discharged on POD 5.

Conclusion
When placing magnetically controlled growing rods in juvenile patients, it is important to closely monitor the fixation points since they are limited to 2-4 rib hooks cephalad and 2-4 pedicle screw caudad. This is especially true regarding rib fixation due to their poor strength. In this patient, because of the compromise of the fixation points, postoperative distraction is delayed, possibly compromising correction.

CD-7. Time and Distance: The Temporal and Travel Burden Associated with Growth-friendly Surgical Treatment of Early Onset Scoliosis

Ryan McFadden, BS; Lucas Hauth, BS; Jason B. Anari, MD; Jaysson T. Brooks, MD; Jeffrey R. Sawyer, MD; Maxwell D. Marshall, BM; Pediatric Spine Study Group; Robert F. Murphy, MD

Hypothesis
There is a significant time and travel burden on patients and families who undergo growth-friendly (GF) surgical treatment of Early Onset Scoliosis (EOS)

Design
Multi-center retrospective review

Introduction
Patients who undergo GF treatment for EOS undergo multiple clinical and surgical encounters and frequently travel long distances for their treatment. We sought to quantify the temporal and travel burden of these patients and estimate the subsequent cost.

Methods
Four high volume centers in the Pediatric Spine Study Group combined data on all registry patients with EOS who underwent surgical GF treatment from 2006-2021. Data collected included demographics, scoliosis etiology, GF implant, visit type (clinical office visit, surgical lengthening, MCGR clinic lengthening, spinal fusion), and one-way driving distance between the patients' home and treating institution. We applied 2022 IRS and BLS data or $0.625/mile and $208.2/day off work to calculate a relative financial burden.

Results
A total of 372 patients were analyzed (57% female). Scoliosis etiology was diverse (30.1% congenital, 19.6% idiopathic, 32% neuromuscular, 18.0% syndromic). Average age at index GF procedure was 6 (range 0-17). Index GF implant was VEPTR or TGR (250, 67%) and MCGR (122, 33%). For the 372 patients, there were a total of 6,538 encounters (average 21 encounters per patient; range 2 -76). Visit type was 2940 clinical office visits, 2147 surgical lengthenings, 1245 MCGR lengthenings, and 206 spinal fusions (Fig 1). Twenty-one days off work estimated a loss of $4,372.2 in income. There was no significant relationship between EOS etiology and number of clinical or surgical encounters. On average, patients traveled between their home and treating institution of 350 miles per encounter (range 2.4 - 5,654), with a cumulative average driving distance of 4,826 miles for the entirety of their treatment (range 16.8 - 90,552), at an estimated cost of $3,016.25.

Conclusion
EOS patients and their families who undergo GF treatment average 21 encounters at their treating institution, and travel on average 350 miles per encounter, with a total average mileage+work cost of $7388.45. These data inform families about the commitment required of a GF treatment program, and highlight the impact EOS treatment has on patients and families.

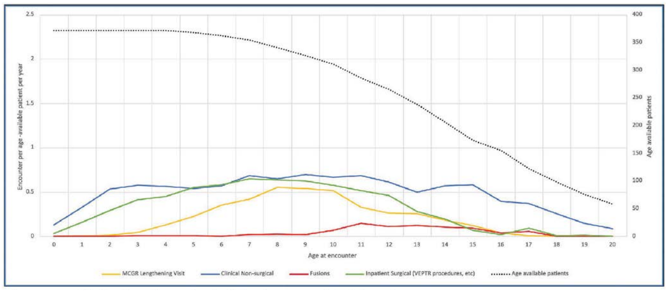


Figure 1. Clinical and surgical visits by age of EOS patients

CD-8. Withdrawn

CD-9. Posterior Temporary Internal Distraction with Anterior Release and Subsequent Spinal Fusion for the Treatment of Severe Scoliosis

Daisuke Yamabe, MD, PhD; Hideki Murakami, MD, PhD; Hirooki Endo, MD, PhD; Yusuke Chiba, MD, PhD; Hirotaka Yan, MD; Minoru Doita, MD, PhD

Hypothesis
To investigate the efficacy and safety of posterior temporary internal distraction with anterior release and subsequent posterior spinal fusion for the treatment of severe scoliosis.

Design
a case report

Introduction
It is known that corrective surgery for severe scoliosis with a Cobb angle of 100° or more and flexibility of less than 20% is difficult to obtain adequete correction, and the risk of neurological complications is high.

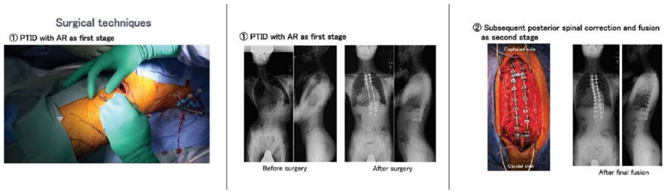
Methods
Three scoliosis patients with severe and rigid curve who underwent a two-stage surgery using posterior temporary internal distraction with anterior release and subsequent posterior spinal correction with pedicle screw instrumentation were retrospectively reviewed. These were 2 male and 1 female patients with a mean age of 18 years (range 16-20 years) at the time of surgery.

Results
The preoperative major curve of 101 degrees (range 90-107

degrees) was corrected to 52 degrees (range 38-67 degrees) after the internal distraction correction surgery, with a mean scoliosis correction rate of 48%. During definitive surgery, the major curve were further corrected to 36 degrees (range 21-47 degrees), with a mean scoliosis correction rate of 64%. There were no neurological complications or any deep wound infections. No complication of instrumentation was found at final follow-up.

Conclusion

Posterior temporary internal distraction with anterior release and subsequent spinal fusion is a good alternative correction method to maximizing curve correction and to reduce perioperative complications such as neurological complication in the treatment of severe and scoliosis.



CD-10. Outcomes after Completing Growth-Friendly Surgical Treatment for Early-Onset Scoliosis in Patients with Skeletal Dysplasia

Antti J. Saarinen, MD; Paul D. Sponseller, MD, MBA; George H. Thompson, MD; John B. Emans, MD; Patrick J. Cahill, MD; Steven W. Hwang, MD; Lindsay M. Andras, MD; Klane K. White, MD; Amer F. Samdani, MD; Pediatric Spine Study Group; Ilkka J. Helenius, MD, PhD

Hypothesis

Patients with skeletal dysplasias have increased risk of complications and unplanned returns to the operating room during the growth-friendly treatment when compared to patients with syndromic early onset scoliosis.

Design

A retrospective review of a prospectively collected international database.

Introduction

Patients with skeletal dysplasias have limited growth potential. Additional benefit of growth-friendly treatment of early onset scoliosis remains unclear in these patients.

Methods

Fifteen skeletal dysplasia patients from PSSG database who had completed their growth-friendly treatment were identified. Of these patients, two patients had achondroplasia, one had cleidocranial dysplasia, three had diastrophic dysplasia, one had metatropic dysplasia, one had mucopolysaccharidosis, two had spondyloepiphyseal dysplasia, three had spondylometaphyseal dysplasia, and two had unspecified skeletal dysplasia. These patients were compared to patients with syndromic early onset scoliosis who had completed the growth-friendly treatment (n=297).

Results

Clinical characteristics were similar between the groups. Final fusion was performed to 60% (9/15) patients in the skeletal dysplasia and 77% (229/297) in the control group. Index spinal deformity correction was similar between the groups. At the last follow-up, the mean major curve was 39° in the skeletal dysplasia group and 48° in the control group (p=0.153). Annual spinal growth was similar between the groups during the growth-friendly treatment (1.4 cm vs. 1.1 cm, p=0.587). In the skeletal dysplasia group, 87% of the patients experienced at least one complication when compared to 83% in the control group (p=0.699). Skeletal dysplasia patients experienced more unplanned revisions (RR 1.49, 95%CI 1.1–2.0), implant related complications (RR 1.2, 95%CI 1.1–1.3), and neurologic complications during the treatment (RR 4.9, 95%CI 2.5–9.4). There were no significant differences between the groups in the rate of implant breakage and deep surgical site infections.

Conclusion

Patients with skeletal dysplasias experienced significantly more unplanned revisions, implant complications, and neurologic complications during their growth-friendly treatment when compared to syndromic patients without skeletal dysplasias.

	Skeletal dysplasia	SD / range	Syndromic	SD / range	P-value
N	15		297		
Female	11		156		
Age at surgery, years	6.3	2.6	6.0	2.3	0.740
Follow-up, years	9.1	3.4	6.8	2.6	0.023
Preoperative Major Curve, °	68	21	75	21	0.275
Preoperative Spinal Height, mm	237	62	256	49	0.283
Preoperative Thoracic Height, mm	142	46	159	35	0.192
Preoperative kyphosis, °	66	29	54	23	0.129
Postoperative Major curve, °	37	14	47	18	0.030
Postoperative Spinal height, mm	280	69	295	48	0.484
Postoperative thoracic height, mm	175	51	182	32	0.676
Postoperative kyphosis, °	49	21	40	19	0.189
Final follow-up major curve, °	39	24	48	20	0.153
Final follow-up spinal height, mm	307	68	346	56	0.067
Final follow-up thoracic height, mm	194	43	213	39	0.129
Final follow-up kyphosis, °	54	28	56	23	0.800
Annual spinal growth, mm	14	17	11	14	0.587
At least 1 complication, (%)	13 (87%)		246 (83%)		0.699
Total number of complications, (mean)	80 (5.3)	1–13	1003 (3.4)	1–23	
Implant related, (mean)	37 (2.5)	0–8	410 (1.4)	0–9	
Implant break, (mean)	9 (0.6)	0–3	168 (0.6)	0–7	

Outcomes of Growth-friendly management in the skeletal dysplasia and syndromic early onset scoliosis.

CD-11. Congenital Dislocation Spine: A Rare Case Report with Diagnostic Dilemma

Shah Waliullah, PhD, MBBS, MS

Hypothesis

Vertebral Column Resection(VCR) is an effective method to correct Congenital Dislocation of the Spine.

Design

Case Report

Introduction

The congenital dislocated spine (CDS), a rare spinal malformation, has been defined as the potentially most serious form of congeni-

Case Discussion Abstracts

tal kyphosis with an abrupt single-level displacement of the spinal canal.

Methods

Case Report: the 13-year-old kid was referred from the peripheral health centre as a case of Post tubercular Kyphotic deformity. The patient presented with back pain and difficulty walking. On examination, the patient had Kyphotic deformity at the dorso-lumbar region, and neurology was intact. X-ray showed Kyphotic deformity of around 100 degrees with acute translation and dislocation at the dorso-lumbar junction. Computed tomography and magnetic resonance imaging of the whole spine was done. Diagnosis of CDS was made.

Results

The patient was managed by 2-level vertebral column resection(VCR) at the dorso lumbar junction with posterior instrumentation and fusion under neural monitoring. The kyphotic deformity was corrected to 42 degrees postoperatively, and the translation was fully corrected. At the final follow-up of two years, the patient has solid fusion and no back pain.

Conclusion

CDS is a rare deformity; diagnosis requires thorough clinical and radiological evaluation. These deformities can be managed by meticulous planning, and VCR is an effective method to correct these deformities.

Pre Op CT and Xray images

CD-12. The Case for Posterior Spinal Fusion Surgery in Severe Thoracolumbar Neuromuscular Scoliosis with Chronic Hip Dislocation

Paige M. Miller, BA; Lauren Lamont, MD

Hypothesis

PSF can be an appropriate treatment option in GMFCS V CP patients with NMS and chronically dislocated hips.

Design

Case Series

Introduction

This case series presents three cases of patients with severe (>90°) thoracolumbar neuromuscular scoliosis secondary to GMFCS Level V quadriplegic spastic cerebral palsy (CP) with concomitant chronic hip dislocation that underwent posterior spinal fusion (PSF) surgery. Despite the documented risks for surgery in NMS patients with severe curves, these cases serve to highlight how surgical intervention can significantly improve reported back pain, hip pain, sitting ability and balance, and quality of life for these non-ambulatory patients.

Methods

Case 1 is a 17-year-old non-ambulatory nonverbal female with NMS of the thoracolumbar region and tetraplegic CP with preoperative spine PA x-ray demonstrating a 92° right thoracolumbar curvature. Case 2 is a 15-year-old male non-ambulatory minimally verbal male with NMS of the thoracolumbar region and quadriplegic spastic CP with a preoperative 122° right thoracolumbar curvature. Case 3 is a 10-year-old non-ambulatory non-verbal female with NMS of thoracolumbar region and spastic quadriplegic CP with a preoperative 127° lumbar curve.

Results

These cases demonstrate how PSF may help to reduce overall pain levels in GMFCS V patients with severe NMS and chronic hip dislocation without major complication. All three patients were not surgical candidates for hip relocation due to irreversible damage to the femoral head and arthritic changes that would not allow for concentric hip reduction. Following PSF, none of the patients presented have needed major bony surgery to date and patient caretakers have overall seen improvement in their generalized pain levels and quality of life.

Conclusion

Patients with severe (>90°) NMS have an increased risk of intraoperative and postoperative complications following PSF compared to patients with less severe curves. In addition, in the setting of a chronically dislocated hip with multiple pain generators, the benefit is unclear. Despite these risks, the presented cases support the use of PSF surgery in patients with NMS secondary to quadriplegic spastic CP to improve hip pain. PSF should be considered as an appropriate treatment option in GMFCS V patients with severe pain, severe NMS, and chronically dislocated hips.

Pre Operative Curves

Post Operative Curves

Podium Presentation Abstracts

1. Twenty-year Follow-up after Single Level Lumbar Fusion, a Retrospective Analysis

José M. Spirig, MD; Shayan Golshani, MD; Mazda Farshad, MPH; Michael Betz, MD

Hypothesis

Patients with single level lumbar fusion have a high re-operation rate after 20 years despite their benefit from the initial surgery

Design

cohort study

Introduction

The aim of this study was to analyze outcomes of single level lumbar spinal fusions focusing on revision rate and subjective outcome measures during a 20-year follow-up period

Methods

All available patients from our tertiary spinal care center who had single level lumbar spinal fusion between 1994 and 2001 were recruited for a radiological and clinical follow-up. Patients were screened for subsequent surgeries during the follow-up time and their risk factors. Outcomes were assessed using the Oswestry disability index and the visual analog scale for pain. Radiological parameters such as lumbar lordosis, pelvic incidence and coronal cobb angle were assessed with a EOS whole body X-ray at follow up and compared to the preoperative lumbar X-ray if available.

Results

Forty-four patients (26 female:18 male) with a mean age of 65 years at follow-up could be recruited. Mean follow-up time was 21.3 years. The rate for subsequent surgery during this time was 56.8% (25/44). Mean time to second surgery was 14.59 years. Adjacent segment disease (ASD) was the reason for revision in 40.9% (18/44) of all patients. Patient reported outcome favors non-revised patients with however a clear benefit for both groups.

Conclusion

Subsequent surgery after single level lumbar fusion is very probably within a time frame of 20 years. The primary cause for a second surgery is ASD. Despite of a high rate of re-operations, subjective outcomes show improvements in all patient populations.

2. Change in Spinal Bone Mineral Density as estimated by Hounsfield Units following Osteoporosis Treatment with Romosozumab, Teriparatide, Denosumab, and Alendronate: An Analysis of 318 Patients

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Hypothesis

Romosozumab and teriparatide improve Hounsfield units.

Design

Retrospective chart review.

Introduction

Low spinal bone mineral density (BMD) as estimated by CT based opportunistic Hounsfield units (HU) has been shown to be a risk factor for mechanical complications following spine fusion surgery. While teriparatide has been shown to improve HU, the impact of other osteoporosis medications on spinal HU is unknown. The purpose of this study was to determine the effect of osteoporosis medications on spinal bone mineral density as estimated by opportunistic CT based HU, including romosozumab, teriparatide, alendronate, and denosumab.

Methods

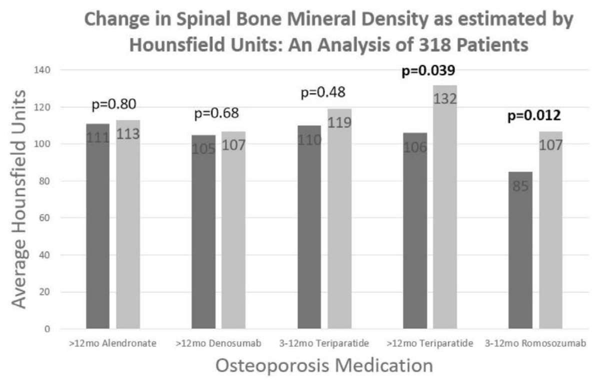
A retrospective chart review identified spine and non-spine surgery patients treated with 3 to 12 months of romosozumab, 3 to 12 months of teriparatide, greater than 12 months of teriparatide, one year of denosumab, and one year of alendronate with a CT scan performed before and after treatment. Hounsfield units were measured in the L1, L2, L3, and L4 vertebral bodies with three measurements per level on axial CT images. One-way analysis of variance (ANOVA) compared the mean change in HU between the five treatment regiments.

Results

Three hundred and eighteen patients (70% women) were included with an average age of 69 and average BMI of 27. There was a significant difference in the mean HU improvement (p=<0.001) between romosozumab (n=32), 3 to 12 months of teriparatide (n=30), >12 months of teriparatide (n=44), denosumab (n=123), and alendronate (n=100). Treatment with an average of 10.5 months of romosozumab significantly increased mean HU by 26% from a baseline of 85 to 107 (p=0.012). Patients treated with >12 months of teriparatide (average 23 months) improved mean HU by 25% from 106 to 132 (p=0.039). Compared to mean baseline HU, there was no significant difference after treatment with 3 to 12 months of teriparatide (110 to 119, p=0.48), denosumab (105 to 107, p=0.68), or alendronate (111 to 113, p=0.80).

Conclusion

Patients treated with an average of 10.5 months of romosozumab and 23 months of teriparatide improved spinal bone mineral density as estimated by CT based opportunistic HU. Given the shorter duration of effective treatment, romosozumab may be the preferred medication for optimization of osteoporotic patients in preparation for elective spine fusion surgery.



3. ASD with High PT have Decreased Hamstring Lengths Both in Standing Position and During Walking

Guillaume Rebeyrat, MS; Ayman Assi, PhD; Rami Rachkidi, MD, MS; Abir Massaad, PhD; Mohammad I. Karam, PhD; Ismat Ghanem, MD, MS; Helene Pillet, PhD; Wafa Skalli, PhD

Hypothesis

ASD with increased pelvic retroversion have static and dynamic stiff hamstrings.

Design

Prospective

Introduction

Spine surgeons often notice stiff lower limb muscles in ASD with severe malalignment, especially in the hamstrings. This can be due to chronic pelvic retroversion in some patients. This study aims to evaluate lengths of the lower limb muscles in standing position and during walking in ASD patients using 3D subject-specific musculo-skeletal modeling.

Methods

90 primary ASD and 36 controls underwent both biplanar Xrays and 3D gait analysis for the calculation of spinopelvic, postural, and joint kinematic parameters. Patient-specific 3D volumetric muscles were obtained both in standing and during walking, by personalizing a generic musculoskeletal model combined with image-registration technique. Normalized muscle lengths were obtained both in standing and during walking. PT adjusted to PI was calculated (adj.PT=0.37*PI-7°). Patients with high adjusted PT (>2SD in controls) were grouped as ASD-highPT, otherwise as ASD-normalPT. Between groups comparisons of static and dynamic muscle lengths were investigated.

Results

26/90 patients were classified as ASD-highPT (PT=31°). In standing, ASD-highPT had a decreased length of hamstrings (biceps-femoris=52%, semi-tendinus=61%, semi-membranus=52% vs. 56%,64%,55% resp.), as well as for the gluteus maximus, rectus femoris, sartorius, adductor longus & vastus medialis compared to ASD-normalPT and controls (all $p<0.05$). When walking, ASD-highPT had an increased dynamic PT (29 vs 17° in other groups) with a decreased knee range of motion (49 vs 59°). While most of the lower limb muscles regained a normative length during walking, this was not the case for the biceps-femoris (53 vs 57%), semi-tendinus (62 vs 65%) & semi-membranus (53 vs 56%; all $p<0.05$). The reduced hip and knee range of motion were correlated to the reduced muscle lengths ($0.30\leq r\leq 0.55$; $p<0.001$).

Conclusion

ASD patients with high pelvic retroversion present shorter lower limb muscles in standing position. While most of the lower limb muscles stretched during walking, hamstring muscles exhibited a dynamic stiffness associated with decreased hip and knee ranges of motion. This study confirms the clinical observation of stiff hamstrings both during static and dynamic in ASD compensating with an increased pelvic retroversion.

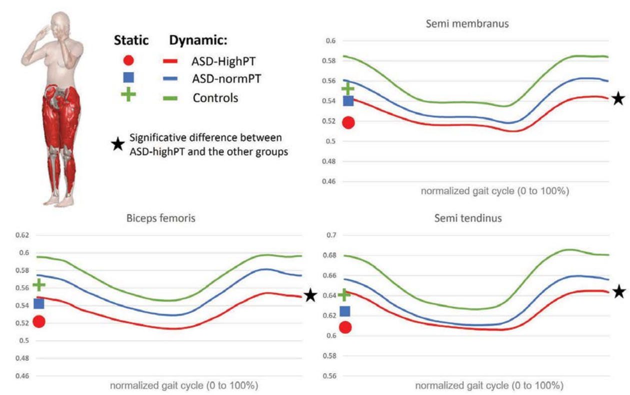


Fig.1: Static and dynamic hamstring lengths in ASD and controls.

4. Osteoporotic Patients on Teriparatide Have Lower Pseudoarthrosis Rate Compared to Patients with Osteopenia

Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Erik Lewerenz, BS; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis

Osteoporotic patients(pts) on Teriparatide(OP-T) therapy have superior pseudoarthrosis outcomes versus pts with osteopenia(OPE).

Design

Two cohorts of pts with >2-year(2Y) follow-up: pts with (1)OPE and pts w (2)OP on Teriparatide(OP-T). This retrospective analysis included 1:3 propensity score matched(PSM) pts undergoing PSF for deformity. Pts had ≥1 of the following: PI-LL≥25°, TPA≥30°, SVA≥15cm, thoracic scoliosis≥70°, thoracolumbar scoliosis≥50°, coronal malalignment≥7cm, or undergoing 3CO.

Introduction

National databases indicate that odds of pseudarthrosis in pts with either, OPE and OP are >2x and >3x higher, versus pts with normal bone density. Osteo-anabolic compound, Teriparatide, currently has narrow indications: only OP pts with high fracture risk who have failed other therapies.

Methods

Primary outcome was 2Y reoperation for pseudoarthrosis+/-implant failure. Secondary outcomes were 2Y PJK rate and patient reported outcomes(PROs)[SRS, ODI]. Pts were matched using 1 OP-T to 3 OPE pts based on age, sex, total instrumented levels(TIL), 3CO,

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preop PI-LL, and preop T1PA. Clinical outcomes analyzed using conditional logistic regression resulting in odds ratios.

Results

100 pts(79[79%] OPE, 21[21%] OP] had 2Y follow up. Mean age was 60.6(0.73), BMI 25.5(0.54), TIL 16.4(0.25) levels, baseline(b/l) T1PA 25.2(1.53), b/l PI-LL was 22(2.03), and T Score -1.81(0.06). 88%(88) were female and 10%(10) underwent 3COs. Overall, 11% underwent 2Y reoperation, 10% had pseudoarthrosis+/-implant failure, and 8% had PJK. 21 OP pts were matched to 63 OPE pts. Among matched pts, there was no difference in age [P=0.36], TIL[P=0.51], %3CO[P=0.64], %female[P=0.26], b/l T1PA[P=0.56], b/l PI/LL(P=0.53), and b/l PROs aside from SRS-pain: OPE pts had worse pain(P=0.0053). Among matched pts, 14.3%(9) of OPE and 9.5%(2) of OP pts had 2Y reoperation(OR 0.33, P=0.2888). 14.3%(9) vs 4.8%(1) had pseudoarthrosis (OR 0.13, 95% CI: 0.003 - 0.93, P= 0.04), and 9.5%(6) vs 9.5%(2) had PJK(OR=0.67,P>0.99), respectively. At 2Y postop, PROs were significantly better among OP pts(vs OPE pts): [SRS Function[3.65(0.15) vs 4.17 (0.15),P=0.02], SRS Mental[3.96(0.12) vs 4.3 (0.05),P=0.01], and total SRS score [82.6(3.09) vs 91.9(2.29), P=0.01]

Conclusion

OP-T pts have superior clinical, and PROs versus OPE pts. The rate of pseudoarthrosis/implant failure was 66% lower among OP-T pts, suggesting OPE pts could benefit from osteo-anabolic agents

Table. Demographic characteristics, spinal alignment preoperatively and at two-year postoperatively, patient reported outcomes (PROs) at baseline and two-year postoperatively, and clinical outcomes within the propensity matched cohort.

	Propensity Score Matched Cohort		
	Osteopenia [N=63]	Teriparatide [N=21]	P Value
Demographics			
Demographic Characteristics			
Age in Years (SEM)	60.8 (0.74)	62.33 (1.46)	0.3572
Body Mass Index (BMI)	23.91 (1.11)	19.62 (2.37)	0.1119
Total Instrumented Levels (TILL)	16.97 (0.3)	16.6 (0.46)	0.5045
Operative Characteristics			
3CO	4 (10.81)	2 (5.41)	0.6365
Bone Health Measures			
T Score	-1.64 (0.05)	-2.70 (0.21)	-
Gender, Female (% of Cohort)	50 (79.37)	16 (76.19)	0.7647
Spinal Alignment			
Preoperative Spinal Alignment			
Pelvic Incidence (PI °)	52.54 (1.87)	53.39 (3.54)	0.8332
Lumbar Lordosis (LL °)	36.62 (1.96)	40.47 (4.78)	0.4626
Pelvic Incidence - Lumbar Lordosis (PI - LL °)	15.92 (1.73)	13.92 (2.64)	0.5301
T1PA	21.4 (1.27)	23 (2.41)	0.5611
Thoracic Kyphosis	35.41 (1.78)	43.84 (5.35)	0.1476
C7 Sagittal Vertical Axis	4.22 (0.75)	6.05 (1.38)	0.2524
Cranial Sagittal Vertical Axis to Hip (CrSVA-H)	-1.49 (0.6)	1.53 (1.4)	0.0574
Two-Year Spinal Alignment			
Pelvic Incidence (PI °)	50.52 (1.9)	57.06 (3.58)	0.1164
Lumbar Lordosis (LL °)	44.18 (2.06)	47.08 (2.99)	0.4291
Pelvic Incidence - Lumbar Lordosis (PI - LL °)	6.34 (1.33)	9.98 (1.87)	0.1202
T1PA	16.58 (1.29)	17.89 (1.51)	0.5125
Thoracic Kyphosis	39.38 (1.28)	44.32 (1.87)	**0.0352**
C7 Sagittal Vertical Axis	0.22 (0.57)	1.17 (1.02)	0.422
Cranial Sagittal Vertical Axis to Hip (CrSVA-H)	-2.76 (0.64)	-1.11 (1.34)	0.2754
Patient Reported Outcomes			
Preoperative SRS PRO			
Function and Activity	3.13 (0.1)	3.18 (0.21)	0.8313
Pain	2.56 (0.11)	3.08 (0.14)	**0.0053**
Self-perceived image	2.24 (0.08)	2.32 (0.19)	0.701
Mental health	3.52 (0.12)	3.88 (0.21)	0.1458
Satisfaction	2.54 (0.15)	2.81 (0.29)	0.4145
Mean Score	2.82 (0.07)	3.09 (0.15)	0.1136
Total SRS Score	62.3 (1.55)	67.88 (3.39)	0.1452
Two-Year SRS PRO			
Function and Activity	3.65 (0.15)	4.17 (0.15)	**0.0169**
Pain	3.49 (0.2)	4.05 (0.16)	**0.0316**
Self-perceived image	3.75 (0.18)	4.13 (0.15)	0.1088
Mental health	3.96 (0.12)	4.3 (0.05)	**0.0102**
Satisfaction	4.24 (0.18)	4.31 (0.27)	0.8303
Mean Score	3.75 (0.14)	4.18 (0.1)	**0.0142**
Total SRS Score	82.59 (3.09)	91.88 (2.29)	**0.0177**
Preoperative and Two-Year ODI PRO			
Pre-Operative	40.34 (1.55)	37.11 (3.2)	0.3709
Two-Year	26.92 (3.17)	21.25 (3.29)	0.2193
Clinical Outcomes			
Clinical Outcomes			
2-Year Reoperation	9 (14.29)	2 (9.53)	OR 0.333 95% CI:[0.033 - 1.864, P=0.2888]
Symptomatic Pseudoarthrosis +/- Implant Failure	9 (14.29)	1 (4.76)	**Odds Ratio 0.125 95% CI: 0.003 - 0.932, P= 0.0455**
Proximal Junctional Kyphosis	6 (9.52)	2 (9.52)	OR: 0.667 95% CI: 0.056 - 5.820, P>0.9999

5. Measuring Acetabular Orientation in the Lewinnek Plane is Not Suitable for ASD Patients with High Pelvic Retroversion

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Hypothesis

Increased PT is related to a greater mismatch in acetabular orientation between the Lewinnek and the positional plane.

Design

Prospective

Introduction

Increased pelvic retroversion in ASD is associated with alteration of acetabular orientation, increasing the risk of hip osteoarthritis usually treated by total hip replacement (THR). A safe zone is targeted during cup positioning where acetabular orientation is calculated relatively to the invariant morphological Lewinnek plane, unruled by the patient's position. Higher rates of prosthesis instability were found in ASD, mainly due to different hip positioning encountered in daily life activities. The aim was to evaluate the mismatch between Lewinnek and positional acetabular measurements in variable patient's postures.

Methods

121 ASD and 32 controls underwent biplanar Xrays in standing and sitting positions. 3D acetabular parameters were calculated in both the Lewinnek and radiological positional planes. The planes mismatch (Δ=Lewinnek-Positional) was evaluated. PT adjusted to PI was calculated (adj.PT=0.37*PI-7°). Patients having a high adj. PT (>2SD in controls) were grouped as ASD-HighPT, otherwise as ASD-NormPT.

Results

42 ASD had a high PT and 79 a normal PT. Although all 3 groups had similar PI (52°), ASD-HighPT had a decreased LL (L1S1=33°, PT=31°) and decompensated sagittal malalignment (SVA=76mm). In standing position, ASD-HighPT showed an increased planes mismatch of their acetabular parameters (Δanteversion=-12° vs 2°, Δanterior coverage=13° vs 0°, both p<0.001), compared to other groups. In the sitting position, ASD-HighPT showed an increased mismatch (Δanteversion=-16° vs -10°, Δanterior coverage=16° vs 11°, both p<0.001), but to a lesser extent than the standing position. PT was strongly correlated to Δanteversion (r=-0.74) and Δanterior coverage (r=0.67, fig.1) in standing, and moderately correlated in sitting (r=-0.40 & 0.25 resp., all p<0.001).

Conclusion

This study showed that the Lewinnek plane is not representative of the positional acetabular orientation in the presence of sagittal malalignment. This emphasizes the importance to consider the variation of the acetabular orientation between different postures. It is then necessary to determine a personalized functional safe zone in the preoperative planning of THR to avoid cup instability.

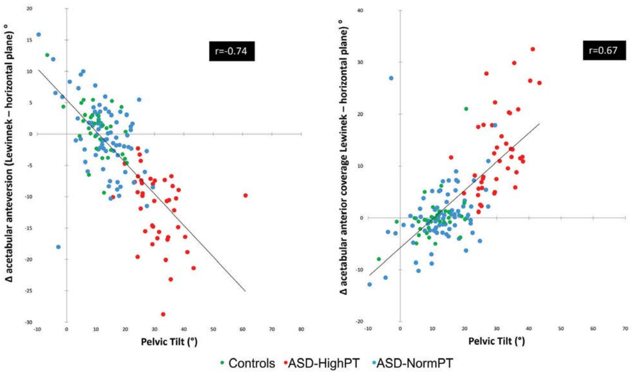

Fig.1: Correlation between PT and planes mismatch of acetabular parameters.

6. Are NIH and Industry Payments Related to the Type of Attention Articles Receive?

Daniel Farivar, BS; Kenneth D. Illingworth, MD; Amar Vadhera, BS; David L. Skaggs, MD, MMM

Hypothesis

Industry provides more monetary support to authors publishing flashy, popular studies that achieve high Altmetric scores while the NIH supports authors publishing studies that achieve more critical acclaim and higher citation counts.

Design

Cross-Sectional Study, III

Introduction

The Altmetric score is a validated tool that measures the online attention an article receives. Studies have shown a relationship between traditional bibliometrics and industry payments for orthopedic surgeons. However, it is unclear if this relationship exists for authors with greater online influence.

Methods

All spine surgery articles published between January 2010 - December 2021 were assessed and selected based on Altmetric scores and citation number. The OpenPayments database was accessed to evaluate industry financial relationships from 2015 to 2021 for the authors of selected articles. Payment data was compared between the Altmetric and citation groups, first and last authors, and neurosurgeon and orthopedic surgeon authors. The NIH Research Portfolio Online Reporting Tool was used to identify all-time NIH funding from the authors of the selected articles. The data was analyzed with the Student t-test, Analysis of Variance, and Chi-squared analysis. Alpha <0.05.

Results

There were 60 and 51 authors with payment data in the top 50 Altmetric and top 50 citation papers, respectively, with 8 authors having papers in both groups. Total industry payments among authors of the top Altmetric papers, top citation papers, and authors in both groups were not significantly different. However, funding by payment type varied, with authors in both groups receiving the most for consulting, travel/lodging, and faculty/speaking fees. For all articles, last authors received significantly more in total industry payments than first authors (p=0.021). A significantly greater proportion of authors with studies in both groups (50%) received NIH support compared to authors from the top Altmetric studies (5%; p<0.001) and top citation studies (12%; p<0.001). Authors receiving NIH support were found to receive significantly less industry payments compared to authors not receiving NIH support (p<0.001).

Conclusion

Industry and the NIH are able to identify studies that simultaneously achieve both critical acclaim (citations) and online popularity (Altmetric scores). Authors receiving funding from industry vs. the NIH are two distinct groups.

7. Comparison of Radiographic and Clinical Outcomes of Adult vs Adolescent Scheuermann Kyphosis Patients: A Matched Cohort Analysis after Surgery

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Hypothesis

Adult Scheuermann kyphosis surgery requires more complexity, yields inferior outcomes and results in more complications

Design

Retrospective analysis of two prospective databases

Introduction

Studies comparing adult vs adolescent idiopathic scoliosis operations report less correction, more complications and less satisfaction in adults. There is limited information in regards to surgery for adult vs adolescent Scheuermann kyphosis. Furthermore, there is no consensus on surgical indications for adults, which may result in more untreated adult deformity. The aim was to compare surgical, radiographic and patient-reported outcomes of adult vs adolescent Scheuermann kyphosis patients.

Methods

Two multicenter databases were queried for patients with ≥2 years follow-up. An adolescent comparative cohort was formed using the radiographic and surgical profile of adult cases. Magnitude of surgical correction, # of levels fused, # of osteotomies, surgical efficiency, infections, mechanical, medical and other complications, and patient-reported outcomes were compared using Chi-Squared, Independent Samples t, Mann-Whitney U and Two-way mixed ANOVA.

Results

52 patients (21F, 31M) were included in the adult (n=24, mean age 28.0±8.2, range 18-42) and the adolescent (n=28, mean age 15.3±1.14, range 13-17) cohorts. Although EBL was similar (1242 vs 1268 ml, p=0.706), surgical time in the adult group was longer (395 vs 297 min, p=001), and adults required a longer

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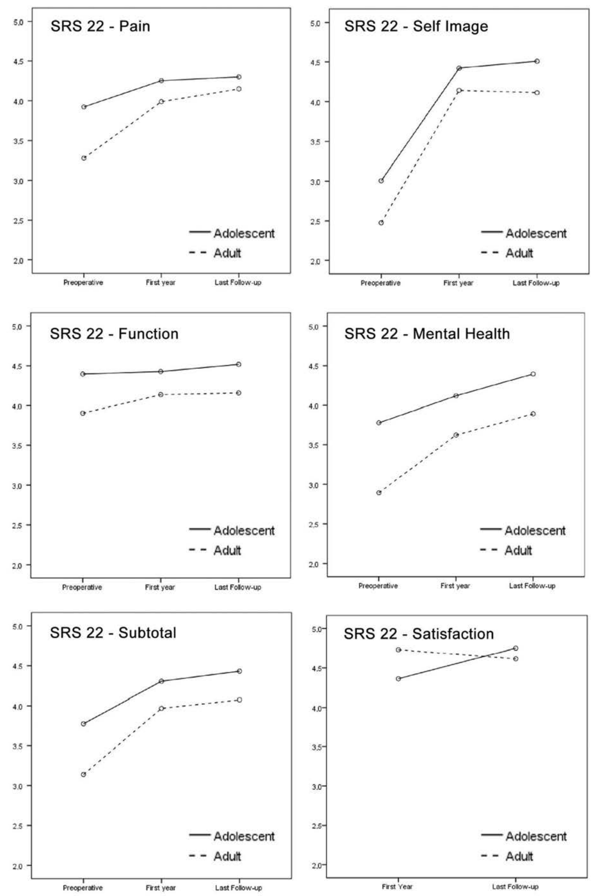
hospital stay (9.6 vs 5.7 days, p<0.0001). # of fused levels were similar (12.9 vs 12.8, p=0.536) and adults did not undergo more 3-COs (4.2% vs 3.6%, p=0.911). Less correction was achieved (52.2°±11.9° vs 44.3°±6.1°, p<0.0001) in adults although preop kyphosis magnitudes was similar (75.0°±9.2° vs 77.9°±8.0°, p=0.718). PJK/PJF, DJK/DJF, implant-related complications and rod fracture rates, as well as infections, wound, iatrogenic, pulmonary and neurologic complications were similar among groups (p>0.05 for all). All SRS-22 subdomains started off lower in adults. Although two groups showed similar improvement patterns, adults had lower scores at the latest follow-up (Fig 1).

Conclusion

Surgery for Scheuermann kyphosis during adulthood resulted in slightly less curve correction and longer hospital stay. Although complication rates were similar, patient-reported outcomes were less favorable at all follow-up time points for adults.



8. Long Term Mechanical Failure In Well Aligned ASD Patients

Sleiman Haddad, MD, PhD, FRCS; Susana Núñez Pereira, MD; Javier Pizones, MD, PhD; Manuel Ramirez Valencia, MD; Caglar Yilgor, MD; Ahmet Alanay, MD; Frank S. Kleinstueck, MD; Ibrahim Obeid, MD; Francisco Javier S. Perez-Grueso, MD; Ferran Pellisé, MD, PhD; European Spine Study Group

Hypothesis

Mechanical complications(MC) are still high even in well aligned Adult Spinal Deformity(ASD) patients and depend on patients' factors and alignment

Design

Retrospective analysis of a prospective multicenter ASD Database

Introduction

MC have been associated to suboptimal postoperative alignment and are the leading cause of revision surgery. Whereas optimal sagittal alignment is subject of debate,"well aligned" patients aren't exempt of MC and factors other than alignment might play an increasingly important role. The objective of this study is to analyse MC rate in well aligned patients and study the relevant risk factors and surgical outcomes associated to MC

Methods

Adult ASD patients (Age>55) with more than 2-yrs f-up and immediate postoperative GAP Score ≤2 were included from a multicenter prospective ASD Database. Continuous and categorical variables were compared and regression models run to identify independent risk factors for MC. ROC analysis defined optimal cutoff value for key parameters

Results

86 patients met inclusion criteria: Mean age 66, 36% had prior spine surgery. Mean number of instrumented levels was 10, 77 fused to Pelvis, 27% 3-CO. 33(40%) suffered at least one MC after a mean f-up of 4-yrs (14 PJKs; 20 nonunion/rod breakage). 15(18%) had revision surgery for MC. Patients having MC were heavier, had worst baseline general health(SF 36) and worst preoperative coronal and sagittal alignment They needed longer stays, more instrumented levels and achieved worst postoperative coronal and sagital alignment (Table). Neither 3-CO, postoperative brace nor the addition of an anterior approach altered MC risk in well aligned ASD. Binary regression models identified residual coronal lumbosacral curve, number of instrumented levels and RSA as independent risk factors for MC. Optimal residual LS curve and RSA were ≤4º and ≤3º respectively. MC rate increased in a stepwise fashion with GAP score (GAP0 31%, GAP1 54%; GAP2 75%) with RSA being the most important parameter. MC patients had worst functional and radiological outcomes at last f-up

Conclusion

MC rate is still high in sagitally "well aligned" ASD patients and could still be traced to "worst" residual sagittal and coronal alignment. This study confirms the multifactorial nature of MC and the relevance of impeccable postoperative alignment, especially in presence of other risk factors such as high surgical correction, high lever arm (instrumented vertebrae), overweight, and frailty(SF36)

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Table 1: Statistically Significant Differences between patients with Mechanical Complications Vs without MC

		N	Mean Value	Standard Deviation	p-value
Hospital Stay	No MC	50	11.8	4.9	0.034
	MC	33	15.5	10.3	
ICU Stay	No MC	50	30.0	24.1	0.036
	MC	33	57.3	69.4	
Number of Instrumented Vertebra	No MC	49	9.1	4.6	0.036
	MC	33	11.2	3.7	
Number of Implants	No MC	50	16.5	9.0	0.035
	MC	33	20.1	5.9	
Weight (Kg)	No MC	49	64.6	10.5	0.035
	MC	33	69.9	11.6	
Preop - SF36 - General Health	No MC	50	44.3	10.6	0.013
	MC	33	38.0	12.0	
Preop - Coronal Balance (C7PL to CSVL)	No MC	45	25.0	22.3	0.026
	MC	33	39.3	33.0	
Preop - Sagittal Balance (SVA)	No MC	48	63.8	59.8	0.002
	MC	33	109.2	64.3	
Preop - Thoracolumbar L2-T10	No MC	49	7.1	21.4	0.028
	MC	33	17.8	21.1	
Preop - Lordosis (L1-S1)	No MC	50	-43.1	18.5	0.014
	MC	33	-32.3	20.4	
Preop - Global Tilt	No MC	49	30.9	16.4	0.005
	MC	33	41.5	16.1	
Preop – Relative Pelvic Version (RPV)	No MC	50	-9.4	8.5	0.018
	MC	33	-14.1	9.0	
Preop – Relative Lumbar Lordosis (RLL)	No MC	50	-21.4	18.8	0.020
	MC	33	-31.7	20.1	
Preop – Relative Spinopelvic Alignment (RSA)	No MC	49	18.3	13.9	0.001
	MC	33	29.4	15.3	
Postoperative – Coronal Lumbosacral Curve	No MC	23	6.1	4.5	0.025
	MC	22	10.1	6.8	
Postoperative – Sagittal Balance (SVA)	No MC	43	17.2	31.9	0.029
	MC	32	34.3	34.6	
Postoperative – Relative Lumbar Lordosis (RLL)	No MC	50	-2.3	6.1	0.042
	MC	33	-5.1	5.7	
Postoperative – Relative Spinopelvic Alignment (RSA)	No MC	50	4.2	4.9	0.019
	MC	33	6.9	5.4	

T1

9. Validation of Lordosis Distribution Index for Predicting Mechanical Complications After Long Level Fusion Surgery: A Comparison of GAP Score and Roussouly Classification

Myung-Hoon Shin, MD, PhD

Hypothesis

The hypothesis was that the lordosis distribution index of GAP score (G-LDI) would consist of an inhomogeneous group of patients with varying pelvic incidence (PI), indicating that aligned LDI of 50-80% is insufficient to quantify mechanical complications.

Design

Retrospective comparative cohort study

Introduction

Both the GAP score and Roussouly classification account for the LDI, but the G-LDI is typically set to 50-80%, while the LDI for Roussouly classification (R-LDI) varies depending on the degree of PI. This study aims to validate the ability of the G-LDI to predict mechanical complications and compare it with the predictive probability of R-LDI in patients with long-level fusion surgery.

Methods

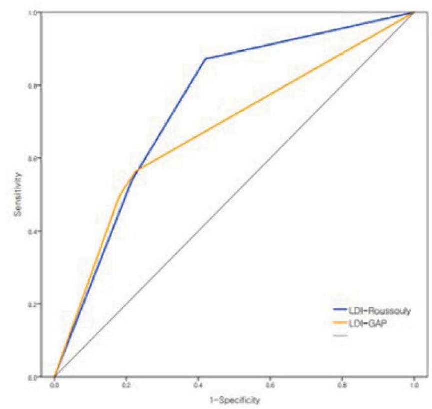
The inclusion criteria for the study were patients who underwent > 4 levels of fusion and had > 2 years of follow-up. Mechanical complications evaluated included proximal junctional kyphosis/failure and implant-related complications. The predictive models for mechanical complications using G- and R-LDI were analyzed using binomial logistic regression and receiver operating characteristic analyses.

Results

One hundred and seventy-one patients were divided into two groups: 93 in the non-mechanical complication (MC) group and 78 in the MC group. The mean age of participants was 66.79 ± 8.56 years, and the mean follow-up period was 45.49 ± 16.20 months. With G-LDI, most patients in the non-MC group had aligned (77.4%), while the MC group had an inhomogeneous composition (43.6% of aligned and 47.4% of hyperlordosis). The agreement between G-LDI and R-LDI was moderate (κ = 0.536, p < 0.001) to fair (κ= 0.383, p = 0.011) for patients with average or high PI,respectively, but poor (κ = -0.255, p = 0.245) for low PI. The G-LDI model explained 15% of the variance in incurring mechanical complications, while R-LDI model explained 28% of the variance. The area under the curve for the G- and R-LDI was 0.674 (95% CI, 0.592-0.757) and 0.745 (95% CI, 0.671-0.820), respectively.

Conclusion

The G-LDI, represented as an absolute numerical value, may not be adequate to quantify normal lordosis across the entire range of PI values. However, the R-LDI, which enables individual quantification of LL for all PI sizes, has been shown to have a higher accuracy in classifying cases and a stronger correlation with the risk of mechanical complications compared to G-LDI.



10. Comparing the Upper Instrumented Vertebrae Tilt Angle Versus Screw Angle in the Development of Proximal Junction Kyphosis after Adult Spinal Deformity Surgery: Which Matters More?

Keyan Peterson, MD, MS; *Hani Chanbour, MD*; Jeffrey W. Chen, BS; Michael Longo, MD; Soren Jonzzon, MD; Steven G. Roth, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH

Hypothesis

Both the upper instrumented vertebrae (UIV) tilt angle and screw angle are associated with proximal junctional kyphosis/failure (PJK/F) in adult spinal deformity (ASD) surgery.

Design

Retrospective cohort study.

Introduction

There is a paucity of data analyzing how UIV tilt angle and screw angle pertain to PJK/F. In a cohort of patients undergoing ASD surgery with UIV in the lower thoracic or lumbar region, we sought

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to determine which aspect of the UIV – tilt angle or screw angle – was more strongly associated with: 1) PJK/F, 2) other mechanical complications and reoperations, and 3) patient-reported outcome measures (PROMs).

Methods

A single-institution, retrospective cohort study was undertaken for patients undergoing ASD surgery from 2011-17. Only patients with UIV at T7 or below were included. The primary exposure variables were: 1) UIV tilt angle: angle of the UIV inferior endplate and the horizontal, and 2) UIV screw angle: angle of the UIV screws and superior endplate. Multivariable logistic regression included age, BMI, osteopenia/osteoporosis, postoperative sagittal vertical axis, postoperative pelvic-incidence lumbar lordosis mismatch, UIV tilt angle, and UIV screw angle.

Results

A total of 117 patients underwent ASD surgery with a minimum of two-year follow-up. 41 (35.0%) patients had PJK. 1) UIV tilt angle: 96 (82.1%) had lordotic UIV tilt angles, 6 (5.1%) were neutral, and 15 (12.8%) were kyphotic. 2) UIV screw angle: 38 (32.5%) had cranially-directed screws, 4 (3.4%) were neutral, and 75 (64.1%) were caudally-directed. On multivariable analysis, both lordotic-angled UIV endplate (OR=1.04, 95%CI=1.00-1.08,p=0.046) and cranially-directed screws (OR=7.86, 95%CI=2.54-24.35,p<0.001) significantly increased the odds of PJK, with a more pronounced effect of UIV screw angle compared to UIV tilt angle (Wald test, 11.80 vs. 2.99). Neither parameter was associated with other mechanical complications, reoperations, or PROMs.

Conclusion

Both a lordotically-angled UIV tilt angle and cranially-directed UIV screws independently increased the odds of PJK, with a stronger association from UIV screw angle than tilt angle. Both UIV tilt and UIV screw angle are modifiable factors directly under the surgeon's control that may mitigate the risk of PJK.

		Univariable			Multivariable		
Outcome variable	**Independent Variable**	**OR (95% CI)**	**Wald-df**	**p-value**	**OR (95% CI)**	**Wald-df**	**p-value**
Mechanical complications	UIV tilt angle	0.99 (0.96-1.02)	-0.76	0.621	1.01 0.97-1.05)	-0.74	0.604
	UIV screw angle	1.04 (0.60-3.27)	-0.40	0.434	1.63 0.48-5.51)	-0.38	0.428
PJK	UIV tilt angle	1.00 (0.97-1.03)	-0.85	0.686	1.04 (1.00-1.08)	2.99	**0.046***
	UIV screw angle	2.88 (1.24-6.67)	5.09	**0.014***	7.86 (2.54-24.35)	11.80	**<0.001***
PJF	UIV tilt angle	1.00 (0.97-1.03)	-0.97	0.846	1.03 (0.98-1.08)	0.90	0.168
	UIV screw angle	1.96 (0.77-4.94)	1.03	0.154	2.16 (0.49-9.35)	0.06	0.302
Rod fracture/ Pseudarthrosis	UIV tilt angle	0.98 (0.96-1.02)	-0.33	0.412	0.99 (0.96-1.03)	-0.99	0.950
	UIV screw angle	0.74 (0.32-1.74)	-0.55	0.503	0.51 (0.16-1.61)	0.31	0.252
Implant related	UIV tilt angle	1.00 (0.95-1.05)	-0.99	0.926	1.04 (0.96-1.12)	0.01	0.316
	UIV screw angle	0.87 (0.16-4.59)	-0.98	0.877	1.02 (0.07-14.15)	-0.99	0.987
Reoperations	UIV tilt angle	0.98 (0.96-1.01)	-0.38	0.430	1.00 (0.96-1.04)	-0.96	0.836
	UIV screw angle	0.87 (0.38-1.98)	-0.90	0.749	0.66 (0.21-2.06)	-0.511	0.481
PROMs	**Independent Variable**	**OR (95% CI)**	**Wald-df**	**p-value**	**OR (95% CI)**	**Wald-df**	**p-value**
MCID NRS-Back	UIV tilt angle	0.98 (0.96-1.01)	-0.50	0.480	0.95 (0.91-1.00)	2.51	0.061
	UIV screw angle	1.64 (0.64-4.17)	0.08	0.298	2.91 (0.69-12.28)	1.12	0.145
MCID NRS-Leg	UIV tilt angle	0.99 (0.96-1.03)	-0.99	0.959	0.98 (0.94-1.03)	-0.84	0.610
	UIV screw angle	2.09 (0.68-6.36)	0.68	0.195	1.09 (0.24-4.85)	-0.99	0.907
MCID ODI	UIV tilt angle	1.00 (0.97-1.03)	0.09	0.753	0.99 (0.95-1.03)	-0.94	0.800
	UIV screw angle	2.06 (0.78-5.42)	1.15	0.142	1.95 (0.48-7.85)	-0.1.2	0.347

UIV tilt angle was treated as a continuous variable, UIV screw angle was treated as a binary, categorical variable (Cranially vs. neutral/caudally directed screws)

Univariable and multivariable logistic regression predicting PJK.

11. Self-Image Is Underestimated as a Primary Driver for Patient Treatment and Surgical Satisfaction In Adult Spinal Deformity (ASD)

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Hypothesis

Self-image is the strongest driver for ASD patients choosing surgical treatment and the strongest correlate with surgical satisfaction.

Design

Retrospective analysis of a prospective, multi-center study.

Introduction

ASD patient assessment typically focuses upon pain and physical function. Self-image is an important outcome measure for pediatric spine deformity, however little information exists regarding the impact that ASD self-image has upon treatment choice and treatment satisfaction.

Methods

Factor analysis and decision tree modeling was performed upon operative and nonoperative treated ASD patients prospectively enrolled into a multi-center study from 2009-2020. Data elements from physical examination, demographics, past medical history, radiographic spinal alignment, and individual PROM questions were evaluated for the variables most correlated with 1) patients electing for surgery and 2) patient surgical satisfaction at minimum 2 year follow up.

Results

1434 ASD patients (mean age 57.2 years, mean scoliosis 40.3 degrees, mean SVA 55.9mm) were enrolled into the study, 1086 elected surgery, 348 elected nonoperative care. Factor analysis of over 2500 patient specific data elements, identified 23 discrete data variables that most strongly associated with ASD patients choosing surgery. Patient self-image (SRS-22r question 4) was the strongest variable associated with patients choosing surgery vs. nonop care, accounting for 36% of the decision tree model, while all other variables individually accounted for <10% of the model (p<0.05; decision tree model ROC for treatment choice training data=0.93, ROC for validation data=0.83, Figure 1A). Postoperative factor analysis again demonstrated patient self-image (SRS-22r question 4) most strongly associated with surgery satisfaction, accounting for 34% of the decision tree model (p<0.05; ROC for training data=0.93, ROC for validation data=0.73). The next strongest postoperative variables associated with surgical satisfaction included pain with personal care and maximal scoliosis, accounting for 14% and 5.2% of the decision tree model, respectively (Figure 1B).

Conclusion

Patient self-image is the strongest driver for ASD patients pursuing surgery treatment and is most strongly associated with patient surgical satisfaction. Patient self-image is a critical measure that must be assessed in ASD.

Figure 1A; ASD Treatment Choice

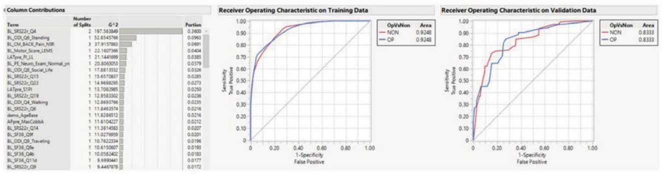
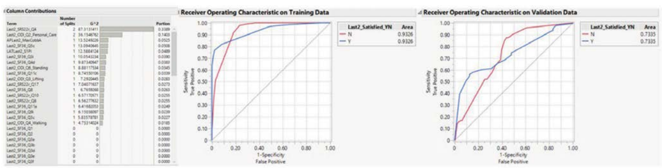


Figure 1B; ASD Surgical Satisfaction



12. Adult Spinal Deformity Patients Revised for Pseudarthrosis have Comparable 2Yr Outcomes to those not undergoing any Revision Surgery

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Hypothesis

Adult deformity(ASD) pts undergoing revision for symptomatic pseudarthrosis have comparable 2Y outcomes as pts who do not experience pseudoarthrosis.

Design

Retrospective 1:1 propensity score matched(PSM) study of pts undergoing revision for pseudoarthrosis following ASD surgery. All pts had ≥1 criteria: PI-LL≥25°, TPA≥30°, SVA≥15cm

Introduction

Pseudarthrosis accounts for ~50% of reoperations following ASD surgery. Symptomatic pts experience sagittal malalignment with detrimental HRQoL

Methods

We compared pts whose indexed procedure was revision for pseudoarthrosis(pseudo) w/ pts who underwent a primary procedure and did not have pseudoarthrosis by 2Y postop(nonpseudo). Key outcomes were 2Y PROs(SRS&ODI) and reoperation. First, univariate & multivariable logistic models discerned factors associated with pseudoarthrosis. Pts were propensity matched(PSM) based on baseline(BL) sagittal alignment, specifically C7SVA and CrSVA-Hip. W/in matched cohorts, binary outcomes were evaluated using McNemar test and continuous outcomes using Wilcoxon rank-sum test. A Kaplan-Meier survival curve examined reoperation-free survival.

Results

224 pts w/ min 2yr FU were included (pseudo=42, non-pseudo=182). Compared to Non-Pseudo, Pseudo pts were more often female(P=0.0018) and had worse BL sagittal alignment, including T1PA(P=0.02], C2-C7 SVA[P=0.0002], and CrSVA-Hip[P=0.004]. After 37 PSM pairs were generated, there was no significant difference in demographics, BL and 2Y alignment, or operative/procedural variables. PSM pairs did not report any significantly different PROs at BL. Consistently, at 2Y, there were no significant differences in PROs, including SRS function[3.9(0.2) vs 3.7(0.2), P=0.44], pain[4.0(0.2) vs. 3.57 (0.2), P=0.12], and ODI[25.7(5.2) vs 27.7(3.7), P=0.76]. There were no differences in 1Y(10.8% vs 10.8%, P>0.99) and 2Y(13.2% vs 15.8%, P=0.64) reoperation, PJK rate(2.6% vs 10.5%, P=0.62), or implant failure(2.6% vs 10.5%, P=0.37). Notably, only 2 pts(5.4%) had recurrent pseudoarthrosis following revision. Kaplan-Meier curves indicated that pts undergoing intervention for pseudoarthrosis had comparable overall reoperation-free survival(log-rank test, $\chi 2=0.1975$ and P=0.66).

Conclusion

Pts undergoing revision for pseudoarthrosis have comparable PRO and clinical outcomes as pts who never experienced pseudoarthrosis. Recurrence of symptomatic pseudoarthrosis was infrequent.

Table 1. Patient Reported and Clinical Outcomes Among Patients Undergoing Revision for Pseudoarthrosis Following ASD Surgery and Patients Undergoing Primary Procedure Without Pseudoarthrosis at 2Y Postop

	Unmatched Cohort			Propensity Score Matched Cohort		
	Without Pseudoarthrosis [N=182]	Pseudoarthrosis +Revision Surgery [N=42]	P Value	Without Pseudoarthrosis [N=37]	Pseudoarthrosis +Revision Surgery [N=37]	P Value
Scoliosis Research Society Questionnaire - Preoperative						
Function and Activity	3.36 (0.07)	2.89 (0.15)	0.0053	3.02 (0.18)	2.94 (0.17)	0.7475
Pain	2.88 (0.07)	2.39 (0.15)	0.0037	2.66 (0.2)	2.43 (0.17)	0.3839
Self-perceived image	2.49 (0.06)	2.2 (0.12)	0.0326	2.35 (0.16)	2.3 (0.13)	0.8091
Mental health	3.54 (0.07)	3.35 (0.17)	0.3037	3.37 (0.21)	3.36 (0.2)	0.9726
Satisfaction	2.79 (0.07)	2.92 (0.21)	0.5583	2.84 (0.24)	2.91 (0.22)	0.8304
Mean Score	3.05 (0.05)	2.73 (0.11)	0.0092	2.86 (0.15)	2.77 (0.12)	0.6409
Scoliosis Research Society Questionnaire - 1 Year						
Function and Activity	3.93 (0.07)	3.36 (0.2)	0.0084	3.89 (0.18)	3.34 (0.21)	0.0506
Pain	3.8 (0.08)	3.33 (0.24)	0.0662	3.85 (0.19)	3.25 (0.26)	0.0669
Self-perceived image	4.14 (0.07)	3.42 (0.2)	0.001	4.14 (0.14)	3.33 (0.22)	0.0029
Mental health	3.94 (0.07)	3.61 (0.18)	0.0904	3.94 (0.19)	3.57 (0.21)	0.1956
Satisfaction	4.41 (0.08)	4.04 (0.22)	0.117	4.45 (0.14)	3.93 (0.24)	0.0663
Mean Score	3.99 (0.06)	3.49 (0.17)	0.0066	4 (0.14)	3.42 (0.19)	0.0166
Scoliosis Research Society Questionnaire - 2 Year						
Function and Activity	3.93 (0.09)	3.67 (0.15)	0.1394	3.91 (0.21)	3.71 (0.15)	0.4412
Pain	3.87 (0.11)	3.57 (0.21)	0.208	4.03 (0.2)	3.57 (0.21)	0.1171
Self-perceived image	3.97 (0.09)	3.77 (0.21)	0.3832	3.92 (0.21)	3.73 (0.21)	0.5244
Mental health	3.94 (0.08)	3.94 (0.13)	>0.9999	3.93 (0.18)	3.98 (0.13)	0.8225
Satisfaction	4.36 (0.1)	4.47 (0.15)	0.5426	4.39 (0.2)	4.35 (0.17)	0.8793
Mean Score	3.97 (0.08)	3.79 (0.13)	0.2402	3.99 (0.16)	3.8 (0.13)	0.3599
ODI						
Pre-Operative	35.56 (1.22)	43.9 (2.96)	0.0105	40.29 (3.11)	41.47 (3.15)	0.7906
One-Year	21.05 (1.42)	31.67 (3.81)	0.0103	20.4 (3.15)	33.5 (4.39)	0.0181
Two-Year	21.57 (1.79)	28.09 (3.73)	0.1177	25.73 (5.16)	27.65 (3.74)	0.7642
Clinical Outcomes						
1-Year Reoperation	13 (7.14)	5 (11.9)	0.3433	4 (10.53)	4 (10.53)	>0.9999
2-Year Reoperation	14 (7.69)	8 (19.05)	0.0402	5 (13.16)	6 (15.79)	0.6831

13. Natural History of Low-Grade Isthmic Spondylolisthesis Found Incidentally in Asymptomatic Children. A Longitudinal Cohort Study of 151 Patients with Minimum 2-Year Follow-Up.

Antoine Dionne, BS; Abdulmajeed Alzakri, MD; Hubert Labelle, MD; Julie Joncas, RN; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

Hypothesis

No clinical or radiological deterioration is expected in asymptomatic children with incidental finding of low-grade spondylolisthesis.

Design

Longitudinal cohort study of 151 asymptomatic children presenting after incidental finding of low-grade spondylolisthesis.

Introduction

Low-grade lumbosacral spondylolisthesis is often observed incidentally in the context of screening for spinal deformity, abdominal symptoms or trauma. Unfortunately, the natural history of incidental low-grade spondylolisthesis in children is unknown, such that there

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are no guidelines as to how these patients should be counselled/monitored. This prospective study investigates the clinical, radiological and health-related quality of life (HRQoL) course of children over a minimum 2-year follow-up after the incidental finding of a low-grade lumbosacral spondylolisthesis.

Methods

We performed a prospective longitudinal cohort study of 151 asymptomatic children (no back pain or neurological symptom) referred to our spine clinic following the incidental finding of a low-grade isthmic spondylolisthesis on radiographs done to rule out a scoliosis. Children with concomitant scoliosis were excluded. All children were followed for a minimum of 2 years after initial presentation. There were 80 boys and 71 girls with a mean age of 12.0±3.2 years at initial presentation. The percentage of slip and lumbosacral angle were assessed from x-rays and HRQoL was assessed from the SRS-22 outcome questionnaire.

Results

The mean initial and final percentages of slip were respectively 15.5±8.4% and 16.5±8.7%. At final follow-up, the slip percentage had increased by ≥10% in 3 patients (12%,18% and 18%), but remained <40%. No patient developed neurological symptoms during follow-up, and surgery was not necessary in any patient. There was a significant improvement (p<0.05) in all SRS-22 domain scores and total score between the initial and final visits (Table).

Conclusion

Incidental low-grade spondylolisthesis in asymptomatic children is generally associated with favorable outcomes and improving HRQoL with non-surgical management. Progression to high-grade spondylolisthesis or development of neurological symptoms are unlikely. Our findings suggest that it is safe to follow these patients only as needed after the initial visit if they develop symptoms.

SRS-22 scores by domain	Initial Presentation, N=151	Final Follow-Up (Minimum 2 Years), N=151	P-value
Function (mean±SD)	4.33±0.64	4.49±0.39	0.002
Pain (mean±SD)	4.25±0.67	4.42±0.59	<0.001
Self-image (mean±SD)	4.13±0.62	4.32±0.64	<0.001
Mental health (mean±SD)	4.26±0.65	4.34±0.57	<0.001
Total (mean±SD)	4.17±0.52	4.36±0.45	<0.001

HRQoL at initial presentation vs follow-up

14. Development of Pelvic Incidence, Sacral Slope and Pelvic Tilt and the Effect of age, Sex, and BMI: An Automated 3D-CT Study of 882 Children and Adolescents

Grant D. Hogue, MD; Eduardo Novais, MD; Mallika Singh, MS; Mohammadreza Movahhedi, BS; Ata Kiapour, PhD

Hypothesis

There will be changes in spinopelvic parameters during growth.

Design

Retrospective cohort

Introduction

Previous studies have demonstrated that spinopelvic parameters could be measured on supine CT with high reliability and validity in adults. This study aims to define normal values of spinopelvic alignment for the pediatric population and to determine the effect of age-related, sex-related, and BMI-related changes using a large cohort of children and adolescents.

Methods

Abdominal CT from 882 patients with appendicitis were used to generate 3D models of the femur, pelvis, and sacrum using a validated automatic segmentation model. The 3D-models were used to automatically measure pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) using validated custom software. Linear regression was used to assess changes in the measurements by age after adjusting for sex and BMI-percentile. A general linear model was used to compare PI, PT, and SS between obese (BMI-percentile >95%) and non-obese subjects, after adjusting for age and sex.

Results

PI and PT were significantly correlated with age in males and females. PI increased by 0.4 degrees per year (95%CI: 0.23, 0.51) after controlling for sex and BMI (P<.001). PT increased by 0.3 degrees per year (05% CI: 0.20, 0.38) after controlling for sex and BMI (P<.001). There were no age-related changes in SS (P=.093). Unadjusted Pearson correlations for age-related changes are shown in Figure 1. Obese subjects had significantly smaller PI (40.9±13.4 vs. 49.1±8.6; P<.001) and smaller SS (29.4±13.2 vs. 35.1±8.4; P<.001) compared to nonobese subjects, after adjusting for age and sex.

Conclusion

We used computerized segmentation software to measure PI, PT, and SS in a cohort of pediatric patients. We found that PI and PT significantly increased with age in males and females. Additionally, obese subjects had lower PI and SS values than non-obese subjects. Our findings may help the pediatric orthopedic surgeon design the appropriate correction of the sagittal spinopelvic balance when planning spine surgery. As patient-specific instrumentation and planning become the norm in spine and hip surgery, it will be essential to understand normal ranges and changes in spinopelvic parameters during growth. Our study provides data on the normal spinopelvic sagittal alignment during growth.

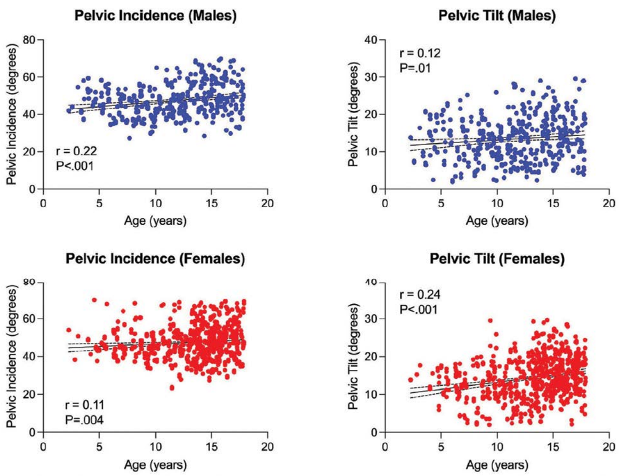

Figure 1. Unadjusted age-related changes in pelvic incidence and tilt for males and females.

Changes in PI and PT

15. Functional Motion and Balance Improve after Posterior Spinal Fusion in AIS

Tori Kinamon, BA; Anthony A. Catanzano, MD; Mary Jackson, PT; Elizabeth Sachs, Research Coordinator; Robert K. Lark, MD

Hypothesis
We hypothesize that patients with Adolescent Idiopathic Scoliosis (AIS) who undergo posterior spinal fusion will have decreased functional movement and dynamic balance compared to their pre-operative scores.

Design
This is a prospective cohort study investigating the timing of return to baseline function in patients in the early postoperative period following spinal deformity correction and fusion for AIS.

Introduction
Patients with AIS have been shown to have limited spinal motion and balance deficits. There is a paucity of data on when or if these patients return to their baseline functional motion after surgery.

Methods
We recruited 20 subjects ages 12-18 with AIS scheduled for posterior spinal fusion. Dynamic movement and balance data were collected and analyzed using the Lower Quarter Y-Balance Test (LQYBT) and Functional Movement Screen (FMS) pre-operatively, and then again at 3, 6, and 12 months post-operatively. SRS-22 data was collected at all study visits. The mean, standard deviation (SD) and 95% confidence interval were calculated for the FMS composite score and each sub-component score, as well as for the LQYBT composite score and each directional score after adjusting for leg length.

Results
Pre-operatively, the mean FMS composite score was 13.3 (95% CI: 12.0-14.6). It decreased to 12.8 (95% CI: 11.6-14.1) at 3 months post-operatively, before increasing to 14.7 (95% CI: 13.9-15.4) and 15.5 (95% CI: 14.3-16.7) at 6 and 12 months after surgery, respectively. Sub-component movement scores were generally consistent with or better than baseline by the 6-month post-operative visit (Table 1A). The mean composite LQYBT score was 93.9 (95% CI: 88.0-99.8) pre-operatively. The most significant change in composite LQYBT score was between 3 and 6 months post-operatively, increasing from 95.1 (95% CI: 89.6-100.6) to 96.5 (95% CI: 92.4-100.5), respectively (Table 1B).

Conclusion
Patients with severe AIS approach baseline functional testing at 3 months post-op with considerable improvements made by the 6-month time point. Contrary to our popular belief that PSF worsens motion, patients with AIS show significant improvements in their functional motion and dynamic balance after undergoing PSF as evidenced by their improved FMS and LQYBT scores. Further research should help elucidate the mechanism responsible for this surprising finding.

Table 1A. Mean FMS Sub-Component and Composite Scores by Visit.

	Pre-Op Visit	3 Month Post-Op Visit	6 Month Post-Op Visit	12 Month Post-Op Visit	p-value
Deep Squat	1.6	1.5	1.8	2.0	**0.0367**
Hurdle	2.1	2	2.2	2.2	0.2687
Inline Lunge	1.8	2.2	2.5	2.6	**0.0011**
Shoulder Mobility	2.7	2.6	2.7	2.8	0.7115
Active Leg Raise	2.7	2.3	2.5	2.7	**0.0096**
Trunk Stability	1.2	1.0	1.4	1.6	**0.0411**
Rotary Stability	1.6	1.5	1.9	2.0	**0.0036**
FMS Composite	13.3	12.8	14.7	15.5	**0.0009**

Table 1B. Mean LQYBT Composite Scores by Visit.

	Pre-Op Visit	3 Month Post-Op Visit	6 Month Post-Op Visit	12 Month Post-Op Visit	p-value
LQYBT Composite	93.9	95.1	96.5	100.5	**0.0037**

Table 1. Mean FMS Sub-Component, FMS Composite (A) and LQYBT Scores (B) by Visit.

16. Surface Topographic Chest Volume Measurements Strongly Correlate with Pulmonary Function Volume Measurements in Pediatric Spinal Deformity Patients

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Hypothesis
Surface topographic (ST) measurements of chest volume difference (CVD) between maximum inhale and exhale will be predictive of forced vital capacity (FVC), vital capacity (VC) and total lung capacity (TLC) as measured by pulmonary function tests (PFTs). Moreover, Cobb angle will not be predictive of PFT or ST CVD measurements.

Design
Retrospective cohort

Introduction
Restrictive pulmonary impairment is associated with severe spinal deformity and thought to result from thoracic distortions and volume limitations. Though spirometry and body plethysmography are the gold standard for PFTs, some patients cannot cooperate with formal PFTs. This study analyzes the correlation of non-ionizing dynamic

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optical ST scanning with standard lung volume measurements from PFTs.

Methods

This study included patients age 10-20 years with spinal deformities who received radiographic and ST scans, as well as PFTs within 7 months of imaging studies. Patients were instructed to inhale and exhale to the fullest extent in the ST scan, which provided volumetric measurements. The CVD between inhalation and exhalation poses was obtained and compared to PFT values. Linear regression analysis was used to examine the relationships outlined in the hypothesis.

Results

Twenty-two patients (14.5 ± 2 years, body mass index 22.2 ± 6.1 kg/m2, 63.6% female, 40.9% asthmatic) were assessed, with a mean major curve of 58.0° ± 19.4° (11.0°-92.6°). Sixteen patients had idiopathic scoliosis, 1 had congenital, 1 neuromuscular and 1 thoracogenic scoliosis, and 3 had kyphosis. CVD measured by ST scanning displayed statistically significant positive correlations with FVC ($R = 0.852$, $p < 0.0001$) and VC ($R = 0.816$, $p < 0.0001$) (Table 1, Figure 1). TLC had a significant, albeit weaker, positive correlation ($R = 0.614$, $p = 0.004$) with CVD. No significant correlations emerged between Cobb angle and ST CVD measurements or PFT values.

Conclusion

ST CVD measurements exhibited significant positive correlations with FVC, VC, and TLC. ST scanning may serve as an inexpensive and reproducible method for analyzing thoracic volume, and may include patients unable to cooperate with formal PFTs or at high risk for sedation in CT/MRI pulmonary volume assessment. Curve severity did not correlate with worsening CVD or PFT values.

Table 1: Correlations between ST CVD, PFT values and curve magnitude

	CVD (L)			Major Curve Angle (degrees)		
	R	R²	P-value	R	R²	P-value
FVC (L)	0.852	0.726	<0.0001	0.232	0.054	0.312
VC (L)	0.816	0.666	<0.0001	0.251	0.063	0.300
TLC (L)	0.614	0.377	0.004	0.015	0.000	0.950

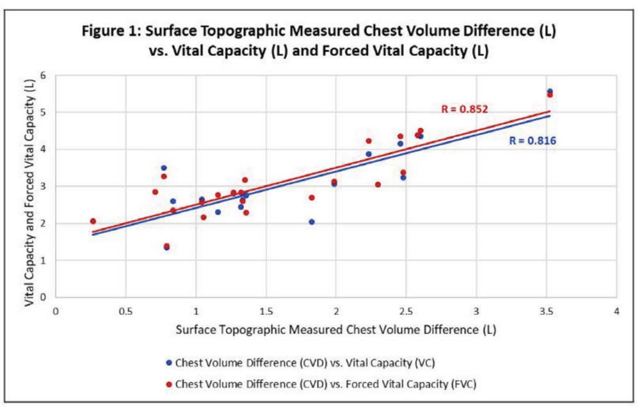


Table 1: Correlations between ST CVD, PFT values and curve magnitude. Figure 1: ST CVD vs. VC and FVC.

17. The Impact of Mental Health on Post-Operative Outcomes for Adolescents Undergoing Posterior Spinal Fusion for Idiopathic Scoliosis at a Tertiary Care Children's Hospital in an Underserved Region

Leila Mehraban Alvandi, PhD; Kathryn Segal, BS; Jorden Xavier, BS; Alexandria Debasitis, BS; Edina Gjonbalaj, BS; David Ge, MD; Jacob F. Schulz, MD; Jaime A. Gomez, MD; Eric Fornari, MD

Hypothesis

AIS-PSF patients with low pre-operative pain and mental health scores were more likely to have worse mental health, self-image, and pain scores post-operatively.

Design

Retrospective chart review

Introduction

Predictive factors such as mental health status and pain for post-operative outcomes have been demonstrated as key risk factors to medical treatment adherence, participation, rehabilitation, and surgical outcomes. Studies in adult patients have shown that pre-surgical depression and anxiety can lead to post-operative pain and new-onset mental illnesses.

Methods

We analyzed the records of 138 AIS-PSF patients (age 14.78±2.06, 67.4% female, 33.3% Hispanic, 39.9% Black),from 2012-2020. Preoperative and postoperative self-reported surveys (SRS-30, SRS-22) and Child Opportunity Index (COI) were analyzed using Pearson bivariate correlations. Survey responses were synthesized into composite scores for function, pain, self-image, and mental health.

Results

Bivariate analyses demonstrated associations at the 0.01-significance level between: pre-operative mental health and 6M post-operative mental health ($r=0.3$); 6M post-operative pain and 6M post-operative mental health ($r=0.48$); 6M post-operative self-image and 6M post-operative mental health ($r=0.55$). It was discovered that 73% of AIS-PSF patients have very Low social and economic COI score. Moreover, 28.3% of patients had worse mental health scores and 35.7% showed decline in pain score after 6 months post-operative, figure (1).

Conclusion

AIS-PSF patients with low pre-operative mental health scores were more likely to have worse mental health, self-image, and pain scores post-operatively. Furthermore, nearly one-third of patients reported worsened mental health following surgery. Our results support the growing literature on the interconnectedness of physical disease, mental health, and general well-being. These results validate the need for proper psychological evaluation and then targeted psychological intervention for at-risk individuals preoperatively as well as post-operatively to help improve their outcomes. This study has the potential to counterbalance several of the negative social determinants of health typically encountered by members of these vulnerable communities. This study has the potential to prevent delay recovery and longer hospital discharge.

Figure1. Mental health score difference between Pre-op and 6M follow up.

F1

18. Have We Improved Anterior Vertebral Body Tethering Outcomes Over Time? An Examination of Survivorship Trends

Joshua Tadlock, MD; Peter O. Newton, MD; Tracey P. Bastrom, MA; Stefan Parent, MD, PhD; Ahmet Alanay, MD; Dan Hoernschemeyer, MD; Firoz Miyanji, MD; Harms Non-Fusion C. Study Group

Hypothesis

With greater experience and revised indications, we hypothesize improved survivorship for anterior thoracic vertebral body tethering (VBT) over the past decade.

Design

Retrospective Kaplan-Meier (K-M) survivorship

Introduction

There are several VBT early follow-up studies but few investigations have examined the survivorship of VBT over the long term, especially survivorship trends over time as techniques and indications have evolved.

Methods

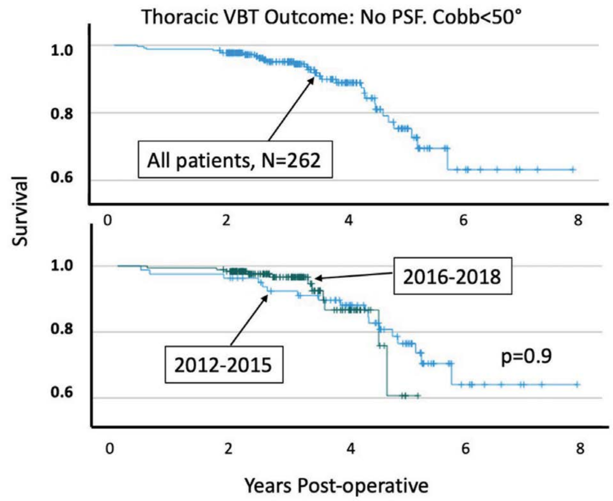
Patients undergoing thoracic VBT for idiopathic scoliosis from a multicenter retrospective registry with 2-8 year follow-up were included. Given the varied length of follow-up, "survivorship", defined as no revision to posterior spinal fusion (PSF) and a major curve <50° was analyzed at final follow-up. The cumulative proportion of patients surviving was plotted according to K-M. We also compared patient characteristics and survivorship between an early (operated in 2012-2015) and a later cohort (2016-2018).

Results

There were 262 patients, (early: n=81, later: n=181). During the study period 29 patients developed a major curve >50° or had revision to PSF at varying timepoints post-op. Survivorship for the entire cohort at 8 years was projected at 65% (Figure). There were no significant differences between early and later cohorts for pre-op thoracic coronal deformity (49.8° vs 48.1°, p=0.2) or age (11.9 vs 12.2 yrs, p=0.1); however, more had open triradiate cartilage in the early cohort (75% vs 47%, p<0.001). The cumulative proportion of survival for the first 2 years after surgery was ~98% for all. Given the shorter possible follow-up in the later cohort, the 2 cohorts were compared by K-M and survivorship at 4 years was similar between the early and later cohorts, 88% and 86% respectively (log-rank test, p=0.9)(Figure). In both cohorts, survivorship began to tail off 3-4 years post-op and decreased to 65% at 6 years.

Conclusion

Long term survival (no PSF, <50°) of thoracic VBT for cases prior to 2018 can be expected for ~65-85% of patients. Survivorship at 2 years was high: 98-99%, but decreased in subsequent years. There was no demonstrable difference in VBT survival between 2012-2015 and 2016-2018 cases despite greater experience and evolving indications. It will be important to evaluate the causes of failure, cases after 2019 (HDE approval date), and newer technologies with follow-up to 5+ years/skeletal maturity.



19. Outcomes of Anterior Vertebral Body Tethering in Lenke 1AR vs. 1AL Curve Types

Joshua M. Pahys, MD; Steven W. Hwang, MD; Terrence G. Ishmael, MBBS; Alejandro Quinonez, BS; Jason Woloff, BS; Maureen McGarry, BS, BBE; Kaitlin Kirk, BS; Emily Nice, BS; Amer F. Samdani, MD

Hypothesis

Anterior vertebral body tethering (VBT) in Lenke 1AR curves will have an increased failure rate in adolescent idiopathic scoliosis (AIS) patients with an open triradiate cartilage (TRC) and when the lowest instrumented vertebra is cephalad to the last touched vertebra (LTV).

Design

Retrospective, single center study

Introduction

The rate of adding-on after posterior spinal fusion for AIS has been reported to be significantly higher when the LIV is cephalad to the LTV and/or in patients with open TRC. However, there is there is limited data on the outcomes and best practices for VBT in Lenke 1AR vs. 1AL curves types to date.

Methods

All AIS patients with Lenke 1AR or 1AL curve types who underwent VBT at our institution with a minimum 2 year followup were reviewed. Demographic and surgical data, as well as preop, first erect, and radiographs every 6-12 months thereafter were analyzed.

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Results

118 patients met criteria (1AR, n=66; 1AL, n=52). The mean preop thoracic Cobb, age, menarche status, Sanders score, and percentage of patients with open triradiate cartilage (TRC) was similar for both groups (p>0.1). Reoperation rates were similar for the 1AR (28.8%) vs. 1AL (19.2%) groups. However, the revision rate was significantly higher in 1AR patients with open TRC vs. closed TRC (51.7% vs. 10.8%, p=0.001), and trended towards a higher revision rates vs. 1AL patients with an open TRC (25%), p=0.08. The revision rates were not significantly different in either 1AR or 1AL groups if the LIV=LTV, or if the LIV was cephalad to the LTV.

Conclusion

Lenke 1AR patients with open triradiate cartilage (TRC) demonstrated a higher revision rate (52%) compared to 1AR patients with closed TRC (11%), and was half that, 25%, for 1AL patients with open TRC. Contrary to data for spinal fusion there were surprisingly no increased revision rates or adding-on if the LIV was cephalad to the last touched vertebra for both 1AR and 1AL patients. Thus, skeletal immaturity (open TRC) was a significant factor for adding-on/revision surgery after VBT in Lenke 1AR and 1AL curve types, but surprisingly, LIV relative to the last touched vertebra was not.

	Lenke 1AR	Lenke 1AL	p value:
Total patients	66	52	
Age at surgery years (mean)	12.5 ± 1.5	12.6 ± 1.5	0.5
Preop Sanders (mode)	3	3	0.3
Preop Open Triradiate Cartilage	44% (n=29/66)	38% (n=20/52)	0.6
Preop Main Thoracic Cobb (mean)	53.9 ± 10.3	50.8 ± 8.1	0.07
Preop Lumbar Cobb (mean)	25.9 ± 10.7	30.9 ± 7.7	**0.01**
Preop Thoracic Kyphosis (mean)	15.1 ± 9.6	21.2 ± 10.0	**0.001**
FE Main Thoracic Cobb (mean)	27.0± 10.8	25.7 + 7.6	0.5
FE Lumbar Cobb (mean)	15.5 ± 7.8	16.8 ± 6.9	0.5
FE Thoracic Kyphosis (mean)	17.5 ± 9.1	22.1 ± 8.1	0.3
Latest Main Thoracic Cobb (mean)	20.0 ± 16.6	20.1 ± 12.5	0.9
Latest Lumbar Cobb (mean)	13.8 ± 8.8	18.1 ± 8.5	**0.01**
Latest Thoracic Kyphosis (mean)	18.8 ± 11.6	20.6 ± 12	0.4
Followup years (mean)	4.4 ± 2 (range: 2 - 9.3)	4.8 ± 2.1 (range: 2-9.75)	0.3
Latest F/U Sanders (mode)	8	8	0.5
Required Revision Surgery	28.8% (n=19/66)	19.2% (n=10/52)	0.3
Required Revision Surgery: Preop Closed TRC	10.8% (n=4/37)	15.6% (n=5/32)	0.7
Required Fusion: Preop Closed TRC	8.1% (n=3/37)	9.4% (n=3/32)	0.9
Required Tether Release for Overcorrection: Preop Closed TRC	0% (n=0/37)	3.1% (n=1/32)	0.8
Required Revision Surgery: Preop Open TRC	51.7% (n=15/29)	25.0% (n=5/20)	0.1
Required Fusion: Preop Open TRC	10.3% (n=3/29)	15.0% (n=3/20)	0.7
Required Tether Release for Overcorrection: Preop Open TRC	20.7% (n=6/29)	5.0% (n=1/20)	0.2
Tethered to last touched vertebra (LIV=LTV)	30% (n=20/66)		0.5
Required revision surgery (LIV=LTV)	15% (n=3/20)		0.5
Tethered above last touched vertebra (LIV<LTV)	69.7% (n=46/66)		0.5
Required revision surgery (LIV<LTV)	17.4% (n=8/46)		0.5

FE: First Erect
TRC: tri-radiate cartilage
LIV: lowest instrumented vertebra
LTV: last touched vertebra

20. Does Screw Density Influence Transverse Plane Correction in AIS Instrumentation: A Comprehensive 3D Biomechanical Study Complementary to the MIMO Clinical Trial?

Mathieu Chayer; A. Noelle Larson, MD; Christian Bellefleur, Eng; David W. Polly, MD; Christiane Caouette, PhD; Stefan Parent, MD, PhD; Carl-Eric Aubin, PhD

Hypothesis

Using more vs. fewer screws for Lenke 1A AIS instrumentation results in similar 3D correction but lower bone-screw forces.

Design

3D and computer simulation correction analysis in AIS instrumentation.

Introduction

The Minimize Implants Maximize Outcomes (MIMO) Clinical Trial of equivalence (NCT01792609) revealed that more vs. fewer screws resulted in similar coronal plane correction for Lenke 1A curves. We aim to determine whether transverse plane correction is correlated with screw density, and how 3D correction is affected by overall implant density (OID) and apical implant density (AID).

Methods

45 MIMO cases (Cobb 45-65°) were clustered between high (HD) and low-density (LD) (>1.8 and ≤1.4 screws/level respectively). The spine was reconstructed in 3D (preop and at 2-yr). 3D correction between groups was compared using bilateral t-tests, and Pearson's correlation coefficient was calculated as a function of OID and AID. We further simulated 3D correction after segmental translation and vertebral derotation using patient-specific computer models of 30 MIMO cases. For each case, 10 different screw patterns were simulated with an OID from 1.2 and 2, and AID from 0.7 and 2 (600 simulations).

Results

For the OID, none of the differences were significant although there was a slightly higher correction for the HD group: mean % MT correction (75±9% vs 69±14%) and apical vertebral rotation (AVR) correction (32±46% vs 40±45%) (p>0.05). There was no difference in balance change (13±11 vs 14 ±14 mm), lumbar lordosis (6±4° vs 8±7°), and thoracic kyphosis (TK) (9±8° vs 12±7°). The results for AID are similar, with same trends. A low correlation (r<0.3) was found between 3D correction and implant density (OID and AID). For the simulations, the presenting MT (62±11°), TK (27±20°), and AVR (14±7°) were reduced after segmental translation to 22±7°, 26±5°, and 14±7°. Apical vertebral derotation resulted in further improvements to 16±8°, 24±4°, and 4±5°, respectively. There was no significant difference in MT between screw patterns; HD had lower bone-screw forces (p<0.05). The vertebral derotation maneuver reduced AVR by 70%, positively correlated with AID (r=0.825, p<0.05). There was no difference in TK.

Conclusion

There is a non-significant trend towards better 3D correction with HD.

21. Epidemiology of Surgical Management for Pediatric Spondylolysis and Spondylolisthesis

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Hypothesis
A minority of patients with a diagnosis of pediatric spondylolysis and spondylolisthesis would receive surgical treatment.

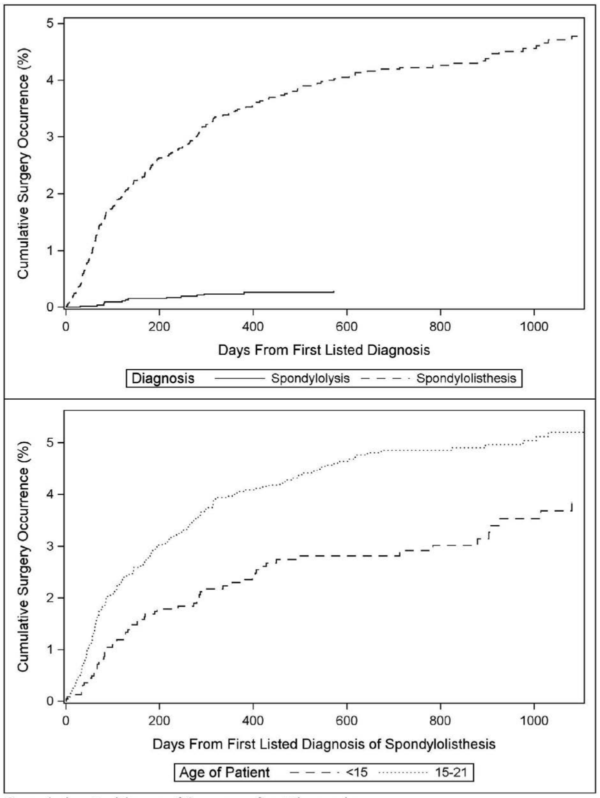
Design
Retrospective

Introduction
Spondylolysis and spondylolisthesis are common causes of back pain in children and adolescents. Previous studies of the incidence of surgical management of these conditions have been limited by relatively low sample size in the setting of a relatively low overall prevalence of the disease.

Methods
This was retrospective cohort study of a large database of commercial insurance claims. All patients with at least two years of consecutive enrollment in the database, age ≤21, and an ICD-10-CM diagnosis of either spondylolysis or spondylolisthesis were included. A one-year wash-out period was implemented. The date of first diagnosis occurrence was recorded, as was the date of surgical intervention, if applicable. CPT codes were used to identify cases of direct vertebral repair and fusion. The occurrence of surgical management was analyzed with both Kaplan-Meier curves as well as Cox proportional hazards regression. The latter adjusted for potential confounding variables.

Results
In total, 5,734 patients with spondylolysis and 7,036 patients with spondylolisthesis were included. Most patients had PPO insurance (55.1% spondylolysis, 55.6% spondylolisthesis). The mean age was 15.6 (SD 2.8) for spondylolysis, and 15.9 (SD 3.4) for spondylolisthesis. Surgical management of spondylolysis with direct repair was rare, and occurred in 0.3% (n=14) of patients 2 years after first diagnosis. A greater incidence of surgery was observed for spondylolisthesis, with a 4.2% cumulative incidence at 2 years post-diagnosis. Among patients with spondylolisthesis, occurrence of surgery was substantially greater among patients of age 15-21 vs. those <15 years (HR 1.61, 95% CI 1.21 – 2.14, p=0.001).

Conclusion
At two years post diagnosis, 0.3% of patients with spondylolysis and 4.2% of patients with spondylolisthesis underwent direct vertebral repair and fusion, respectively. These results are important for counseling patients regarding expected management.



Cumulative Incidence of Surgery after Diagnosis

Cumulative Incidence of Surgery after Diagnosis

22. Thoracic Kyphosis Maintenance in Lenke 1 AIS: Vertebral Body Tethering Versus Posterior Spinal Fusion

Baron S. Lonner, MD; Ashley Wilczek, BS; Peter O. Newton, MD; Dan Hoernschemeyer, MD; Amer F. Samdani, MD; Stefan Parent, MD, PhD; Firoz Miyanji, MD; Ahmet Alanay, MD; Burt Yaszay, MD; Suken A. Shah, MD; Harms Study Group

Hypothesis
PSF will result in greater kyphosis improvement compared to VBT.

Design
Multicenter retrospective study

Introduction
The essential lesion in Adolescent Idiopathic Scoliosis (AIS) is a relative overgrowth of the anterior spine and decreased thoracic kyphosis. A major goal of AIS surgery is to restore kyphosis. There has not been a focused analysis on kyphosis restoration or maintenance comparing Vertebral Body Tethering (VBT) to the gold standard Posterior Spinal fusion (PSF) previously for Lenke 1 AIS which is the purpose of this study.

Methods
Inclusion criteria were AIS diagnosis, Lenke 1 curvature, main thoracic curve ≤70 degrees, and min. 2 yr follow-up (FU) after surgery. 141 VBT patients met inclusion criteria along with 473 PSF patients. 141 PSF patients were propensity score-matched using the nearest neighbor approach with the 141 VBT patients. 3-D kyphosis was calculated for each patient at pre-op. Pathological PJK and DJK

were defined as minimum 10° and an increase from pre-op ≥10°. A hypokyphosis analysis was performed by assessing all patients who fell below the mean 3-D kyphosis for each group. Continuous variables were compared using Welch's t-test and categorical variables were compared using Chi-square.

Results

Pre-op parameters were similar except for age and major curve magnitude which was greater in PSF (Table). There was a 13.5° increase in kyphosis (T5-T12) for VBT compared to 17.2° in PS-F($p<0.001$). FU kyphosis was less in VBT although by <4°. There was no difference in pathological PJK and DJK between groups. For hypokyphotic patients, mean increase in kyphosis was 14.5° for VBT and 22.8° for PSF ($p<0.0001$) and remained markedly decreased although low normal in VBT vs. PSF (12° vs 21°, $p<0.0001$).

Conclusion

Kyphosis is restored after both VBT and PSF but to a greater extent after PSF, especially in markedly hypokyphotic AIS patients with Lenke 1 curves.

	VBT N=141	PSF N=141	P-value
Baseline Demographics			
Age	12.1±1.6 (8-17)	15.5±2.03 (11-21)	<0.0001
Sex (F)	122 (86.5%)	120 (85.1%)	0.865
Risser 0|1|2|3|4|5	95 (67.4%) | 10 (7.1%) | 15(10.6%) | 17(12%) | 4 (2.8%) | 0	0 (0%) | 0 (0%) | 1 (.71%) | 1 (.71%) | 109 (77.3%) | 30 (21.3%)	<0.0001
FU (years)	2.2±.5	2.3±.5	0.92
MTC			
preop	47±8.75	55.6±5.39	<0.0001
1st erect	26.8±8.11	17.2±5.9	<0.0001
FU	24.9±10	19.9±6.72	<0.0001
% Correction	46.7±20.7	64.2±11.7	<0.0001
T5-T12			
3D preop	7.19±10.4	6.33±10.5	0.495
1st erect	18.2±11.4	22.5±7	0.0002
FU	19.6±12.7	23.3±6.83	0.003
|Δ|	13.5±8.15	17.2±9.49	<0.001
T2-T12			
preop	26.5±11.8	31.8±13.4	0.0006
1st erect	26±12.5	33.1±9	<0.0001
FU	27.4±13.8	34.5±9.72	<0.0001
|Δ|	7.43±6.1	9.73±6.95	0.003
T10-L2			
preop	-2.82±9.8	-1.77±10.3	0.381
1st erect	-1.95±9.5	.475±9.12	0.03
FU	-1.82±10.1	-1.35±9.98	0.697
|Δ|	6.74±5.1	8.4±6.72	0.02
LL			
preop	-59.7±12.8	-60.1±12.9	0.757
1st erect	-56.3±14.1	-53.6±11.5	0.078
FU	-57.5±14.0	-59.9±11.2	0.107
|Δ|	7.74±6.12	8.59±6.77	0.27
PJK			
preop	6.89±3.66	5.69±4.38	0.013
1st erect	6.83±3.72	6.65±4.15	0.706
FU	7.44±4.62	6.7±4.76	0.184
|Δ|	3.60±3.18	3.83±3.33	0.559
% Pathological	2.12%	3.55%	0.72
DJK			
preop	-2.11±8.2	-7.13±8.1	<0.001
1st erect	-1.43±7.71	-2.24±7.55	0.374
FU	-.74±8.3	-4.2±9.5	0.001
|Δ|	3.98±3.72	5.36±4.31	0.004
% Pathological	0.71%	1.42%	0.92

23. Prediction of Curve Progression in Adolescent Idiopathic Scoliosis with Bone Microarchitecture Phenotyping by an Unsupervised Machine Learning Protocol

Kenneth GP Yang, PhD, MBBS; Wayne YW Lee, PhD; Lik Hang Alec Hung, MBBS, MS, FRCS; Jack C. Cheng, MD, FRCS; Tsz-Ping Lam, MBBS, FRCS

Hypothesis

Bone microarchitecture phenotypes are associated with the risk of curve progression in Adolescent Idiopathic Scoliosis (AIS).

Design

A longitudinal cohort study

Introduction

Previous studies assessed bone parameters individually and overlooked the interactions between bone density, bone geometry and bone microarchitecture in AIS. This study aims to (a) identify common combinations of bone quality parameters (i.e., bone microarchitecture phenotypes), and to (b) investigate their association with risk of curve progression in girls with AIS.

Methods

Girls around peripubertal peak height velocity with AIS were recruited. Skeletal maturity stage was determined by the validated Thumb Ossification Composite Index (TOCI). Patients were followed up for 6 years till skeletal maturity. Curve progression was defined when the Cobb angle reached the surgical threshold (50º) or the patient had received surgery. Bone qualities were evaluated with high-resolution peripheral quantitative computed tomography (HR-pQCT) at recruitment and at the end of the follow-up. Bone microarchitecture phenotypes were clustered by fuzzy c-means.

Results

A total of 101 consecutive girls (12.26±0.87y/o) with AIS (Cobb:26.02±8.82º) were recruited. Three bone microarchitecture phenotype clusters were identified. Patients with Phenotype-2 had significantly higher cortical volumetric BMD, cortical thickness, cortical area, and trabecular thickness, and significantly lower periosteal perimeter and trabecular area than those with Phenotype-1 (Fig.1A-1F). In Phenotype-3, the cortical parameters mentioned above were significantly lower with decreased trabecular bone volume fraction and trabecular thickness compared with Phenotype-1. The observed differences between the different phenotypes were persistent throughout the 6 years (Fig.1D-1F). The group with Phenotype-3 had a significantly increased risk of curve progression (hazard ratio=4.09, P=0.045) after adjustment for baseline Cobb angle and bracing treatment (Fig.1G).

Conclusion

AIS girls with bone microarchitecture Phenotype-3 characterized by poor cortical bone qualities and trabecular microarchitecture were found to be associated with an increased risk of curve progression to the surgical threshold. Bone microarchitecture phenotypes did not shift with rapid growth during the peripubertal period in AIS. (RGC of Hong Kong no. 14130216)

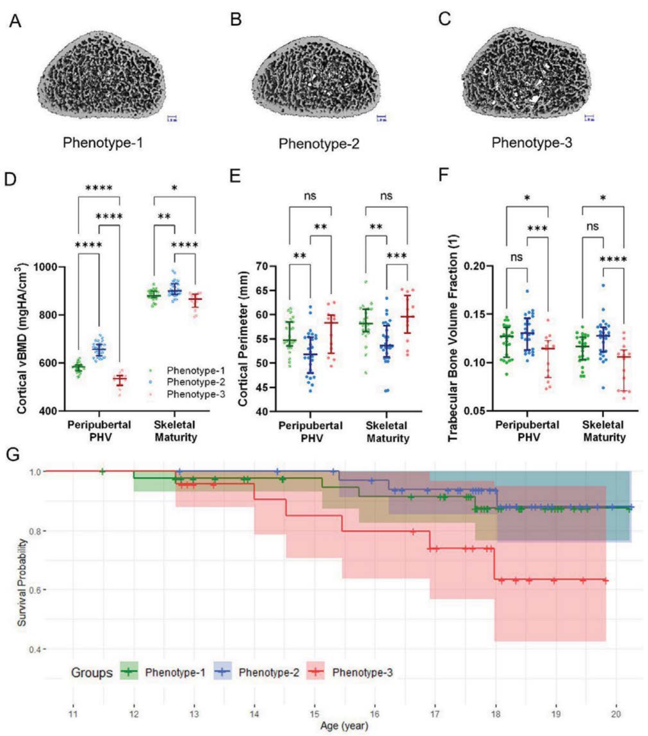


Figure 1

24. Predicting Outcomes of Thoraco-Lumbo-Sacral Orthosis Treatment in Adolescent Idiopathic Scoliosis

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Hypothesis
Outcomes can be predicted from wear time, baseline triradiate cartilage (TRC), and baseline primary Cobb angle.

Design
Cohort, prospective, multi-center

Introduction
A thoraco-lumbo-sacral orthosis (TLSO) is commonly prescribed for adolescent idiopathic scoliosis (AIS) patients at risk of progression. Previous studies suggest a dose-response for wear time. However, these studies only used the first six months of wear time data[1] and did not rigorously account for confounders[1,2]. Published models predicting the risk of treatment failure generally do not include wear time or report uncertainty[3]. Our goal was to develop a risk model for treatment failure that incorporates wear time and produces uncertainty bounds.

Methods
We enrolled individuals with AIS, 10-16 yr, Risser 0-2, and primary Cobb angle 20°-45°. Patients were prescribed 18 hr/day of wear (full time wear, FTW) until Risser 4, one year post-menarche, and exhibiting slowing growth, then were progressively weaned until Risser 5. Wear time during FTW was computed using thermocrons[4]. Baseline and end-of-wean primary Cobb angles were the average of three blinded measurers. Treatment failure was defined as progression to 50° or surgery recommended before end-of-wean. We used logistic regression to estimate risk of failure as a function of wear time (hr/day), TRC (open, closed), and primary Cobb angle (deg). Models using TRC outperformed those using Risser or Risser + TRC.

Results
We recruited 218 individuals and retained 145. Others were lost to follow-up or had significant gaps in wear time data. Wear time during FTW was 16.3 hr/day (17.7 TRC open, 14.7 TRC closed) and failure rate was 28% (45% TRC open, 16% TRC closed). The risk model had an accuracy of 79% (81% NPV, 68% PPV). Significant effects were found for wear time (coeff. med (sd) = -0.08 (0.04)), TRC open (2.24 (0.51)), and curve magnitude (0.18 (0.04)). The risk model for an individual shows the effect of TLSO treatment (Figure).

Conclusion
We developed a clinical tool to identify potential benefit from TLSO treatment. Our model incorporates wear time, TRC, and cobb angle. The model is accurate and provides explicit risks and uncertainties. 1. N Engl J Med 2013;369:1512-1521 2. J Bone Joint Surg Am 2016;98:1253-9 3. Spine Def 2019;7:890-898.e4 4. Spine 2012;37(4):309-15

This patient is predicted to benefit significantly from 18 hr/day of wear. Vertical bars show the 95% CI.

25. Chronic Nerve Root Injury in Pediatric Patients with Chronic Lumbar Stress Fractures

<u>Cole D. Tessendorf, MS3</u>; Kyle Haddick, Student; John W. McClellan, MD

Hypothesis
We hypothesize that pediatric patients presenting with chronic spondylolysis and dorsiflexion or plantarflexion weakness are at risk for nerve injury and may be assessed via EMG testing.

Design
Retrospective Analysis

Introduction
Many orthopedic providers currently treat chronic spondylolysis as a self-limited stress fracture. While the condition has previously been associated with back pain in pediatrics, little attention has been placed on the risk of neurologic harm. Electromyography (EMG) is

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a common study used to evaluate nerve injury, but it has not been previously reported for testing pediatric patients with stress fractures. This analysis shows that pediatric patients with chronic pars fractures and muscle extremity weakness may benefit from EMG testing.

Methods
120 pediatric patients who underwent EMG testing between 2015 and 2021 were analyzed, and 41(21F,20M) patients with a mean age of 16(13-20) met criteria of chronic lumbar pediatric spondylolysis with weakness on ankle dorsiflexion or plantarflexion. No exclusions were made. Initial EMG testing was indicated for the muscle extremity weakness; pain was not the major concern. All physical exams were completed by the senior author. Thin-cut lumbar CT studies were done at the same institution, and EMGs were completed by one of three physiatrists.

Results
Of the 41 patients, 33 had bilateral and 8 had unilateral fractures with 95% (39/41) of them located at L4 or L5. 55% (18/33) of the bilateral fractures demonstrated chronic nerve injury; 1 demonstrated abnormal EMG but did not meet chronic injury threshold. 75% (6/8) of the unilateral fractures demonstrated chronic nerve injury; 1 demonstrated abnormal EMG but did not meet chronic injury threshold. Overall, 59% (24/41) of patients demonstrated chronic nerve injury upon EMG, and 5% (2/41) had abnormal results but did not reach chronic injury threshold.

Conclusion
Chronic pars fractures have historically been treated as a self-limited injury. However, our analysis showed that 59% of pediatric patients presenting with chronic spondylolysis and dorsiflexion or plantarflexion weakness have developed a chronic nerve injury. This study is the first to demonstrate the risk of neurologic harm in unhealed pediatric lumbar stress fractures, and it indicates the importance of EMG testing in young patients presenting with chronic spondylolysis and muscle extremity weakness.

26. The Kids Are Not Alright: The Decline of Pre-Operative SRS Scores over Time in Patients with Adolescent Idiopathic Scoliosis

Adam Jamnik, BA; David C. Thornberg, BS; Chan-hee Jo, PhD; Jaysson T. Brooks, MD; Amy L. McIntosh, MD; Brandon A. Ramo, MD

Hypothesis
Preoperative Scoliosis Research Society (SRS) questionnaire scores for patients with Adolescent Idiopathic Scoliosis (AIS) have declined over the past two decades.

Design
Retrospective review

Introduction
The SRS questionnaire has been widely used to evaluate patients' perception of their scoliosis. Since the SRS' development, there have been significant societal changes that impact the lives of adolescents, which may alter patients' experience with scoliosis. This study will seek to determine how preoperative SRS scores have evolved over time.

Methods
Single-center, retrospective review of SRS scores for AIS patients that underwent surgery between 2002-2022. First, a multivariate linear regression was performed with the SRS domain scores as the outcome of interest, year of surgery as the variable of interest, and patients' age, gender, BMI, race, major cobb angle, and Lenke type as potential confounding variables. Second, SRS scores for 3052 healthy adolescents were taken from a separate published study, and our AIS patients' scores were dichotomized as being above or below a threshold set at 2 standard deviations below the healthy adolescents' mean scores. A logistic regression was performed with the same independent variables and the outcome as a binary SRS score for patients with AIS.

Results
A total of 1380 patients (79.2% female, mean age at surgery 14.85 ± 2.03 years old) were included for analysis. Of the potential confounders in the linear regression, age, gender, race, BMI, and major cobb angle were found to be significantly associated with multiple domains. Later surgery years (more recent surgery date) had a significant negative association with Pain (coefficient = -0.03, p<.0001), Activity (coefficient = -0.02, p<.0001), Mental Health (coefficient= -0.01, p<.0001), and Total score (coefficient= -0.01, p<.0001) (Figure 1). Similarly, AIS patients in later years were more likely to fall 2SD below the healthy adolescent mean in Pain (OR: 1.061, p<.0001), Appearance (OR: 1.023, p= 0.0301), Activity (OR: 1.044, p= 0.0197), and Total score (OR: 1.06, p<.0001). Surgery year's effect on Mental Health approached statistical significance (OR: 1.082 per year, p= 0.0609).

Conclusion
Over the past two decades, AIS patients' SRS scores have declined both in absolute terms and in relation to the scores of healthy adolescents.

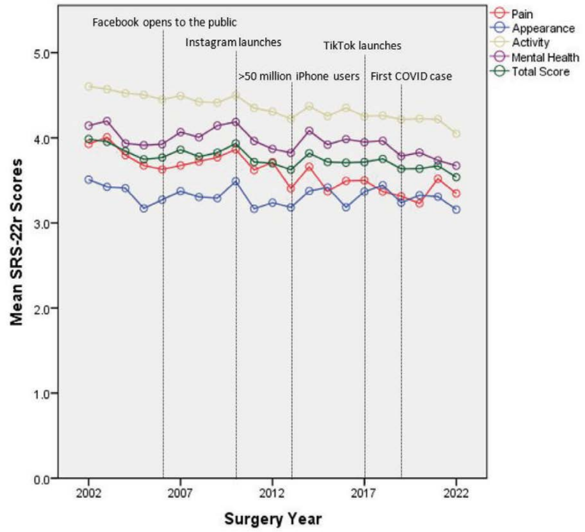

Figure 1: Mean SRS-22r Scores Over Time

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27. The Oswestry Disability Index is Valid in Children

Karina A. Zapata, PT, DPT; Chan-Hee Jo, PhD; Brandon A. Ramo, MD; Jaysson T. Brooks, MD

Hypothesis

The Oswestry Disability Index (ODI) is valid in children.

Design

Cross-sectional survey

Introduction

The ODI is a commonly used questionnaire that quantifies disability due to back pain, but it has not been formally validated in children. The 9-item ODI (ODI-9) excludes 1 question from the ODI pertaining to sexual activity. The purpose is to utilize simultaneously given PROMIS Pediatric Computer Adapted Test (CAT) Pain Interference and Mobility measures and the Pain Catastrophizing Scale (PCS-C) as anchors to determine the concurrent validity of the ODI-9 in children.

Methods

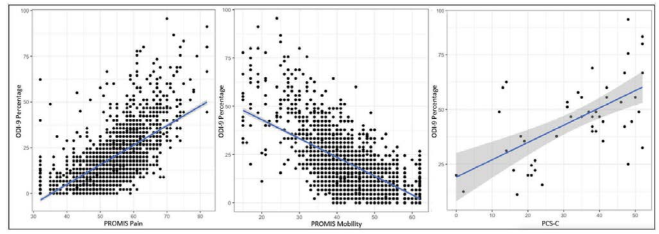
2,123 children (1466 girls, 657 boys) ages 14.2±2.6 years (range: 5-18 years) referred to a tertiary pediatric orthopedic institution for spine conditions who completed the ODI-9 when answering "yes" to back pain were retrospectively evaluated from April 2021 to April 2022. Racial/Ethnic make-up was 45% White, 30% Hispanic, 11% Black, 9% Other, 4% Asian, and 1% Indigenous American. All children/caregivers completed the ODI-9 (n=2123), PROMIS Pain measure (n=2103), PROMIS Mobility measure (n=2103), and PCS-C, when pain was rated ≥4/5 (n=51).

Results

Average ODI-9 scores were 27.7%±21.0%, indicating moderate disability, although the majority (68%) reported minimal disability (ODI-9 ≤20%). Moderate, statistically and clinically significant associations were seen between the ODI-9 and PROMIS Pain measure ($r = 0.68$, $p < 0.001$), the ODI-9 and the PROMIS Mobility measure ($r = -0.68$, $p<0.001$), and the ODI-9 and the PCS-C ($r = 0.59$, $p < 0.001$, Figure). In children with Cobb angles measured due to concerns of scoliosis (n=1268), increased Cobb angles were mildly associated with increasing ODI scores ($r=0.14$, $p<0.001$). White children reported significantly higher ODI-9 scores compared to Non-whites (19.1% vs. 17.7%, p=0.030).

Conclusion

Increasing ODI-9 scores correlate with increasing PROMIS Pain T-scores, decreased PROMIS Mobility T-scores, and increasing PCS-C scores. The ODI-9 demonstrates adequate concurrent validity as a patient-reported outcome measure of disability in children ages 5-18. Stronger associations were not expected, as the ODI-9 asks specific questions related to back pain versus more generalized pain and mobility questions of the PROMIS measures and catastrophic thinking of the PCS-C.



Scatter plots between the ODI-9 scores and the PROMIS Pain measure, PROMIS Mobility measure, and PCS-C

Papers #28-39 have been renumbered and moved to Case Discussion Abstracts.

40. Does Weight Loss Reduce the Risk of Obesity-Related Complications in Spine Fusion Surgery?

Camryn Myers, BS; Abel De Varona-Cocero, BS; Fares Ani, MD; Constance Maglaras, PhD; Themistocles S. Protopsaltis, MD

Hypothesis

Preoperative improvement in BMI category will decrease perioperative complications.

Design

Single center retrospective analysis.

Introduction

Benefits of BMI reduction have been shown to improve patient health and satisfaction. ASA grading is directly related to BMI as well as other comorbid conditions. What remains unclear is the effect of preoperative weight loss on complications and outcomes after lumbar spinal fusion. This study evaluated the association of postoperative complications and return to the OR after lumbar fusion in patients who lost weight, those with a normal BMI, and those who remained morbidly obese.

Methods

Retrospective chart review for 1-4 level lumbar fusions 2017-2020 was performed for demographics, surgical characteristics, postoperative complications, BMI readings and nutrition/bariatric consultations. Three cohorts were developed; patients with normal BMI (normal), patients who maintained severe to morbid obesity (obese), and patients who preoperatively reduced their BMI from severe/morbidly obese to Overweight/Normal (weight loss). ANOVAs and chi-square analysis compared intraoperative/postoperative outcomes.

Results

703 patients were included (n=362 normal, n=204 obese, and n=136 weight loss). The weight loss patients dropped an average of 4.63 BMI points preoperatively, with an average weight loss duration of 1896 days. Demographics demonstrated a significantly higher amount of females in the normal group (66.7% v 59.40% v 48.10%; p=<.001) compared to the obese and weight loss group. Patients in the normal and weight loss group had significantly lower operative time, blood loss, and length of stay compared to obese patients. Post-hoc analysis revealed significant differences

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in operative time between the normal group and both the obese and weight loss group (p=0.002, p<0.001). Estimated blood loss was greater in the obese group compared to normal but there were no significant differences between the severely obese and weight loss groups. Deep surgical infections were found to be significantly lower in the weight loss group compared to the obese group (0.0%v3.45%;p=.027).

Conclusion

Obese patients who lost weight preoperatively had shorter operative time, blood loss, and length of stay. Though their metrics did not improve to the level of normal BMI patients, weight loss patients had significantly fewer postoperative complications including deep wound infections compared to obese patients.

Table 1: Baseline Demographics, Surgical Characteristics, Intraoperative Complications and Postoperative Complications for Patients who have normal BMI, severely Obese BMI, and a Preoperative Decrease in BMI

	Normal BMI (N=362)	Severe-Morbidly Obese (n=204)	Weight Loss (n=136)	p-value
Demographics				
Age (years)	60.24 ± 13.85	57.39 ± 11.60	60.64 ± 12.633	0.023
Gender (% Female)	66.70%	59.40%	48.10%	<0.001
CCI	2.47 ± 2.06	2.73 ± 1.90	3.24 ± 2.14	0.001
Smoking	6.90%	6.90%	11.80%	0.165
Surgical Characteristics				
Pre-op Radiculopathy	49.20%	51.00%		0.26
Open vs. MIS	89.8% vs. 10.2%	88.2% vs. 11.8%	94.1% vs. 5.9%	0.191
Levels Fused	1.76 ± 0.969	1.83 ± 0.896	1.90 ± 1.04	0.307
Operative Time (min)	219.77 ± 5.085	267.09 ± 7.935	257.00 ± 10.49	<0.001
Estimated Blood Loss (mL)	247.21 ± 14.860	385.50 ± 38.506	335.04 ± 41.017	<0.001
Length of Stay (days)	3.01 ± 0.108	4.12 ± 0.235	3.82 ± 0.266	<0.001
Intraoperative Complications				
Neuromonitoring	2.80%	2.90%	3.70%	0.866
Durotomy	5.00%	4.40%	2.20%	0.394
Postoperative Outcomes				
Cardiac	5.50%	5.90%	4.40%	0.342
Neurological Deficit	4.20%	4.90%	3.00%	0.786
Superficial Surgical Site Infection	0.30%	2.90%	1.50%	0.025
Deep Surgical Infection	0.00%	3.45%	0.00%	0.007
Reoperation				
Return to OR in 30 Days	1.90%	3.40%	2.20%	0.529
Return to OR within 90 Days	3.30%	2.90%	2.90%	0.96
Instrumentation Revision	0.30%	1.50%	0.70%	0.268
Adjacent Segment Disease	0.60%	2.90%	3.70%	0.028
Pseudarthrosis	1.40%	2.00%	3.70%	0.264

41. Intra-Abdominal Content Movement In Prone Versus Lateral Decubitus Position Lateral Lumbar Interbody Fusion (LLIF.)

Cristiano M. Menezes, MD, PhD; Luciene M. Andrade, MD, PhD; Gabriel C. Lacerda, MD; Marlus M. Salomão, MD; Mark T. Freeborn, MD; J A. Thomas, MD

Hypothesis

There is change in position of the peritoneal contents in individuals in lateral decubitus (LD) versus prone.

Design

Radiographic study of 16 healthy volunteers using magnetic resonance imaging (MRI) obtained in right lateral decubitus and prone positions.

Introduction

Studies have validated the safety of LLIF with regards to visceral, vascular and neurological injury. While LLIF has historically been studied and performed in the lateral decubitus (LD) position, recently the technique has been performed in the prone position. There is still lack of clarity regarding the movement of peritoneal contents between the LD and prone position during LLIF.

Methods

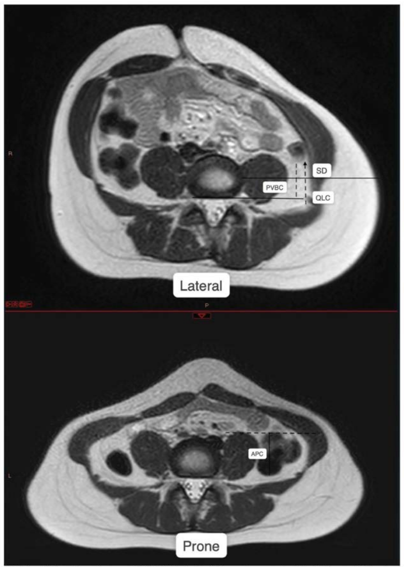
Anatomical measurements were performed on axial MRI images at the L3/4 and L4/5 disc spaces by two independent observers. For the prone scans, the subjects were positioned on a carbon fiber positioner such that the abdomen could hang freely.

Results

Mean age was 42.3 years (25-58) and BMI was 27.8 +-10.5 kg/m2. 56% of the cohort were males and 44% female. Distance between skin and lateral disc surface was increased in the prone position: L-SD=118.9mm versus P-SD=136.6mm, p=0.497. Distance between the posterior annulus and the colon was significantly decreased in the prone position: L-PVBC=43.61mm +-11.87mm versus P-PVBC=27.04mm +-15.34mm, p=0.0266. The colon moved more posteriorly in relation to the anterior margin of the psoas in the prone position: L-APC=1.57mm +-11.9mm versus P-APC=14.62mm, p=0.0485. Lastly, distance between the QL and colon was decreased, though not significantly, in the prone position: L-QLC=44.51 mm +- 12.55mm versus P-QLC 29.32 mm +-13.07mm, p=0.1052.

Conclusion

The study demonstrates increased distance between the skin and disc space as well as a more posterior location of the colon in relation to the spine and psoas muscle in prone versus LD position. The presence of the colon within the intended LLIF access corridor was almost invariable. Surgeons should be alerted to the potential increased risks of this surgical approach in the prone position.



SD (line) Skin-Disc distance/ PVBC (dash line) Posterior vertebral body line to left colon/. QLC (dash arrow) Quadratus lumborum to left colon distance/ APC (bottom picture line) distance from anterior Psoas margin to most posterior part of colon

42. Surgeons Beware! Defining the "No Surgery Recommended" (NSR) Patient Who Should Not Undergo ASD Surgery

Jeffrey L. Gum, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Jeffrey P Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D.Kojo Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis

There will be distinct baseline characteristics that help identify NSR ASD patients

Design

Post-hoc analysis

Introduction

Substantial work is devoted to identifying the patient and surgical characteristics that lead to a "best outcome" in ASD surgery. These findings guide preop pt selection/optimization, alignment goals, and surgical strategy. Fewer studies focus on identification of unsatisfied patients despite postop optimal outcomes and alignment. It would be valuable to identify these NSR pts prior to surgery to potentially avoid or at minimum, alter the preop counseling and expectations.

Methods

Operative ASD pts with min 2-yr follow up were included. NSR pts were defined as being radiographically aligned postop (SRS-Schwab ASD criteria), with no major complications or revision, but still unsure or not satisfied with surgery based on SRS-22r q21 and q22. NSR pts were compared to satisfied (Control:C) pts with the same characteristics but satisfied responses to q21 and q22. Preop demographics, PROMS (SRS-22r, SF-36, ODI, NRS back and leg pain), radiographic and surgical parameters were included. Multivariate models were constructed using a decision tree analysis considering 38 variables with preop PROMs, demographic, radiographic, and surgical parameters.

Results

824 of 1539 ASD pts available for analysis (had complete data) with min 2-yr follow-up. 375 met criteria for C (329 (87.7%)) and NSR (46 (12.3%)) groups. Age was similar between groups (C=56.0yrs, NSR=56.5yrs; p>0.05). C had fewer males (20.1%) vs NSR (34.8%; p<0.05). 67.6% of C had prior fusion vs 88.5% of NSR; p<0.05. ASD-FI was 2.8 for C vs 3.6 for NSR; p<0.05. All preop PROMs were significantly worse in the NSR group. 95.7% of NSR pts have a preop SRS Self-Image (SI) score < 3 where as 33.4% of C pts have a score > 3. The majority of patients with SRS-SI < 3, SRS-Mental < 2.6, SRS-Pain < 1.4 fixed to the upper thoracic spine were NSR (86.5% vs 13.5%). The R^2 for the entire series of conditions was 0.522 and the ROC was 0.931 for both the C and NSR groups. Table 1 shows an abbreviated set of conditions that account for 87.0% of NSRs and 9.1% of Cs.

Conclusion

ASD patients that present with poor SRS self-image (< 3) and mental health (< 2.6) scores that need a fusion to the upper thoracic spine have a very high likelihood of being a "no surgery recommended" patient again emphasizing the importance of self-image in patient evaluation.

Table 1.

	C (N)	NSR (N)
Preop SRS-SI <3.0 and Preop SRS-MH <2.6 and UT UIV and Preop SRS-Pain <1.4	0	5
Preop SRS-SI <3.0 and Preop SRS-MH <2.6 and UT UIV and Preop SRS-Pain ≥1.4	5	8
Preop SRS-SI <3.0 and Preop SRS-MH <2.6 and TL UIV	16	4
Preop SRS-SI <3.0 and Preop SRS-MH ≥2.6 and Preop BMI ≥22.5	2	5
Preop SRS-SI <3.0 and Preop SRS-MH ≥2.6 and Preop Steady Gait and Preop PCS <28.8 or ≥25.4 and Preop SF36 GH ≥50.6	3	9
Preop SRS-SI <3.0 and Preop SRS-MH ≥2.6 and Preop Steady Gait and Preop PCS <28.8 or ≥25.4 and Preop SF36 GH <50.6 and Preop Opioid use=Yes and Preop CCI <2	1	4
Preop SRS-SI <3.0 and Preop SRS-MH ≥2.6 and Preop Steady Gait and Preop PCS <25.4 and Preop SF36 VT <30.2 and Preop CCI <2	3	5

43. Achievement and Maintenance of Optimal Alignment Following Adult Spinal Deformity Corrective Surgery: A 5 Year Outcome Analysis

Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Renaud Lafage, MS; Virginie Lafage, PhD; D.Kojo Hamilton, MD, FAANS; Peter G. Passias, MD

Hypothesis

Patient specific factors contribute to the durability of radiographic alignment.

Design

Retrospective cohort

Introduction

Assessment of factors associated with maintenance of optimal alignment till five year post adult spinal deformity (ASD) surgery can provide insight to components that lead to durable outcomes.

Methods

Operative ASD patients with baseline and at least 5-year (5Y) data were included. Durable alignment (D) was defined as improving in at least one SRS-Schwab modifier without worsening in any SRS-Schwab modifier. A robust outcome (R+) was defined as achieving D at 2Y that was maintained at 5Y. Predictors of robust outcomes were identified using multivariate regression analysis.

Results

297 ASD patients met inclusion (Age 59±14yrs, 79% F, BMI 27±5kg/m2, CCI: 1.6±1.7, ASD-mFI: 6.5±4.9, levels fused 11±4). BL SRS-Schwab modifiers: 36.4% ++PI-LL, 31.8% ++SVA, 25.1% ++PT. At 5Y: 12.1% ++PI-LL, 10.6% ++SVA, 17.6% ++PT. 20.7% were matched at 5Y in Lafage age-adjusted alignment goals. 77% met D at 6W and 54% at 2Y, with 89.4% of those went on to meet D at 5Y (D5). R cohort was younger, had lower BMI and frailty (all p<.05). Those that did not achieve D2 had higher rates of reoperations due to implant failure and sagittal imbalance(all p=.01). 70%

of R- had junctional failure, compared to 33% in R+ (p=.01), and had 17% reoperation rate due to loss of alignment. Pseudarthrosis rates was higher in R-. Multivariate regression controlling for gender, baseline age, BMI, CCI, osteoporosis, frailty, invasiveness, BL PT, SVA, and PI-LL, and prophylaxis identified the following predictors of R+: BL to 6W decreased correction in PT, increased correction in PI-LL (p<0.05). Higher age, BMI, and invasiveness were significant non-radiographic predictors for R-: Age OR: 1.025, BMI OR: 1.098, Invasiveness OR: 1.028 (all p<.05).

Conclusion

Durability of achieving optimal alignment following corrective ASD surgery was sustained in half of the patients at 5 years. While the majority of patients at 2 years sustained their radiographic outcomes at 5 years, major contributors to loss of alignment included junctional failure and adjacent region compensation, with only a minority of patients losing correction through the existing construct. Reoperation rate for loss of alignment was 17.2%. Loss of alignment requiring reoperation had a detrimental effect on 5 year clinical outcomes.

44. Neuro-monitoring can be Safely Stopped 20 Minutes After Pediatric Spine Deformity Correction. The 20-minute Rule.

John T. Smith, MD; Nancy Campbell, DO; Jonathon Umina, BS; Joshua Klatt, MD; John A. A. Heflin, MD; Jayden Brennan, BS

Hypothesis

Stopping Neuro-monitoring 20 minutes after final deformity correction is safe and will not result in undetected neurologic events.

Design

Retrospective review of a prospective Neuro-monitoring database

Introduction

While it is agreed that Neuro-monitoring enhances patient safety during spine deformity surgery, the length of time to monitor evoked potentials signals after correction is controversial. In a true neurologic event, motor evoked potentials (MEP's)are lost first, followed by sensory evoked potentials (SSEP's) 20 minutes after MEP's. Based on this phenomenon, we follow a "20-minute rule", whereby we only continue monitoring for twenty minutes after correction. We hypothesized that twenty minutes is sufficient to detect all neurologic events after deformity correction.

Methods

A single institution neuro-monitoring database of all pediatric spine deformity cases by 4 surgeons from 2013 to 2022 were reviewed. All spine procedures with neuro-monitoring were included. The timing of all neurologic events in relation to deformity correction were reviewed.

Results

A total of 1516 pediatric spine deformity cases were monitored between 2015-2022. Ages ranged from 9 months to 24 years. All patients had a total intravenous anesthetic (TIVA). There were 90 true neuro-monitoring alerts. The diagnosis in patients who had neurologic events were 15 AIS, 32 neuromuscular, 43 and kypho-scoliosis. All events occurred before or within twenty minutes after correction. We followed the Neuro-monitoring Alert Checklist (Vitale et.al). One patient had normal signals 20 minutes after correction and developed loss of motor and sensory function 8 hours after correction thought to be related to an undetected holo-syrinx. Our overall catch rate of neurologic events within the 20 minute window was 99.93%.

Conclusion

Neurologic injury following pediatric spinal deformity is a life changing event. MEP and SSEP monitoring are the standard of care and proven to be highly sensitive to detect neurologic injury. Monitoring requires a TIVA anesthetic, which in our institution results in prolonged wake up times. These data support the safety and practice of the "Twenty Minute Rule" and allows us to stop the TIVA anesthetic and stop monitoring 20 minutes after final correction.

45. Metal Hypersensitivity Prevalence in Pediatric Spine Surgery

Alvin C. Jones, MD; Nichole S. Leitsinger, BS; Lindsay R. Schultz, BS, CCRP; Viral V. Jain, MD

Hypothesis

Metal allergy testing prior to surgical intervention can aide in detecting potential metal hypersensitivity reaction.

Design

Retrospective Chart Review

Introduction

Pediatric spinal instrumentation involves implanting devices composed of various metals and/alloys, including aluminum, nickel, molybdenum, carbon, titanium, cobalt, chromium, vanadium, etc. [1] Nickel, cobalt, and chromium are known to historically have high rates of contact allergy and allergic contact dermatitis.[2] Concerns exist for delayed metal hypersensitivity reactions in orthopaedic surgery.[3-7] Systemic and/or local reactions can lead to post-operative complications, including dermatitis, delayed wound healing, recurrent pain, swelling, erythema, and osteolysis. At times, these reactions can result in the need for a revision procedure or removal of the metallic implants.

Methods

A single site, retrospective chart review was conducted on patients who underwent spinal instrumentation with or without a fusion during January 1, 2014, to December 31, 2020. All patients were prescreened for metal sensitivity prior to surgery. Patients that did not indicate sensitivities or complete patch testing prior to spinal surgical intervention were excluded.

Results

830 patients received spinal instrumentation procedures from 2014 to 2020. (14.6%) screened positive for metal hypersensitivity. However, the number of patients with documented evidence of metal hypersensitivity diminished to 33 (4.0%) after patch testing. Over half of those who tested positive had reaction to Nickel and Cobalt.

Conclusion

These results indicate a small percentage of our pediatric spine patient population have the potential for a metal hypersensitivity reaction. Specifically, surgeons should be aware that Nickel and/or Cobalt represent the highest rates of hypersensitivity when determining implants.

Year	Spinal Instrumentation Patients	Screened Positive	Tested Positive	Tested Negative
2020	103	11	3	8
2019	122	14	8	6
2018	110	12	3	9
2017	113	16	4	12
2016	121	22	3	19
2015	122	21	6	15
2014	139	25	5	20
Totals	**830**	**121**	**32**	**89**

Table 1. Metal Hypersensitivity Screening and Testing Results

Nickel	18 (56.3%)
Cobalt	17 (53.1%)
Stainless Steel Trace Metals	6 (18.8%)
Manganese Chloride	5 (15.6%)

Table 2. Number and Percentage Specific Metal Hypersensitivities in Positive Tests

46. Intrawound Vancomycin Powder Reduces Delayed Deep Surgical Site Infections in Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis Patients

Kensuke Shinohara, MD; Peter O. Newton, MD; Michael P. Kelly, MD; Vidyadhar V. Upasani, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Harms Study Group

Hypothesis
Vancomycin powder (VP) placed in the surgical site prior to wound closure reduces the rate of delayed deep surgical site infections (DSSI) after posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) patients.

Design
Multicenter retrospective clinical cohort study

Introduction
DSSI after PSF in AIS patient remains a significant major complication. The use of VP to prevent acute surgical site infection has been reported; however, the effectiveness of VP for Delayed SSI was the purpose of this study.

Methods
AIS patients treated over the past 20 years with posterior spinal fusion and instrumentation from a large muti-center database were reviewed. Patients were divided into two groups: intraoperative vancomycin powder placed in the wound (VP) or no antibiotics placed in the wound (No VP). DSSI was defined as an infection that occurred > 90 days after surgery and required surgical intervention in the operating room. Patients who developed a DSSI had secondary verification of VP use or not. Chi square and Kaplan-Meier (K-M) survivorship analyses were used to compare demographics and the incident rate of DSSI between groups.

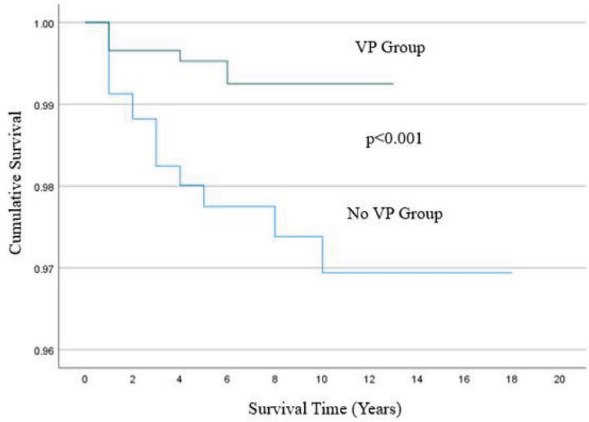
Results
3771 cases met inclusion with the demographics and perioperative data differing between the groups as seen in the Figure. The historical No VP group had longer hospital stays, more blood loss, and longer fusions. The effect sizes were small except for blood loss differences (medium). A total of 38 DSSI cases were identified (1.0%). The incidence of DSSI for the VP group was 0.4% (9/2203), and 1.8% (29/1568) in the No VP group ($p<0.001$). Given the difference in follow-up for the 2 groups a Cumulative Survival and Kaplan-Meier analysis revealed the VP group had significantly better "survival" (no DSSI) than the No VP group ($p<0.001$; Figure).

Conclusion
This study shows that the use of VP in the spinal fusion wound prior to closure and minimizing EBL are associated with a significantly lower DSSI rate during PSF with instrumentation. Given the historical nature of the No VP group, other changes in surgical technique may also play a role in reducing DSSI; however, VP should be considered as a preventive measure against DSSI in posterior correction surgery for AIS patients.

Figure: Comparison of Demographics Between Groups and the K-M Survivorship Graph

	VP Group	No VP Group	Effect size*	p-value
Age (yrs)	14.7±3.1	15.0±2.2	0.003	0.002
Major Curve (°)	58.5±12.5	53.2±8.9	0.001	0.08
Thoracic Kyphosis (°)	31.8±13.8	32.6±19.9	0.001	0.07
Length of Hospital Stay (days)	4.4±1.6	5.2±2.5	0.04	<0.001
Surgical time (min)	267.5±93.5	303.7±105.4	0.03	<0.001
Estimated blood loss (cc)	591.5±438	1033.9±894.0	0.10	<0.001
Fixation levels (N)	10.8±2.2	11.3±2.1	0.01	<0.001

*Partial eta square: $\eta 2 = 0.01$ indicates a small effect, $\eta 2 = 0.06$ indicates a medium effect, $\eta 2 = 0.14$ indicates a large effect



47. Monthly Multidisciplinary Adult Spinal Deformity Conference is Cost-Effective: Cost-Analysis Utilizing Lean Methodology and Time-Driven Activity-Based Costing

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Hypothesis
Implementing a multidisciplinary adult spinal deformity conference results in cost-savings.

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Design

Single institution prospective cohort.

Introduction

Cost-effective pathways in healthcare are vital in this current healthcare system. Applying lean methodology with accurate cost accounting provides further descriptions of value for specific interventions. In this study, we apply time driven activity-based costing (TDABC) to assess the cost-effectiveness of a multidisciplinary adult spinal deformity conference that was designed based on value streams under lean methodology.

Methods

Total time spent by each team member in conference preparation, presentation, and follow-up tasks was recorded for each conference2. Data was aggregated to determine the average amount of time required to prepare and present one patient. Using a 2022 mean hourly rate based on our urban hospital setting, a wage value was calculated for each personnel type and applied to the minutes spent by that personnel type. Total cost of the conference was annualized and then calculated from the time spent in the three phases of conference multiplied by the wage rate. Published data regarding complication rates before and after conference implementation as well as costs associated with different complications were used to calculate total cost reduction.

Results

Implementation of a multidisciplinary approach to adult spinal deformity resulted in a 51% decrease in all complications at 30 days (RR 0.49 [95% CI 0.30-0.78]). Total cost savings from complication reduction was $418,518 annually. With 3 active adult spine surgeons there were 108 patients presented per year. Total time investment was 237.06 minutes/patient (total annual cost $16,411). Implementation of this conference resulted in a savings of $402,107/year.

Conclusion

The decision to implement a cost saving tool in the management of patients with complex spinal disorders lies heavily on the shoulders of the spine team to lead a multidisciplinary conference. This combination of TDABC and lean methodology showed significant cost-savings associated with implementation of a multidisciplinary adult spinal deformity conference. These findings should be used to encourage clinicians and administrators to allocate appropriate resources to improve the safety and value of their patient care through the reduction of complications and costs.

48. "Too Much of a Good Thing": High Cell Saver Autotransfusion is Associated with Perioperative Medical Complications

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Hypothesis

Higher volume of processed red blood cells(RBCs) from Cell Saver(for comparable blood loss[EBL]) is associated w/ increased 30-day(30D) medical readmissions.

Design

Retrospective, single center, propensity matched(PSM) study. Pts underwent ≥8 level posterior fusion(PSF) for deformity[PI-LL≥25°± TPA≥30°± scoliosis≥50°].

Introduction

High blood loss during adult spine deformity(ASD) surgery is mitigated partially by intraop cell salvage(CS). A concern is CS' impact on RBCs' rheologic properties(i.e., suboptimal performance of washed RBCs) which can precipitate medical complications.

Methods

Two strategies were adopted: "absolute CS volume" & "CS/EBL ratio" strategies. CS Volume Strategy: "Case"(>550mL CS) & "ctrl"(<550mL CS) pts were 1:1 PSM matched for EBL and total antifibrinolytics administered(TXA). Ratio Strategy: Ratio of CS/EBL was created. Pts w/ CS/EBL<0.33(ctrl) & CS/EBL>0.33(case) were compared. Outcomes were transfusion requirements, intraop complications, in-hospital adverse events(AE), length of stay(LOS), and 30D readmission for medical reasons. Following PSM, binary outcomes assessed by McNemar test; continuous outcomes assessed by Wilcoxon rank-sum test

Results

Overall: 278 pts, 67.6% female, mean age 61.3[SEM 0.9], and frailty score 3.1[0.2] were studied. Mean CS Volume was 543.8mL(33.0) & CS/EBL ratio was 0.32(0.01). Higher EBL[31.6(1.6),<0.0001] and higher total TXA [0.04(0.009), <0.0001] were independent drivers of higher CS volume in regression models. CS Volume: ≥550mL vs <550mL: 28 PSM pairs generated after matching by EBL and total TXA. PSM pairs only differed by CS Volume[772 vs 323, P<0.0001] but not EBL (P=0.95), pt demographics, baseline(b/l) alignment, b/l labs, or operative complexity. No difference observed in LOS(P=0.73) & % pts with in-hospital AEs[36%(≥550) vs 21%(<550), P=0.28]. Pts w/ ≥550mL CS had higher 30D readmissions[39.3%(11) vs 3.57%(1) pt, P=0.02). Intraop transfusions were comparable (P>0.99). CS/EBL Ratio; ≥0.33 vs <0.33: 155(56%) pts had CS/EBL<0.33. Both cohorts had comparable alignment, preop labs, operative complexity, and EBL(P=0.94). LOS[P=0.79] & in-hospital AE rate[P=0.89] were comparable. 30D readmission rate was higher among pts w/ CS/EBL≥0.33 (21.9% vs 5.16%, P<0.0001).

Conclusion

Superfluous Cell Saver Autotransfusion is associated with higher thirty-day medical readmissions. CS volume should be limited to 550mL ± CS/EBL ratio of <0.33.

Table 1. Perioperative clinical outcomes in three comparisons: Ratio adjusted strategy where patients with CS/EBL ratio of >0.33 were compared to patients with CS/EBL<0.33; Unmatched Cell Saver Volume Strategy which was a comparison of patients with CS volume of >500 versus CS volume<550 without matching; Propensity Matched Cohort which was the same comparison as the "Unmatched Cell Saver Volume Strategy" but here, patients were matched for their blood loss(EBL) and total TXA administered in 1:1 pairs.

		Ratio Adjusted Cohort			*Unmatched Cohort*			*Propensity Score Matched Cohort*		
	Overall Cohort [N=278]	Cell Saver / EBL Ratio < 0.33 [N=155]	Cell Saver / EBL Ratio ≥ 0.33 [N= 123]	P Value	Cell Saver ≥ 550 [N=73]	Cell Saver < 550 [N=205]	P Value	Cell Saver ≥ 550 [N=28]	Cell Saver < 550 [N=28]	P Value
Outcome Variables										
Operative Complexity										
Length of Hospital Stay	6.61 (0.22)	6.55 (0.28)	6.67 (0.35)	0.7891	7.54 (0.44)	6.2 (0.25)	**0.0092**	6 (0.62)	5.75 (0.38)	0.7326
Intraoperative Complication	36 (12.95)	15 (9.68)	21 (17.07)	0.0744	27 (36.99)	9 (4.39)	**<0.0001**	5 (17.86)	0 (0)	0.0736
Adverse Event										
Postoperative, Pre-discharge	63 (22.66)	36 (23.23)	27 (21.95)	0.8855	25 (34.25)	38 (18.54)	**0.0088**	10 (35.71)	6 (21.43)	0.2888
Thirty Day(30D) Readmission	35 (12.59)	8 (5.16)	27 (21.95)	**<0.0001**	12 (16.43)	23 (11.22)	0.3035	11 (39.29)	1 (3.57)	**0.0159**
Intraoperative Allogenic Transfusion										
Blood Transfusion	224 (80.58)	110 (70.97)	114 (92.68)	**<0.0001**	73 (100)	151 (73.66)	**<0.0001**	25 (89.29)	26 (92.86)	>0.9999
PRBC Units	1.56 (0.13)	1.93 (0.21)	1.2 (0.16)	**0.0061**	2.49 (0.29)	1.15 (0.13)	**<0.0001**	1.96 (0.51)	2.36 (0.44)	0.5551
FFP Units	0.44 (0.09)	0.6 (0.15)	0.29 (0.1)	0.0867	0.75 (0.24)	0.31 (0.08)	0.0852	0.5 (0.43)	0.82 (0.27)	0.5317
Cryoprecipitate Units	0.27 (0.07)	0.32 (0.1)	0.23 (0.1)	0.5251	0.85 (0.21)	0.02 (0.01)	**0.0002**	0.14 (0.08)	0.14 (0.08)	>0.9999
Platelet Units	0.15 (0.03)	0.18 (0.05)	0.12 (0.04)	0.3496	0.36 (0.09)	0.06 (0.03)	**0.0021**	0.11 (0.08)	0.29 (0.16)	0.3204
Thirty Day(30D) Readmission										
Cardiac Etiology	7 (2.52)	2 (1.29)	5 (4.07)	-	3 (4.11)	4 (1.95)	-	2 (7.14)	0 (0)	-
CNS Etiology	2 (0.72)	0 (0)	2 (1.63)	-	0 (0)	2 (0.98)	-	0 (0)	0 (0)	-
GI Etiology	5 (1.8)	1 (0.65)	4 (3.25)	-	1 (1.37)	4 (1.95)	-	1 (3.57)	0 (0)	-
Infectious Etiology	5 (1.8)	0 (0)	5 (4.07)	-	4 (5.48)	1 (0.49)	-	1 (3.57)	0 (0)	-
MSK Etiology	5 (1.8)	0 (0)	5 (4.07)	-	1 (1.37)	4 (1.95)	-	2 (7.14)	0 (0)	-
Renal Etiology	3 (1.08)	0 (0)	3 (2.43)	-	2 (2.73)	1 (0.49)	-	0 (0)	0 (0)	-

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49. The Evolution of ERAS: Assessing the Clinical Benefits of Developments within Enhanced Recovery After Surgery Protocols in Adult Cervical Deformity Surgery

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Andrew Chen, BS; Neel Vallurupalli, BA; Neel Anand, MD; Peter G. Passias, MD

Hypothesis

ERAS protocols are dynamic and evolving, and improvements over time may impact outcomes after adult cervical deformity (CD) surgery.

Design

Retrospective

Introduction

Enhanced Recovery After Surgery (ERAS) can help accelerate patient recovery and assist hospitals in maximizing the incentives of bundled payment models while maintaining high-quality patient care. However, there remains a paucity of literature assessing how developments have impacted outcomes after adult cervical deformity (CD) surgery.

Methods

Operative CD patients ≥18yrs with pre-(BL) and 2-year(2Y) postop data who underwent ERAS protocols were stratified by increasing implantation of ERAS component: Early (multimodal pain program), Intermediate (Early protocol + paraspinal blocks, early ambulation), and Late (Early/Intermediate protocols + comprehensive prehabilitation). Differences in demographics, clinical outcomes, radiographic alignment targets, peri-operative factors and complication rates were assessed via Bonferroni-adjusted means comparison analysis.

Results

131 patients were included (59.4±11.7 years, 45% female, 28.8±6.0 kg/m2). Of these patients, 38.9% were considered Early, 36.6% were Intermediate, and 24.4% were Late. Peri-operatively, rates of intraoperative complications were lower in the Late group (p=.036). Post-operatively, discharge disposition differed significantly between cohorts, with Late patients more likely to be discharged to home versus Early or Intermediate cohorts (ĸ2(2)=37.973, p<.001). In terms of post-operative disability recovery, Intermediate and Late patients demonstrated incrementally improved 6W mJOA scores (p=.004), and Late patients maintained significantly higher mean EQ5D and mJOA scores by 1Y (p<.001, p=.026). By 2Y, cohorts demonstrated incrementally increasing SWAL-QOL scores (all domains p<.028) domain scores versus Early or Intermediate cohorts. By 2Y, incrementally decreasing reoperation were observed in Early vs Intermediate vs Late cohorts (p=.034).

Conclusion

The present study demonstrates that patients enrolled in an evolving ERAS programs demonstrate incremental improvement in pre-operative optimization and candidate selection, greater likelihood of discharge to home, decreased post-operative disability and dysphasia burden, and decreased likelihood of intra-operative complications and reoperation rates.

50. Clinical and Patient-Reported Outcomes of Adult Spinal Deformity Surgery with Ten-Year Follow-Up

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Stephane Owusu-Sarpong, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD

Hypothesis

Ten-year follow-up after ASD surgery may demonstrate unique outcomes past the 2Y mark.

Design

Retrospective

Introduction

Previous literature has described that ASD corrective surgery to significantly improve patients' quality of life and reduce disability with durable results. Yet, there remains a paucity of literature assessing such effects beyond short-term follow-up.

Methods

Operative ASD patients ≥18yrs with complete pre-(BL) and 10-year(10Y) postop radiographic/HRQL data were isolated in a single-surgeon cohort. Demographics, patient-reported outcomes and complication rates were collected and reported. Complications and mortality as recorded by last follow-up. Rates of meeting minimal clinically important difference (MCID) were reported for collected HRQLs [Oswestry Disability Index (ODI), SRS-22, SF-36] collected at each follow-up. Post-operative complications and mortality are reported as a percentage of the studied cohort as of last follow-up.

Results

82 patients (60.3±14.8 years, 75.6 % female, 26.4±5.1 kg/m2) were included. When assessing HRQLs, by 2Y 43.0% of patients met MCID by ODI, 56.0% met MCID by SRS-22 Activity, 60.0% met MCID by SRS-22 Pain, 57.0% met MCID by SRS-22 Appearance, and 22.0% met MCID by SRS-22 Mental. In terms of post-operative complications by 10Y, 82.9% suffered complications of any type, 20.7% suffered major complications, 14.6% suffered medical complications, 15.9% suffered neurological complication, 26.8% suffered mechanical complications (instrumentation failure, screw fracture), 50.0% suffered PJK, 12.2% suffered radiographic PJF, and 29.3% required reoperation. Within 10Y, 5 (6.09%) patients expired; 1 patient due to cancer-related complications, 3 due to natural causes, and 1 due to stroke-related (index surgery unrelated) complications.

Conclusion

The present study assesses outcomes ten-year outcomes of adult spinal deformity surgery in a single-surgeon cohort. Rates of complications remain in line with literature-reported values, though mortality remains significantly decreased despite a relatively frail patient cohort. By ten-year follow-up, improvement in patient-reported outcomes remains robust, with over 75.6% of patients achieved minimal clinically important difference (MCID) in minimum one disability marker.

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51. A Ten Year Review of Pediatric Posterior Deformity Cases Utilizing Tranexamic Acid (TXA) Infusions with New Onset Central Diabetes Insipidus (CDI)

Kyle Hardacker, MD; Pierce Hardacker, BS; Doris M. Hardacker, MD

Hypothesis

Increasing TXA dosage results in an increase in the incidence of CDI.

Design

Retrospective chart review

Introduction

CDI is a rare disorder causing excretion of large volumes of dilute urine (>4ml/kg/hr), plasma volume contraction, hypernatremia and serum hyperosmolality. CDI can occur after pituitary surgery,traumatic brain injury and spinal cord trauma. CDI occurring during pediatric spinal fusions has only been sporadically reported with only one published case report of CDI with a documented suppressed vasopressin level that developed during idiopathic scoliosis correction. CDI presenting during anesthesia has been related to propofol, dexmedetomidine, sevoflurane, ketamine and opioid usage. Our scoliosis surgery protocol uses continuous infusions of remifentanil, propofol, ketamine and TXA(loading dose 10mg/kg, maintenance at 1mg/kg/hour, later increased to 5mg/kg/hour). Since increasing the TXA dosing, there has been an increase in cases of intraoperative CDI marked by sudden development of polyuria and rapidly rising sodium concentrations. We did not have any documented cases of CDI prior to TXA.

Methods

Ten year retrospective review of consecutive pediatric posterior deformity cases.

Results

39 out of 1184 total cases were diagnosed with intraoperative CDI. 25/39 of these curves were idiopathic, 62% were females. Mean urine output during CDI increased to an average 8.3 ml/kg/hour within 1-3.5 hours of the start of TXA infusion. Concomitantly, plasma sodium rapidly increased by an average of 6.3mEq/L. All CDI cases responded to vasopressin infusion with TXA continuation or cessation of TXA alone. No cases of postoperative CDI were noted. Group 1 (TXA at 1 mg/kg/hr) had 0/363 CDI events. Group 2 (TXA at 2-5mg/kg/hr) had 39/821 CDI events. Comparing the CDI rates of Group 1 (0%) vs. Group 2 (4.8%) had a significant p-value of <0.001. There were no statistical differences between Group 1 and Group 2 or the CDI sub group with regards to age or gender. Group 2 and the CDI subgroup had a statistically lower ASA classification than Group 1 (p-value <0.05).

Conclusion

This 10 year review reports a series of new onset intraoperative CDI development in pediatric posterior deformity surgery utilizing TXA infusion.The evidence suggests a dose-dependent association between continuous TXA infusions and CDI. Recognition and treatment of this complication is paramount.

52. Cost-Value of the Spine At Risk Program

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Hypothesis

The cost of a Spine at Risk (SAR) program for preventing peri-anesthetic spinal cord injury (SCI) will be less than health costs for one SCI patient

Design

Retrospective review

Introduction

Children with pathoanatomic spinal anomalies may be at increased risk for spinal cord injury (SCI) when undergoing general anesthesia. We created a SAR program to evaluate and recommend precautions for such patients to avoid neurologic injury. Though the emotional, hospital reputational, and litigation costs associated with SCI are impossible to quantify, the direct healthcare costs of SCI have previously been estimated. We sought to compare the costs and therefore value of the SAR program versus preventing one SCI.

Methods

We performed a 9-year retrospective review of our institutional SAR program. Dedicated staff time, imaging, and SAR-recommended intraoperative neuromonitoring (IONM) costs were tallied, and all non-spine IONM cases from the program were reviewed. The total number of cases in which IONM alerts occurred and were resolved through clinical intervention were considered avoided SCI events. This was multiplied by the estimated total direct lifetime healthcare cost for a SCI patient, based on prior published work, to determine the total financial cost avoided. This was compared to SAR program cost.

Results

For the patients flagged with potential spine concerns by the SAR program, 434 Xrays, 810 MRI scans, and 199 CT scans were obtained to complete precaution recommendations, for $1,221,821 ($103.57/XR, $1,260.98/MRI, $781.30/CT). 0.1 FTE midlevel time was dedicated to perform SAR patient review at a cost of $16,000/yr. 101 non-spine anesthetized procedures were performed under IONM at a cost of $1950, totaling $196,950. The total healthcare costs of the 9yr SAR program was $1,562,771, ($173,641/yr). We identified 10 non-spine anesthetized procedures resulting in IONM alerts requiring clinical intervention. Based on published data, potentially avoided direct healthcare cost if just one of the 10 events had led to an SCI is estimated to be $3,427,993 over a patient's lifetime.

Conclusion

The use of a standardized program to identify children at risk for intraoperative SCI during non-spinal procedures is cost effective in our institution's high risk population. The annual costs to administer this program are significantly less than the direct annual healthcare costs associated with avoided potential SCIs.

53. Apical Region Correction and Global Balance Surgical Strategy Can Improve Pulmonary Function in Patients with Severe Thoracic Scoliosis at 2-year Follow-up

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Hypothesis

Apical region correction and global balance (ACGB): a 3 rods surgical strategy is not only effective for the treatment of severe scoliosis, but it also can improve patients' medium term pulmonary function (PF).

Design

Prospective study.

Introduction

Patients with severe thoracic scoliosis (Cobb angle >90°) often have pulmonary dysfunction. The surgical treatment of these patients is still challenging. ACGB surgical strategy can provide reasonable correction and low incidence of complications, however, the effects of this strategy on medium-term PF have not been reported.

Methods

Eligible patients with severe thoracic scoliosis were enrolled in a prospective study and received ACGB surgery to treat scoliosis. PF values (forced vital capacity [FVC], forced expiratory volume in 1 second [FEV1], and percent-predicted values FVC%, FEV1%) and radiological outcomes were evaluated preoperatively and at 2 years follow-up. The relationships among PF values improvements and all possible variables collected in this study were analyzed.

Results

A total of 36 cases with mean age 20.1 years underwent ACGB surgery in one center from 2015 to 2020 were enrolled. The correction rate for scoliosis was 51.5%. When 2 years after operation, average PF values showed significant improvements (FVC,1.86 to 2.58L; FEV1,1.56 to 2.24L; FVC%,57.4% to 67.7%; FEV1%,56.7% to 66.5%). PF values improvements showed significant correlation with age, changes of thoracic height, preoperative FVC% and preoperative FEV1%.

Conclusion

ACGB surgical strategy can significantly improve the pulmonary function of patients with severe thoracic scoliosis at 2-year follow-up. The underlying mechanism for the improvement of pulmonary function may be due to the increase in the thoracic height. The patients with poorer pulmonary function before operation may have more improvement after operation.

A 12-year-old female patient with severe neuromuscular scoliosis. The preoperative Cobb

A 12-year-old female patient with severe neuromuscular scoliosis. The preoperative Cobb angle was 118 °, the thoracic height was 16.9cm (A), the kyphosis was 82° (B). Preoperative PFs values: FVC =1.52 L, FEV1=1.40 L, FVC% =55.5%, FEV1% =58.9%. ACGB surgery was performed from T3 to L3. After 2-year follow-up, scoliosis and kyphosis were corrected to 33° (D), and 51 ° (E). Postoperative thoracic height was 21.1cm (D). The PFs values were improved to FVC =2.37 L, FEV1=2.14 L, FVC% =74.6%, FEV1% =75.5%.

54. Thoracolumbar Fusions for Adult Lumbar Deformity Show Superior QALY Gain and Lower Costs Compared to Upper Thoracic Fusions

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Hypothesis

In patients with Schwab type N or L curves, thoraco-lumbar (TL) fusions result in lower cost/QALY compared to upper thoracic (UT) fusions.

Design

Retrospective Review of a prospective, multicenter registry

Introduction

Adult spinal deformity (ASD) patients with primary sagittal plane deformity (N) or with structural lumbar/TL curves (L/TL) can be treated with fusions stopping at TL junction or extending up to UT spine. Proximal extension of the fusion may reduce risks of PJF, but at the expense of increased index costs and greater functional limitations. This study evaluates the impact on cost/QALY in patients treated with TL vs UT fusions.

Methods

ASD patients with >4 level fusion and 2-yr follow-up were included. Index and total episode of care (EOC) cost in 2022 dollars were estimated using average itemized direct costs obtained from the administrative hospital records. Cumulative QALY gained were calculated from pre-op to 2-yr post-op change in SF-6D scores. Patients with upper instrumented vertebra (UIV) at T9-T12 level were in TL group and those with UIV at T2-T5 in UT group. Multivariate generalized linear models was used to compare predicted cost and QALY gain between the groups.

Results

Of 1299 patients eligible, 826 (64%) had complete data and 587 (71%) had type N/L curves. The mean age was 61.9+13.4 yrs, 73% were female, and 93% Caucasians. No baseline differences in BMI, frailty, CCI, SRS-Schwab pelvic tilt and PI-LL modifiers, BMP

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use, reoperation rates, blood loss, LOS, ODI or SF-6D scores (all P>0.05). Patient in TL group were older (+4 yrs; p=0.002) with better global alignment (SVA, p=0.001), less thoracic kyphosis (34 vs 48°; p<0.001), lower surgical invasiveness (-30; p<0.0001), fewer 3-column osteotomies (18% vs 33%; p<0.0001), and shorter OR time (-34 min; p=0.01). Both index and total costs were 22% lower in TL group than UT group (p<0.0001). Cost/QALY was 65% lower in TL group (492,174.6 vs 963,391.4) and 2-yr QALY gain was 40% higher in TL group (0.15 vs 0.10; p=0.02) than UT. Multivariate model showed TL fusions were associated with lower total EOC cost (p=0.001) and higher QALY gain (p=0.03) than UT fusions.

Conclusion
In Schwab type N or L curves, TL fusions demonstrated lower 2-yr cost and improved QALY gain without increased reoperation rates or LOS than UT fusions.

55. Neck and Shoulder Pain 10 Years After Posterior Spinal Fusion for Thoracic Adolescent Idiopathic Scoliosis

Masayuki Ohashi, MD, PhD; Kei Watanabe, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Toru Hirano, MD, PhD

Hypothesis
Clinically significant neck and shoulder pain (NSP) may occur 10 years after posterior spinal fusion (PSF) for thoracic adolescent idiopathic scoliosis (AIS), which may be associated with radiographic parameters.

Design
Retrospective study

Introduction
Previous studies have reported that AIS is associated with NSP persisting over time. In addition, PSF for thoracic AIS requires dissection of the neck or back extensor muscles, which might cause postoperative NSP. However, the prevalence, clinical significance, and predictors of long-term postoperative NSP remain unclear.

Methods
Patients who underwent PSF for thoracic AIS (Lenke 1 or 2) between 1999 and 2011 with a 10-year follow-up were included. NSP was evaluated using the visual analogue scale (VAS, 10 cm) at 10 years. Differences in VAS between AIS patients and healthy controls and correlations between VAS and radiographic parameters were analyzed. Statistical significance was set at p <0.05.

Results
Forty-one patients (35 females) with an average of 10.7±1.5 years follow-up (follow-up rate 70%) were included. The average age at the time of surgery and 10-year follow-up were 14.9±2.7 and 25.9±2.8 years, respectively. The average VAS was 3.6±3.2 cm at 10 years. Female patients had significantly severe NSP than healthy females did (VAS, 4.1 vs 2.8, p=0.021). Moreover, post-PSF VAS was significantly negatively correlated with the total SRS-22 (r=-0.332, p=0.03). Post-PSF VAS was significantly correlated with cervical lordosis (C2-7, r=-0.369, p=0.0018), lumbar lordosis (r=0.470, p=0.002), and sacral slope (r=0.425, p=0.006). On the other hand, it was not significantly correlated with any preoperative parameters and postoperative coronal parameters. At 10-year follow-up, cervical lordosis was significantly correlated with T1 slope (r=0.821, p<0.0001) and thoracic kyphosis (T1-12, r=0.632, p<0.0001; T5-12, r=0.416, p=0.007).

Conclusion
NSP 10 years after PSF was a clinically significant long-term issue in thoracic AIS. The VAS of NSP was higher in patients after PSF than healthy controls and was associated with a worse SRS-22 score. Restoration of thoracic kyphosis and T1 slope, which are controllable factors, might improve cervical lordosis and alleviate NSP at 10-year follow-up.

56. The Modified Proximal Humerus Ossification System Predicts Surgical Curve Progression in Unbraced Patients with Adolescent Idiopathic Scoliosis

Tristen N. Taylor, BS; Callie Bridges, BS; Tiffany Lee, BS; Brian G. Smith, MD

Hypothesis
When the Modified Proximal Humerus Ossification System (MPHOS) is used to grade skeletal maturity in patients with adolescent idiopathic scoliosis, it can be used to predict progression to curves >45 in patients that do not brace or brace for <8 hours.

Design
Case Series

Introduction
The progression to surgical range curves in patients with adolescent idiopathic scoliosis (AIS) has previously been shown to correlate well with the initial Cobb angle combined with the stage of Modified Proximal Humerus Ossification System (MPHOS). We aimed to evaluate the rate of progression to a surgical range in unbraced or minimally braced patients from the Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST) to the MPHOS stage, the Cobb angle, and validate the Cobb-MPHOS score which can be used clinically to predict progression.

Methods
Patient data and imaging from the BrAIST study, which used a temperature logger to reliably measure brace wear-time in AIS patients from 2007 to 2011, was analyzed for demographics, initial and final major angle, brace wear-time, and MPHOS stage. Patients were included if they were unbraced or braced for less than 8 hours. and diagnostic statistics for the progression to surgical range (>45) was calculated for each category of MPHOS, Cobb angle, and the Cobb-MPHOS score (Major Cobb Angle – (10 * MPHOS grade)). In the equation, 3A = 3 and 3B = 3.5.

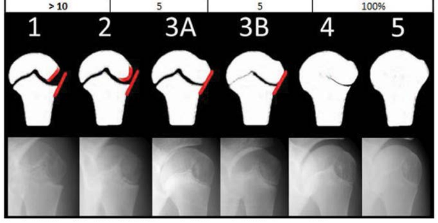
Results
53 patients (83% female) were included. The average age at diagnosis (standard deviation) was 12.4 (1.2) years and follow up was 24.1 (10) months. The mean initial major curve was 30.5 (6.5) and final curve was 44.4 (9.5) (P<.001). Overall, 28 (53%) patients progressed to a surgical range, with 80% being stage 3A or lower. Risk of curve progression is associated with both MPHOS and Cobb angle until stage 3B (P=.005). By the Cobb-MPHOS score, 17/18 (94%) patients progressed to a surgical range, and yielded

a specificity of 0.96, positive predictive value of 0.94, and positive likelihood ratio of 15.

Conclusion

Patients with MPHOS staged 3A or below have a higher rate of progression than patients stage 3B. The Cobb-MPHOS score is a clinically useful tool that is capable of predicting the progression to a surgical range curve in unbraced patients. Patients who score >5 are most likely to progress to a surgical range.

Predictability of Cobb-MPHOS Score in Unbraced Patients			
Curve - (10*MPHOS)	Total No. of Patients	No. in Surgical range	Positive Predictive Value
< -10	4	0	0%
< -9	4	0	0%
< -8	8	0	0%
< -7	8	0	0%
< -6	8	0	0%
< -5	10	0	0%
< -4	12	0	0%
< -3	14	1	7%
< -2	17	1	6%
< -1	22	4	18%
< 0	25	6	24%
> 0	31	24	77%
> 1	28	22	79%
> 2	24	21	88%
> 3	23	20	87%
> 4	22	20	91%
> 5	18	17	94%
> 6	15	15	100%
> 7	15	15	100%
> 8	11	11	100%
> 9	6	6	100%
> 10	5	5	100%



Predictability of Cobb-MPHOS Score in Unbraced AIS Patients and Stages

57. Five-year Longitudinal Outcomes Following Selective vs Non-selective Fusion for Adolescent Idiopathic Scoliosis: Is Lumbar Fixation Warranted

Richard E. Campbell, MD; Monica Arney, MD; Alexander Hafey; Theodore Rudic; Elizabeth Driskill, MS; Peter O. Newton, MD; Harms Study Group; Keith R. Bachmann, MD

Hypothesis

We hypothesize that lowest instrumented vertebrae (LIV) will not have an effect on outcomes following spinal fusion for adolescent idiopathic scoliosis (AIS).

Design

Retrospective Cohort Study

Introduction

Surgeons are interested in the selection of more cranial LIV to preserve motion in the treatment of AIS; however, there is concern for deformity progression. The purpose of this study is to evaluate the relationships between LIV and longitudinal postoperative outcomes including deformity, spinal flexibility, and patient-reported outcomes in patients with AIS.

Methods

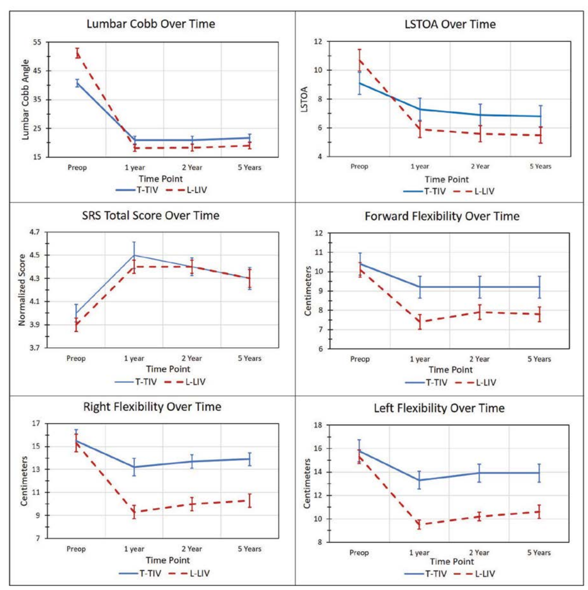
Patient parameters were retrieved from a multicenter, prospective longitudinal database. Patients with Lenke 1-6 B or C deformities with 1, 2, and 5 year data were included. Patients were stratified into 2 groups: T-LIV if the LIV was L1 or cranial, and L-LIV if the LIV was L2 or caudal. Outcome variables included postoperative LSTOA, lumbar Cobb angle, flexibility, and SRS-22 scores. The data was analyzed with chi-squared tests, t-tests, and generalized linear models.

Results

A total of 301 patients were included (T-LIV: 111, L-LIV: 190). Longitudinal analysis of postoperative parameters demonstrated larger LSTOA and lumbar Cobb angles in the T-LIV group compared to the L-LIV group (p< 0.01); however, there was no significant change in the difference between groups over time (group × time interaction), nor progression of LSTOA or lumbar Cobb angles during the postoperative period. The T-LIV group demonstrated greater forward, right, and left bending flexibility compared to the L-LIV group (P < 0.01). There was no significant change in the difference between groups over time (group × time interaction). Forward flexion did not change over time during the postoperative period; however, both right and left flexion improved over time in the total cohort (P < 0.01). There was no difference in postoperative SRS sub-scores, or total score between groups.

Conclusion

Selection of an LIV of L1 or cranial results in greater postoperative spinal flexibility at the expense of greater residual lumbar coronal deformity; however, the extent of deformity did not worsen over time. Spinal fusion with an LIV of L1 or cranial may be indicated for a larger subset of patients than previously identified.



Longitudinal 5 year outcomes following L1 and cranial vs lumbar spinal fusion.

Podium Presentation Abstracts

58. The Impact of Closed Suction Wound Drain on Immediate and Persistent Pain in Adolescents Undergoing Posterior Spinal Fusion For Idiopathic Scoliosis

Linda Helenius, MD, PhD; Paul Gerdhem, MD, PhD; Matti Ahonen, MD, PhD; Johanna Syvänen, MD, PhD; Ilkka J. Helenius, MD, PhD

Hypothesis
We hypothesized that the postoperative hemoglobin change would be larger and pain scores higher in the group with subfascial drain. We expected no difference between the groups in the incidence of persistent pain at 2-year follow-up.

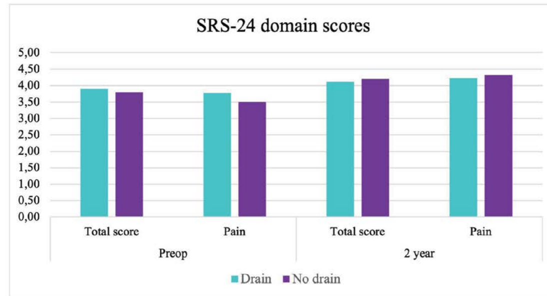
Design
A randomized, multicenter clinical trial on adolescents undergoing pedicle screw instrumentation for idiopathic scoliosis.

Introduction
Closed suction subfascial drain is used worldwide after instrumented posterior spinal fusion for adolescent idiopathic scoliosis. Postoperative drain output has been associated with up to 50% of total blood loss in these patients. However, there are no studies evaluating the effects of postoperative drain on the hemoglobin levels or persistent pain in adolescents undergoing instrumented spinal fusion for idiopathic scoliosis.

Methods
Ninety consecutive adolescents were randomized in drain or no-drain group at the time of wound closure. Exclusion criteria were any coagulation disorder, smoking, vertebral column resection or a need for anteroposterior surgery. Primary outcome was hemoglobin change during first two postoperative days. Secondary outcome was pain and opioid consumption during first 48 h after surgery and incidence of persistent pain at 2-year follow-up.

Results
The total postoperative blood loss was bigger in the group with subfascial drain than in the no-drain group (1004 ± 535 mL vs. 635 ± 547 mL, p< 0.001). The 48-hour postoperative decrease in hemoglobin did not differ between the groups (mean 48-hour decrease: 32 ± 15 g/L vs. 36 ± 15 g/L, p=0.29). The mean ± SD 48-hour opioid consumption was significantly higher in the no-drain group (2.0 ± 0.8 mg/kg vs. 1.5 ± 0.7 mg/kg, p=0.03). At 2-year follow-up the SRS-24 pain domain scores did not differ between the groups (58 patients). The mean pain domain score was 4.28 ± 0.70 in the drain vs. 4.35 ± 0.40 in the no-drain group, p=0.613. Twelve per cent of the patients in the drain group (3 of 25) reported moderate to severe pain (NRS over 4) at 2-year FU compared to 9% (3 of 33) in the no-drain group.

Conclusion
Use of subfascial drain increases total blood loss after spinal fusion but is not associated with decreased postoperative hemoglobin level. Patients treated without subfascial drain required 30% more opioids postoperatively. The incidence of persistent pain at 2-year follow-up did not differ between the groups.



SRS-24 domains

59. Subclassification of Sanders Maturation Stage 3: Differences in Spine and Total Height Velocity Between 3A and 3B in Patients with Idiopathic Scoliosis

Yusuke Hori, MD, PhD; Burak Kaymaz, MD; Luiz Silva, MD; Kenneth J. Rogers, PhD; Petya Yorgova, MS; Irene Li, MS; Peter G. Gabos, MD; Suken A. Shah, MD

Hypothesis
Subclassification of Sanders Maturation Stage (SMS) 3 has a different spine and total height velocity.

Design
Retrospective case-control study

Introduction
Predicting peak height velocity is essential for the management of scoliosis. SMS 3 represents the early phase of rapid adolescent growth and has been subtyped into 3A and 3B. However, there is limited literature available that clearly describes the growth difference between 3A and 3B. Therefore, this study aims to compare the spine and total height velocity between SMS 3A and 3B.

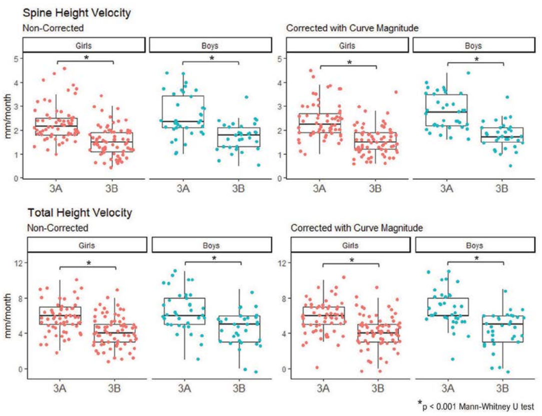
Methods
The current study included consecutive patients with idiopathic scoliosis in SMS 3 at the initial visit from January 2012 to December 2021. T1-S1 spine height, total body height, and curve magnitude were measured at the initial and follow-up visits. In addition to the measured spine and total height velocity calculated per month, corrected height velocity was estimated for curve magnitude using a validated formula. Mann-Whitney U test was used to compare SMS 3A and 3B outcomes, followed by a multiple linear regression model to evaluate the association of the SMS subclass to growth velocity adjusted for confounding factors.

Results
Among 204 patients, 98 (63% female) were classified as SMS 3A, and 106 (69% female) were 3B. At the initial visit, patients in SMS 3A were significantly younger, skeletally immature, and had shorter spine and total body height. Compared to SMS 3B, SMS 3A patients had significantly higher spine growth velocity in both girls (2.3 vs 1.5 mm/month) and boys (2.6 vs 1.7 mm/month), as well as total height velocity in girls (5.8 vs 4.3 mm/month) and boys (6.6 vs 4.5 mm/month) (image). Corrected velocity showed similar results with higher spine and total height velocity in SMS 3A (image). Multivariate analysis indicated a significant association of the SMS

subclass to the spine and total height velocity. No difference in scoliosis curve progression rate was seen between SMS 3A and 3B.

Conclusion

Patients with idiopathic scoliosis and SMS 3A had a significantly higher spine and total height velocity than 3B. Therefore, the subtype classification of SMS 3 into 3A and 3B is critical for managing scoliosis treatment, including observation, bracing, and surgical interventions with fusion and growth modulation.



Boxplot of spine and total height velocity between SMS 3A and 3B

60. Should We Adopt Gradual or Immediate Brace Weaning for AIS? - A Randomized Controlled Trial

Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Prudence Wing Hang Cheung, PhD, BDSc (Hons)

Hypothesis

Gradual brace weaning results in better maintenance of Cobb angle and truncal balance, and superior health-related quality of life (HRQoL) as compared with immediate brace weaning for adolescent idiopathic scoliosis (AIS).

Design

Randomized controlled trial.

Introduction

It is unclear whether reduced hours of brace-wear or immediate brace removal results in better outcomes for AIS. A randomized controlled trial is conducted to compare resultant Cobb angle changes, truncal balance, and HRQoL between gradual and immediate brace weaning protocols.

Methods

AIS patients with full-time underarm bracing and indicated for weaning (Risser ≥4, >2 years post-menarche, and no growth between 2 visits) were randomly allocated into gradual weaning (nocturnal brace-wear for 6 months) and immediate weaning. Primary outcome was major curve Cobb angle and whether there was curve progression (increase >5⁰), static curve (<5⁰ change) or curve regression (reduction >5⁰). Secondary outcomes were truncal balance (trunk shift, C7-CSVL deviation) and HRQoL scores (SRS-22r, EQ-5D-5L). Parameters were studied at post-weaning 6-months, 1-year and 2-year. The effect of weaning protocols on Cobb angle, truncal balance and HRQoL changes whilst controlling for curve type, weaning Cobb and maturity status was evaluated.

Results

369 patients were randomized to immediate (n=193) and gradual (n=176) weaning. There were no intergroup differences in patient demographics at baseline (p>0.05). Adjusted mean difference of Cobb angle changes between gradual and immediate weaning at post-weaning 6-months, 1-year and 2-years were 1.7⁰ (95%CI:0.5-2.9⁰, p=0.006), 1.3⁰ (95%CI:-0.1- 2.6⁰, p=0.064), 0.6⁰ (95%CI:-0.1-2.3⁰, p=0.463) respectively. At 2-years, there were no significant differences between groups for change in truncal shift (2.6 vs 2.4mm, p=0.897) and change in C7-CSVL deviation (2.3 vs 1.7mm, p=0.695). Comparing immediate and gradual weaning, there were minimal differences in SRS-22r total score (0.22 (95%CI:0.15-0.30) vs 0.27 (95%CI:0.18-0.37), p=0.407), EQ-5D utility score (0.016 (95%CI:0.007-0.024) vs 0.023 (95%CI:0.010-0.036), p=0.360) and EQ-VAS (2.1 (95%CI:-0.6-4.7) vs 1.4 (95%CI:-1.2-4.0), p=0.730).

Conclusion

Gradual weaning has no obvious benefits over immediate weaning in terms of post-weaning curve magnitude and truncal balance maintenance, and HRQoL. Standardization of immediate weaning allows for earlier return to normalcy without risks.

61. LncAIS: A Novel and Significant Long Non-coding RNA Identified by Microarray Analysis and Implicated in the Pathogenesis of AIS and Associated Osteopenia

Qianyu Zhuang, MD; Jianguo Zhang, MD

Hypothesis

There are key lncRNAs that regulates osteogenic differentiation of AIS-MSCs, therefore playing a significant role in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.

Design

Microarray approach, bioinformatic analysis and functional experiments

Introduction

The pathogenesis of AIS and the accompanying generalized osteopenia remain unclear. Our previous study (2016 IMAST, Whitecloud Best Basic Research Paper Prize Nomination; 2020 IMAST) suggested increased proliferation ability and decreased osteogenic differentiation ability of BM-MSCs of AIS. However, the underlying mechanism required further research and elucidation.

Methods

Microarray analyses were performed in BM-MSCs derived from 5 healthy donors and 12 AIS patients. Comprehensive bioinformatics analyses were then used to enrich datasets for Gene Ontology and pathway. Among the top downregulated lncRNAs in AIS BM-MSCs, we focused on an uncharacterized lncRNA that we called "lncAIS". Further functional experiments were finally used to explore the regulated mechanism.

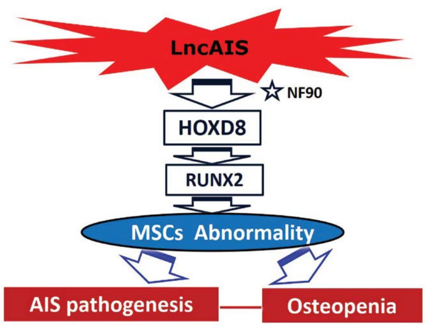
Podium Presentation Abstracts

Results

A total of 1483 lncRNAs were differentially expressed in AIS BM-MSCs versus normal BM-MSCs. Pathway analysis revealed dys-regulated MAPK signaling pathway; PI3K-Akt signaling pathway, and Notch signaling pathway, all of which have been reported to play important role in regulating the osteogenic differentiation of MSCs. Among the top downregulated lncRNAs in AIS BM-MSCs, "lncAIS" (gene symbol: ENST00000453347) was selected. "lncAIS" knockdown/overexpression can suppress/promote in vitro osteogenic differentiation of MSCs and in vivo bone formation. LncAIS-ILF3-HOXD8-RUNX2 pathway was found to be associated with osteogenic differentiation of normal BM-MSCs.

Conclusion

This study reports the differential lncRNAs expression profiles of BM-MSCs from AIS patients and related potential pathways for the first time. We demonstrate that "lncAIS", a significant lncRNA regulates osteogenic differentiation of MSCs from AIS patients, therefore playing a significant role in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.



The illustrate diagram of the regulation mechanism of LncAIS

62. Asymmetry Index Derived from Mobile Device 3D Scanning Accurately Detects Idiopathic Scoliosis: A Pilot Study

Jack B. Michaud, BS; Christopher A. Jin, BS; Yousi A. Oquendo, MSE; Xochitl M. Bryson, BA; Michael Gardner, MD; Kali R. Tileston, MD; John S. Vorhies, MD

Hypothesis

Asymmetry Index, derived from a mobile device-based white light 3D scan, will be well correlated with cobb angle.

Design

Prospective, single-center study

Introduction

Diagnosis and monitoring of adolescent idiopathic scoliosis (AIS) is currently dependent on physical exam and radiographs. Recently, 3D depth sensors have been used to measure asymmetry index, a measure of back surface asymmetry. Previous studies showed strong correlation between Asymmetry index (AI) and cobb angle but relied on floor mounted sensors for 3D scanning. This study investigates an accessible, replicable method of 3D image capture using a mobile device.

Methods

In this pilot study, patients 10 - 18 years old without previous bracing presenting for spinal deformity evaluation with radiographs within 30 days were enrolled. 3D scans were taken in the forward bend position. An automated pose detection application programming interface was used to automatically detect a rectangular region of interest from which to calculate the AI. AI was then compared to manual measurement of cobb angle from radiographs. A univariate logistic regression model was developed using AI to predict the likelihood of cobb angle ≥ 20° and receiver operating characteristic (ROC) curve and subsequent area under the curve (AUC) were calculated using a predicted probability cutoff of 50%.

Results

114 patients were enrolled. 68.4% were female. The median age was 13 (IQR 12-15) with median BMI of 19.2 (17.5-21.4). The median major curve magnitude (MCM) was 20 (14-28), and median AI was 1.76 (1.27 – 2.69). There was no difference in Age or BMI amongst patients with MCM≥20 vs <20. The correlation between AI and MCM was 0.614 (p<.001). The logistic regression model demonstrated a 2.42 (95% CI = 1.54 - 3.81, p-value < 0.001) increase in odds of MCM≥20 for every whole number increase in AI. The AUC was 0.7645 (95% CI: 0.6749 – 0.8541) (Figure 1). Using a predicted probability cutoff of 50%, AI was able to correctly categorize 71.9% of our observations. With this cut-off, the sensitivity and specificity for MCM ≥ 20° were 68.3% and 75.9%, respectively.

Conclusion

Mobile device 3D body scanning can be used to calculate an Asymmetry Index which is strongly correlated with cobb angle and can be used to predict moderate scoliosis (major curve ≥ 20°).

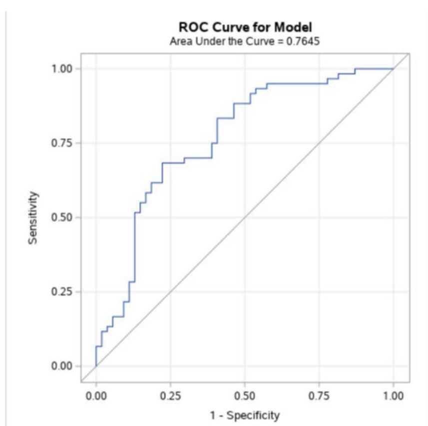


Figure 1: Logistic Regression AUC

Figure 1: Logistic Regression AUC

63. Anterior Vertebral Body Tethering: A Single Center Cohort with 5+ Years of Follow-Up

Dan Hoernschemeyer, MD; Nicole Tweedy, PNP; Melanie Boeyer, PhD

Hypothesis

We hypothesize that: (1) the postoperative success would decrease, (2) the surgical revision and suspected broken tether rate would increase, and (3) additional patients would convert to a Posterior Spinal Fusion (PSF).

Design
Prospective, single center.

Introduction
VBT is recognized as a non-fusion alternative for idiopathic scoliosis in the adolescent patient population. To date, there are several published VBT studies reporting both success and revision rates with no more than two years of follow-up. Little has been published on the clinical outcomes of VBT beyond two years.

Methods
This is a prospective review of our first thirty-one consecutive patients (Hoernschemeyer et al., 2020) with an average follow-up of 5.7±0.7. Radiographic measurements were taken of the proximal thoracic, main thoracic, and thoracolumbar curves, the sagittal profile, and skeletal maturation at latest follow-up. Using the same definition of success (i.e., cobb ≤ 30°; no PSF), we revisited the success rate, revision rate, broken tether rate, and conversion to PSF.

Results
Of our first 31 patients treated with VBT, 29 patients returned for follow-up after publication. At five years, the success rate drops to 65% and the revision rate increases to 28%. Three additional suspected broken tethers were identified for a broken tether rate of 55%. No additional broken tethers were identified beyond four years. 93% of this cohort continues to avoid PSF. We observed an average cobb increase of 4° in the thoracic spine and 8° in the lumbar spine. Statistically significant progression of both the thoracic ($p < 0.001$) and lumbar curves ($p = 0.047$) were seen only in Lenke 1B/1C patients where we tethered only the main thoracic curve.

Conclusion
With more than 5 years of follow-up on our VBT cohort, we observed: (1) a decrease in postoperative success as progression of the deformity was observed in most subgroups, and (2) an increase in the revision and suspected broken tether rate. No additional patients were converted to a PSF. To date, 89% (24 of 27; 2 Lost; 2 PSF) of patients remain less than 40° potentially indicating long-term survivorship.

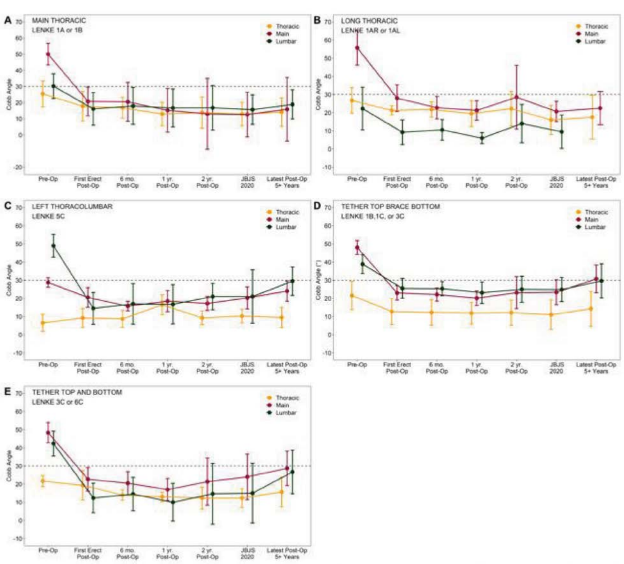


Figure 1. Deformity Measures by Subgroup: represented separately for proximal thoracic (gold), main thoracic (red), and lumbar curves (green).

64. Should the C7-T1 Junction Be Feared? The Effect of a T1 UIV on PJK Risk in AIS Patients at Long-Term Follow-Up

Jaysson T. Brooks, MD; Jennifer M. Bauer, MD; Amit Jain, MD; Firoz Miyanji, MD; Stefan Parent, MD, PhD; Peter O. Newton, MD; Vidyadhar V. Upasani, MD; Patrick J. Cahill, MD; Daniel J. Sucato, MD, MS; Paul D. Sponseller, MD, MBA; Amer F. Samdani, MD; Harms Study Group; Jayden Brennan, BS

Hypothesis
In patients with adolescent idiopathic scoliosis (AIS), a T1 upper instrumented vertebra (UIV) does not result in proximal junctional kyphosis (PJK) at long term follow-up.

Design
A retrospective review of a prospective, multi-center AIS registry.

Introduction
Junctional kyphosis is a complication that spine surgeons try to avoid and may occur most often in patients with preoperative kyphosis. Equipoise remains however, regarding how stopping a fusion proximally at the C7-T1 junction affects the future development of PJK. The purpose of this study was to determine the rate of PJK in patients with AIS who had a UIV of T1 vs those with a UIV of T2 at 5 years of follow-up.

Methods
A query was performed of all patients within the multi-center AIS registry who received a PSF with at least 5 years of follow-up. Patients with a T1 UIV (n=29) were compared to those with a T2 UIV (n=622). Demographics along with preoperative and postoperative radiographic parameters were collected. PJK was defined as a proximal junctional angle (PJA) > 10 degrees . Mann-Whitney U and T-tests were used to compare radiographic parameters and SRS22 scores.

Results
There was no significant difference between T1 and T2 UIV cohorts in mean age, BMI, preoperative T5-T12 kyphosis, UIV anchor, or LIV level. Patients with a T1 UIV had larger preoperative PT curves (43.3° ± 14° vs 36.3° ± 10°; p=0.01) and MT curves (64° ± 13° vs 59° ± 13°, p=0.03), than patients with a T2 UIV. At 5-years of follow-up , there was no significant difference in the PT or MT curve magnitudes or the T5-T12 kyphosis (Table 1). Most importantly, no patients with a T1 UIV experienced PJK at 5 years of follow-up, with 14.1% of patients with a T2 UIV experienced PJK (p=0.02). Fortunately, no patients in the T2 UIV cohort required revision surgeries for their PJK. At 5 years postoperatively, patients with a T1 UIV had a mean PJA of 1.9° (range -12° to 18°)(p=0.07. At 5 years postoperatively their was no change in SRS22 domains.

Conclusion
While T1 is generally an uncommon UIV in AIS compared to T2, at 5 years of follow-up, a T1 UIV in AIS patients did not result in PJK, nor did it result in decreased patient reported outcome scores. If a T1 UIV would benefit the patient, surgeons should feel justified in utilizing this UIV level without fear of poor outcomes at the cervicothoracic junction.

Table 1.

Variable	T2 UIV	N	T1 UIV	N	p-value
Age (years)	14.5 ± 2	622	14.3 ± 2	29	0.24
BMI	21.3 (range: 13 to 39)	556	21.3 (range: 16 to 29)	22	0.87
UIV Anchor					
Screw	57.8%	359	72.4%	21	0.11
Hook	42.2%	262	27.6%	8	
LIV Level					0.06
T8	0.2%	1	3.%	1	
T10	0.2%	1	0	0	
T11	2.7%	17	7%	2	
T12	22%	138	14%	4	
L1	28%	177	45%	13	
L2	26%	162	21%	6	
L3	16%	101	7%	2	
L4	4%	25	3%	1	
5 YR PT Curve	18.8° ± 7°	621	18.9° ± 10°	29	0.67
5 YR MT Curve	20.6° ± 8°	622	22.8° ± 10°	29	0.24
5 YR T5-T12 Kyphosis	19.1° ± 8°	614	17.5° ± 11°	29	0.11
5 YR Proximal Junc. Angle	4° (range: -12° to 18°)	602	1.9° (range: -10° to 7°)	29	0.07
PJK (PJA>10°)					
Yes	14%	85	0%	0	**0.02***
No	86%	517	100%	29	
Variable	**T2 UIV**	**SD ±**	**T1 UIV**	**SD ±**	**p-value**
5 YR SRS22 Pain	4.29	0.74	3.98	0.57	0.19
5 YR SRS22 Self Image	4.38	0.57	4.24	0.63	0.44
5 YR SRS22 Gen. Function	4.49	0.53	4.61	0.48	0.48
5 YR SRS22 Mental	4.15	0.68	4.08	0.60	0.73
5 YR SRS22 Satisfaction	4.58	0.63	4.70	0.42	0.55
5 YR SRS22 Total Score	4.34	0.52	4.25	0.43	0.60

* Indicates statistical significance

65. What is the Incidence and Course of Lumbar Vertebral Body Tethering Breakage?

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Hypothesis
Lumbar VBTs break more often than thoracic VBTs but do not require more revision surgery.

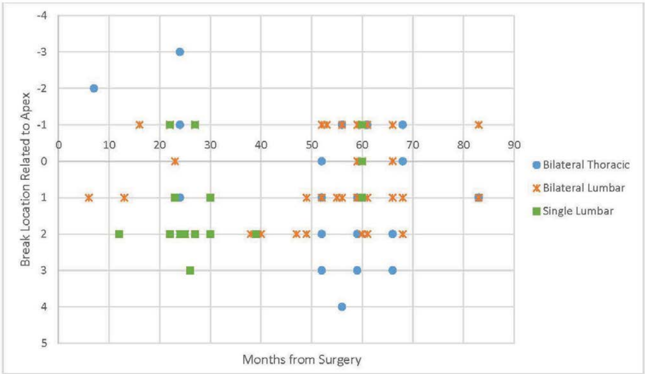
Design
Retrospective single center study

Introduction
With and increasing number of lumbar VBTs being performed, the incidence of lumbar breakage remains unclear. We sought to investigate timing and location of lumbar VBT breakage.

Methods
We retrospectively reviewed all patients undergoing lumbar-only or double (thoracic and contralateral thoracolumbar) VBT with at least 2 years of follow-up. Patients had pre-op, first erect, 6 month, 1 year and annual x-rays thereafter. Any interval increase in coronal curve angle > 5° from the smallest recorded post-op measure to any other post-op interval then underwent segmental interscrew angle (ISA) measurements to confirm breakage (> 5° ISA).

Results
We identified 97 patients with a mean follow-up of 49 months; 73 with bilateral VBT and 24 with lumbar VBT. The mean age was 13 years with a pre-op thoracic curve of 47° and a lumbar curve of 51°. The thoracic curve at last follow-up was 26° and lumbar was 20° (p<0.05). Of the 97 patients, 48 (49%) had an increase in coronal curve > 5° and 36 (37%) had confirmed ISA > 5°. 51 breaks were measured in the 36 patients. In the lumbar spine, 29% of breaks occurred above the apex, 8% at the apex and 63% below. Breaks were identified fairly consistently (5-10 patients/year) each year starting after year 1 with the most (10) at the 4-5 year interval. The mean thoracic curve at diagnosis of break was 26° and 29° at last follow-up. The lumbar curve was 26° at break and 27° at last follow-up. In the 73 double VBTs, 25 (34%) had thoracic coronal curve > 5° and 13 (18%) ISA > 5°. 19 breaks were measured in the 13 patients. In the thoracic spine, 32% of breaks occurred above the apex, 10% at the apex and 58% below. The majority of breaks (10) were identified between years 4-6 at the same visit that associated lumbar breaks were identified as well. The thoracic curve at break was 31° and 32° at last follow-up. Only 4 patients (4%) underwent reoperation; 1 fusion and 3 retethering (1 thoracic and 2 lumbar). When comparing a subgroup of Lenke 5 curves with single VBT (10/23) vs. double VBT (5/15), the break rate was similar (p=0.74).

Conclusion
In our series, 37% of patients had a suspected radiographic break in the tether, but only 4% required further surgery. Most breaks occurred below the apex but the mean coronal curve did not progress significantly by last follow-up.



66. Core Muscle Strengths, Lumbar Flexibility and Quality of Life in AIS Patients Treated with Either Long Fusion or Hybrid Technique Compared to Healthy Individuals

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Hypothesis
Hybrid technique preserves posterior lumbar muscle structure integrity therefore preserve lumbar core muscle strengths (LCMS), lumbar flexibility (LF) and will improve patient outcomes compared with long posterior fusions (LIV L3 or L4) in the surgical treatment of AIS pts with double major curves (DMC)

Design
Prospective study with control group

Introduction
We introduced Hybrid technique including posterior pedicle screw fixation-fusion for thoracic curve and VBT for TL/L curve in order to preserve LF and motion for the surgical treatment of AIS with DMC. Unfortunately there is very limited objective data showing the advantages of TL/L VBT technique over the posterior long fusions. Aim

of this study was to compare the functional results in terms of lumbar core muscle strengths, LF and HRQoL in AIS pts with DMC treated with either with long fusion or hybrid technique, and compare these results with healthy individuals

Methods

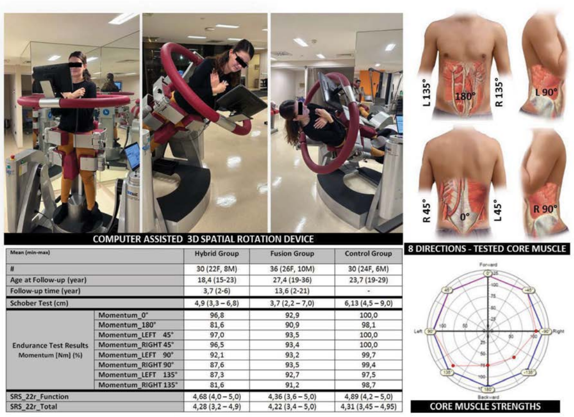
30 pts treated with Hybrid technique (Hyb-Grp) and 36 pts treated with posterior long fusion stopped at L3 or L4(F-Grp) were included. Control group (C-Grp) included age and gender matched 30 healthy individuals. LCMS were evaluated with an endurance test using computer assisted 3D spatial rotation device. Schober test and lumbar ROM measurements was done by two physical therapist. SRS22r scores were used for clinical assessment

Results

Mean f/up was 3.7 yrs in Hyb-Grp and 13.6 yrs in F-Grp. According to Schober test both Hyb-Grp and F-Grp showed decreased flexibility compared to C-Grp ($p<0,05$; U1=179 & U2=28), but F-Grp showed a greater limitation than Hyb-Grp ($p<0.05$; U2=210). In terms of lumbar ROM assessment, Hyb-Grp and C-Grp showed similar ROM values whereas F-Grp showed significant limitation ($p<0.05$). Posterior LCMS were similar in Hyb-Grp and C-Grp ($p>0,05$) but significantly lower in F-Grp ($p<0,05$; U1=201 & U2=369). SRS22r function were significantly higher in Hyb-Grp and C-Grp than F-Grp ($p<0,05$;U1=296 & U2=190). Total SRS22r did not show any difference between groups.

Conclusion

The hybrid technique showed similar lumbar core muscle strengths and lumbar ROM values with healthy individuals. Although the lumbar flexibility of Hyb-Grp was significantly higher than F-Grp, it was lower than C-Grp. SRS22r function was higher and similar in Hyb-Grp and C-Grp, but there was no difference in the total SRS22r between groups.



Mean (min-max)		Hybrid Group	Fusion Group	Control Group
#		30 (22F, 8M)	36 (26F, 10M)	30 (24F, 6M)
Age at Follow-up (year)		18,4 (15-23)	27,4 (19-36)	23,7 (19-29)
Follow-up time (year)		3,7 (2-6)	13,6 (2-21)	-
Schober Test (cm)		4,9 (3,3 – 6,8)	3,7 (2,2 – 7,0)	6,13 (4,5 – 9,0)
Endurance Test Results Momentum [Nm] (%)	Momentum_0°	96,8	92,9	100,0
	Momentum_180°	81,6	90,9	98,1
	Momentum_LEFT 45°	97,0	93,5	100,0
	Momentum_RIGHT 45°	96,5	93,4	100,0
	Momentum_LEFT 90°	92,1	93,2	99,7
	Momentum_RIGHT 90°	87,6	93,5	99,4
	Momentum_LEFT 135°	87,3	92,7	97,5
	Momentum_RIGHT 135°	81,6	91,2	98,7
SRS_22r_Function		4,68 (4,0 – 5,0)	4,36 (3,6 – 5,0)	4,89 (4,2 – 5,0)
SRS_22r_Total		4,28 (3,2 – 4,9)	4,22 (3,4 – 5,0)	4,31 (3,45 – 4,95)

67. Intrathecal Baclofen Pumps Do Not Increase the Risk of Complications in Cerebral Palsy Patients Undergoing Spinal Fusion

Kenneth H. Levy, BS; Burt Yaszay, MD; Suken A. Shah, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; *Paul D. Sponseller, MD, MBA*

Hypothesis

Baclofen pumps increase the risk of complications in CP patients undergoing PSF.

Design

Multicenter Retrospective Cohort Study

Introduction

While intrathecal baclofen pumps (ITBs) help to alleviate spasticity in cerebral palsy (CP) patients, there is concern that their placement may complicate surgical correction of spinal deformity. Previous complication rates reported in the literature have been highly heterogeneous and limited to smaller sample sizes without sufficient follow-up. In this study, we analyze the complication risks associated with ITBs in CP patients undergoing posterior spinal fusion (PSF), utilizing the largest sample size to date.

Methods

A prospectively collected, multicenter database was retrospectively reviewed to identify CP patients undergoing PSF for correction of spinal deformity from 2008-2022, with a minimum follow-up of two years. Patients were divided into two cohorts with and without ITBs implanted. The ITB cohort was also further subgrouped according to whether the ITB was placed prior to the PSF or as a concomitant procedure. Cohorts were then compared in terms of postoperative complications, perioperative complications, and need for revision or reoperation surgery.

Results

A total of 406 patients were included in this analysis: 80 with-ITB and 326 without-ITB. Among the ITB cohort, 54 patients had a prior placement and 26 had their ITB placed concomitantly during their PSF. The average follow-up period among the entire cohort was 3.97 years, ranging from 2 to 10 years. There were no significant differences between the with- and without-ITB cohorts in the rate of perioperative complications, revision surgeries, or any complication type, except for pain which was lower in the with-ITB cohort (Table 1). Further analysis of the ITB cohort similarly revealed no differences whether pumps were placed prior or concomitantly, except for a greater risk of transfusion ($p=0.02$) and pseudoarthrosis ($p=0.04$) complications in the concomitant group.

Conclusion

Although ITBs may make for a more difficult surgery, they do not significantly increase the risk of complications or further reoperation/revision. Furthermore, complication rates are similar regardless of ITBs being placed prior to or during spinal fusion. Despite concerns, ITBs remain an effective treatment option in spastic CP patients.

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	Baclofen Pump (n=80)	No Baclofen Pump (n=326)	P
Total Complications	37 (46.3%)	183 (56.1%)	0.112
Complication Timing			
Early	31 (38.8%)	158 (48.5%)	0.118
Late	14 (17.5%)	65 (19.9%)	0.622
Complication Type			
Surgical Site	14 (17.5%)	51 (15.6%)	0.685
Instrumentation	8 (10.0%)	43 (13.2%)	0.440
Transfusion	2 (2.5%)	2 (0.6%)	0.126
Pulmonary	14 (17.5%)	83 (25.5%)	0.135
Pain	1 (1.3%)	23 (7.1%)	**0.049**
Neurologic	7 (8.8%)	25 (7.7%)	0.748
Medical	14 (17.5%)	59 (18.1%)	0.901
Gastrointestinal	7 (8.8%)	52 (16.3%)	0.090
Pseudoarthrosis	1 (1.3%)	1 (0.3%)	0.280
Death	1 (1.3%)	11 (3.4%)	0.315
SSI			
Deep	4 (5.0%)	28 (8.6%)	0.286
Superficial	2 (2.5%)	6 (1.8%)	0.704
Revision Surgeries	2 (2.5%)	15 (4.6%)	0.400
Reoperations	12 (15.0%)	48 (14.7%)	0.950
Perioperative Complications	4 (5.0%)	21 (6.5%)	0.610

**Categorical variables described as n (%); Continuous variables described as mean (SD)*

Table 1. Outcomes of Full Cohort at Minimum Two-Year Follow-Up

Table 1. Outcomes of Full Cohort at Minimum Two-Year Follow-Up

68. Does the Availability of Baseline Intraoperative Neuromonitoring Data Affect Outcomes in Patients with Cerebral Palsy Undergoing PSF?

Daniel Cherian, MD; Terrence G. Ishmael, MBBS; Alan Stein, MD; Joshua M. Pahys, MD; Steven W. Hwang, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Harms Study Group

Hypothesis

Having baseline IONM data reduces the risk of post-op deficit.

Design

Retrospective review of a prospectively collected multicenter registry

Introduction

Spinal deformity is common in patients with CP. IONM is widely used throughout spine surgery as a means to evaluate the spinal cord. There is a subset of patients with neuromuscular scoliosis that do not have complete baseline data and it is not clear as to how this affects outcomes. Our study sought to evaluate whether the availability of baseline IONM affects outcomes in CP patients undergoing PSF.

Methods

We performed a retrospective review of a prospectively collected multicenter registry of patients with GMFCS 4 and 5 CP undergoing PSF. Baseline characteristics such as demographics, GMFCS level, deformity measures and presence of baseline IONM data were compared. Operative outcomes and perioperative complications were evaluated. Patients had a minimum of 2 years of follow-up. Primary outcomes were presence of new neurological deficit and intraoperative IONM changes. Secondary outcomes were operative duration, EBL, postoperative complications, length of stay and curve correction.

Results

326 patients (23% GMFCS 4 and 77% GMFCS 5) underwent PSF and had IONM attempted. From this cohort, 228 (70%) patients had full (F) baseline IONM obtained, 45 (14%) had partial (P) IONM, and 53 (16%) patients had absent (A) or no obtainable IONM. Group F had smaller curves than groups P and A (80°, 88° and 87°, p<0.05). EBL, LOS and days intubated were lower in group F and higher in group A (p<0.05). Medical complications were higher in group F (p<0.05). Deformity correction was not affected by baseline IONM signals (p > 0.05). In group F, 5% of patients had intraoperative SSEP changes and 11% had tcMEP changes (p>0.05). 2 patients in this group had new immediate post-op neurological deficits, one of which partially recovered. In group P, 9% of patients had SSEP changes and 4% had MEP changes (p>0.05), with no post-op neurological deficits. There were no differences in QOL data at 2 years.

Conclusion

Our study suggests a 13% rate of IONM changes and a 1% new neurologic deficit rate in CP patients undergoing PSF. This implies a substantial rate of neurologic "saves" in this vulnerable population. We feel that it is important to obtain IONM signals when possible in these patients to reduce the risk post-op neurological deficit.

Table 1.

Variables	Total Cohort (n=326)	Full Baseline IONM Obtained (n=228, 70%)	Partial IONM Obtained (n=45, 14%)	No IONM Obtainable (n=53, 16%)
Demographics				
Female	167 (51%)	117 (51%)	21 (46%)	29 (55%)
Male	159 (49%)	111 (49%)	24 (53%)	24 (45%)
Age at Surgery	13.5245 (±2.79742)	13.4474 (±2.79109)	13.3556 (±2.52403)	14 (±3.03822)
GMFCS Level IV	76 (23%)	54 (24%)	12 (27%)	10 (19%)
GMFCS Level V	250 (77%)	174 (76%)	33 (73%)	43 (81%)
Variables	Total Cohort Mean (St. Dv.)	Full Baseline IONM Obtained Mean (St. Dv.)	Partial IONM Obtained Mean (St. Dv.)	No IONM Obtainable Mean (St. Dv.)
Coronal Measure of Major Curve Cobb Angle	82.2 (±24.1)	**79.9 (±22.5)***	88.3 (±25.0)	86.7 (±29.2)
Operation Time (minutes)	409.1(±152.2)	409.4 (±148.1)	436.3 (±162.7)	385.0(±159.4)
Estimated Blood Loss (CCs)	1380.8(±1006.1)	**1260.8 (±876.7)***	1540.1 (±1077.5)	**1755.1 (±1322.0)***
Length of Stay (days)	10.2 (±7.5)	**9.3 (±6.43)***	**12.7 (±10.3)***	**12.3 (±8.7)***
Days Intubated	2.0 (±3.8)	**1.7 (±2.7)***	2.5 (±4.6)	**3.3 (±6.9)***
Intraoperative SSEP Amplitude Change	16 (5%)	12 (5%)	4 (9%)	NA
Intraoperative tcMEP Amplitude Change	26 (8%)	24 (11%)	2 (4%)	NA

Variables	Total Cohort Mean (St. Dv.)	Full Baseline IONM Obtained Mean (St. Dv.)	Partial IONM Obtained Mean (St. Dv.)	No IONM Obtainable Mean (St. Dv.)
2 Year Postoperative Coronal Pelvic Obliquity (% of Correction)	39.1 (±167.1)	36.9 (±182.5)	30.7 (±178.6)	56.2 (±41.0)
2 Year Postoperative Coronal Measure of Major Curve Cobb Angle (% of Correction)	61.3 (±21.2)	60.9 (±21.5)	63.0 (±20.3)	61.4 (±20.9)

* Denotes statistical significance evaluated at $P < 0.05$.

** Denotes statistical significance evaluated at $P < 0.001$.

69. Effects of Conversion from Gastrostomy to Gastrojejunostomy Tube Before Spinal Fusion for Children with Neuromuscular Scoliosis

Candice Legister, BS; Chrystina James, MD; Walter H. Truong, MD, FRCS(C), FAOA; Tenner Guillaume, MD; Danielle Harding, PA-C; Casey Palmer, BS; Sara Morgan, PhD; Eduardo C. Beauchamp, MD; Joseph H. Perra, MD; Daniel J. Miller, MD

Hypothesis

Conversion from gastrostomy tube (G-tube) to gastrojejunostomy tube (GJ-tube) before spinal fusion decreases postoperative pneumonia and gastrointestinal (GI) complications in children with neuromuscular (NM) scoliosis.

Design

Retrospective review

Introduction

Patients with NM scoliosis have high rates of aspiration pneumonia and gastric dysmotility following spinal fusion surgery. At our institution, children with NM scoliosis who use G-tubes are frequently converted to GJ-tubes before spinal fusion in hopes of facilitating enteral feeding in the immediate postoperative period while also aiming to decrease risk of aspiration in the setting of gastroparesis. This study evaluated if preoperative conversion from a G- to a GJ-tube decreased the rate of postoperative pneumonia and GI complications in these children.

Methods
Pediatric patients with NM scoliosis who used a G-tube before spinal fusion were included. Patients were divided into groups based on whether they were converted to a GJ-tube preoperatively. Preoperative characteristics and 30-day outcomes were compared between groups using Chi-square or t-tests.

Results
Of 262 eligible patients, 205 were converted to a GJ-tube while 57 underwent spinal fusion with a G-tube. More patients in the GJ-tube group had a diagnosis of cerebral palsy (74% vs. 58%, p=.03) and a history of GERD (79% vs. 65%, p=.047), and fewer consumed any amount of food/liquids by mouth (55% vs. 72%, p=.03) compared to patients in the G-tube group. Complications following G- to GJ-tube conversion were feeding intolerance (25%), GJ-tube malfunction (18%), and vomiting (17%). Within 30 days of discharge following spinal fusion, 13% of GJ-tube patients and 11% of G-tube patients experienced aspiration pneumonia (p=.82, Table 1). On average, the GJ-tube group received postoperative tube feeds seven hours earlier than the G-tube group (p=.02). One (.4%) patient from the GJ-tube group died of GI complications unrelated to GJ-tube conversion and two (3.5%) patients in the G-tube group died from aspiration pneumonia (p=.12).

Conclusion
Results suggest that preoperative conversion to from G- to GJ-tube may not decrease postoperative pneumonia and GI complications in children with NM scoliosis. Differences in preoperative characteristics indicated that more complex patients were more likely to be converted to a GJ-tube in this study.

	G-tube group (n=57)		GJ-tube group (n=205)		p-value
	n	%	n	%	
Aspiration pneumonia ≤30 days of fusion					0.99
Yes	6	11.3%	25	12.5%	
No	47	88.6%	175	87.5%	
Not noted in chart	4		5		
	Rate	95% CI	Rate	95% CI	
Aspiration pneumonia per 100 patients	11.3	(4.3, 23.0)	12.5	(8.3, 17.9)	0.82[1]
Days from fusion to first tube feeding					<0.001
Postoperative day 1	13	24.0%	63	30.7%	
Postoperative day 2	25	46.2%	109	53.1%	
Postoperative day 3	10	18.5%	25	12.1%	
Postoperative day 4	6	11.1%	8	3.9%	
	Mean	SD	Mean	SD	
Hours from fusion to first tube feeding	51.5	22.2	44.5	18.5	0.02
	n	%	n	%	

Notes. p-values from chi-square tests [or Fisher's exact tests with small Ns] or two-sample t-tests; [1]p-values from generalized linear regression model. Percentages and tests exclude the 'Not noted in chart' responses.

Table 1. Postoperative outcomes

70. Does Tone Affect Outcomes in Cerebral Palsy Patients Undergoing Posterior Spinal Fusion?

Daniel Cherian, MD; Amer F. Samdani, MD; Joshua M. Pahys, MD; Terrence G. Ishmael, MBBS; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Harms Study Group; Steven W. Hwang, MD

Hypothesis
Patients with hypotonic CP obtain greater radiographic correction with less blood loss and operative time than patients with spastic CP.

Design
Retrospective analysis of a prospectively collected multicenter registry

Introduction
Patients with cerebral palsy (CP) are heterogeneous with different types leading to neuromuscular scoliosis (NMS). Our study sought to evaluate whether the type of CP (spastic [SP] vs. ataxic-hypotonic [AH]) affected outcomes in patients who had posterior spinal fusions (PSF).

Methods
We retrospectively queried a multicenter prospectively collected registry from 2008 to 2020 to identify patients with CP and GMFCS grades of IV or V who underwent PSF with at least 2 years of follow-up. Demographic, radiographic, and CPCHILD scores were compared pre-op, post-op, and at 2 years follow-up. Operative variables were also compared.

Results
In total, we identified 390 patients. From this cohort, 309 (79%) patients had spastic CP, 20 (5%) had ataxic-hypotonic CP, 11 (3%) had dystonic CP, and 50 (13%) had mixed CP. When comparing matched SP to AH patients, pre-op demographic and radiographic variables were comparable except SP patients had higher pelvic obliquity (PO) (27.3° vs. 20.2°, p<0.05), while post-op PO (9° vs. 5.6°, p<0.01) was less at 1 and 2 years in the AH group. Other postoperative radiographic variables were not different. While operative time was not different between groups (p>0.05), estimated blood loss (1487±1114mL vs. 905±798mL, p<0.01), post-op pain complications (7.5% vs. 0%, p<0.01), and implant prominence (5% vs. 0%, p<0.01) were higher in the SP group. Broken implants (20% vs. 2%, p<0.005) were higher in the AH group. The reoperation rates were not different between groups (p>0.05). CPCHILD scores were similar at most recent follow-up.

Conclusion
Both groups had similar postoperative improvements in quality of life, level of comfort, overall health, ease of providing care, and most radiographic measures. However, spastic CP patients experienced higher blood loss and implant prominence while ataxic-hypotonic patients had less pelvic obliquity but experienced more broken implants.

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Table. Summary of preoperative and postoperative measurements and complications

	Spastic	SD	Hypotonic	SD	*p- value*
Pre-op Major Coronal Curve (°)	80.02	*17.93*	83.70	*20.03*	*0.45*
Pre-op Kyphosis T2-12 (°)	43.64	*23.28*	34.40	*22.46*	*0.16*
Pre-op Pelvic Obliquity (°)	27.23	*14.09*	20.22	*11.40*	***<0.03***
Pre-op Overall QOL Domain Score	61.00	*23.41*	63.16	*25.35*	*0.73*
Pre-op Total Domain Score	48.32	*14.75*	52.47	*13.03*	*0.26*
2yr Post-op Major Coronal Curve (°)	28.81	*15.40*	25.70	*13.99*	*0.37*
2yr Post-op Kyphosis T2-12 (°)	34.68	*14.67*	28.10	*13.16*	***<0.05***
2nd Post-op Pelvic Obliquity (°)	8.97	*9.18*	5.61	*4.83*	***<0.02***
2yr Overall QOL Domain Score	72.12	*20.74*	65.88	*25.45*	*0.35*
2yr Total Domain Score	56.29	*13.72*	60.06	*10.09*	*0.21*
EBL (mL)	1464.59	*1114.4*	905.00	*798.4*	***<0.01***
Surgical Time (min)	409.20	*160.1*	378.89	*109.8*	*0.29*
Hospital Time (d)	10.64	*9.0*	12.63	*10.8*	*0.46*
Complications (total)	229		21		*0.95*
Death	6 (3%)		1 (5%)		*0.39*
Gastrointestinal	32 (16%)		2 (10%)		*0.44*
Instrumentation	20 (10%)		5 (25%)		***<0.005***
Broken Implants/Implant Failure (Rods/Screws/Connectors)	4 (2%)		4 (20%)		**<0.005**
Prominent Implants	10 (5%)		0		**<0.01**
Loss of Fixation to Bone	6 (3%)		1 (5%)		0.90
Medical	35 (18%)		3 (15%)		*0.75*
Neurological	15 (7.5%)		2 (10%)		*0.52*
Pain	15 (7.5%)		0		***<0.01***
Pseudarthrosis	1 (1%)		0		*0.53*
Pulmonary	51 (26%)		3 (15%)		*0.25*
SSI	33 (17%)		3 (15%)		*0.97*
Reoperation	20 (10%)		2 (10%)		*0.85*
Reoperations due to SSI	19 (10%)		2 (10%)		0.41
Reoperations due to Implants	7 (4%)		0		**0.02**

71. Pelvic Asymmetry in Children with Neuromuscular Scoliosis. 3D Tomographic Analysis

Juan P. Arispe, MD; Mariano A. Noel, MD; Carlos A. Tello, MD, PhD; Lucas Piantoni, MD; Rodrigo G. Remondino, MD; Julian Calcagni, MD; Eduardo Galaretto, MD

Hypothesis
Although the left and right hemipelvises are considered to be symmetrical, in pediatric patients with neuromuscular scoliosis there may be anatomical alterations that can complicate instrumentation.

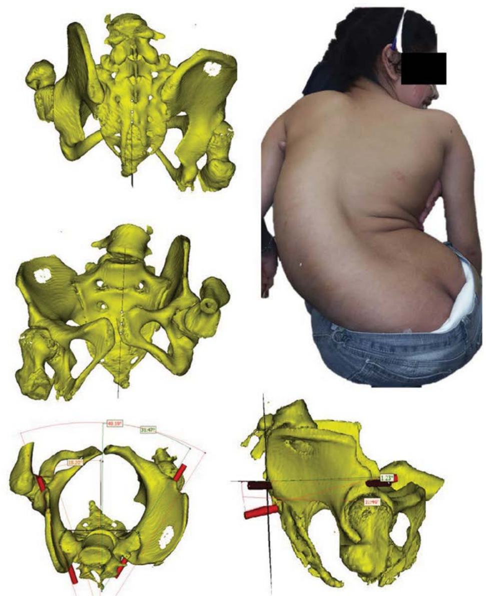
Design
Retrospective, descriptive.

Introduction
In children with neuromuscular scoliosis, fixation of the pelvis is performed when severe pelvic obliquity is present. In some cases instrumentation of the pelvis is technically challenging and associated with a high complication rate, longer operative time, increased exposure to radiation, and increased intraoperative bleeding. The high technical demand of pelvic instrumentation surgery in severe cases led us to develop a tomographic analysis based on 3D images in 53 consecutive neuromuscular patients to better understand the asymmetry and to simulate the instrumentation of the pelvis in the preoperative period.

Methods
3D tomographic analysis of the pelvis was performed in all patients using the Mimics Vs.21 software. Segmentation into all three planes was achieved. Subsequently, simulation of the instrumentation of the pelvis with iliac screws was carried out and the angle value and corresponding screw trajectory were defined in all three planes. A total of 53 CT scans, 48 preoperative and 5 postoperative, were analyzed corresponding to 36 patients with myelodysplasia and 17 with neuromuscular scoliosis.

Results
Pelvic asymmetry was observed in 90% (48 CT scans) of the patients, showing a repetitive characteristic pattern obtained by 3D simulation analysis. The images showed that the hemipelvis on the side with greater weight bearing underwent anatomical changes compared to the contralateral hemipelvis and this asymmetry consisted of a) opening or closure of the pelvis with respect to the sacroiliac joint, b) pivot / rotation of the pelvis with respect to the sacroiliac joint, and c) increased distance between the ischial spine and the coccyx.

Conclusion
In this study, we demonstrate pelvic asymmetry in pediatric patients with neuromuscular scoliosis in 3D images. We identified a particular pattern of asymmetric deformity, which may facilitate the understanding of the anatomy and subsequent surgical instrumentation of the pelvis.



Clinical image of the patient and segmentation of the pelvis, showing the asymmetry of the supporting hemipelvis.

72. Risk Factors for Reoperation for Mechanical Complications after Adult Spinal Deformity Surgery, Minimum 2 Year Follow Up

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Hypothesis
Preoperative radiographic criteria and patient and surgical characteristics may predict risk for reoperation for mechanical complications after adult spinal deformity (ASD) surgery.

Design
Retrospective review of prospectively collected single center database.

Introduction
Complex realignment procedures in ASD surgery are commonly performed for severe or rigid deformities. The relationship between patient and surgical characteristics, and preoperative radiographic

criteria, and mechanical complications is continually evolving. We sought to report the incidence of reoperation for mechanical complications and evaluate predictors.

Methods

Patients undergoing ASD surgery, > 5 levels, coronal Cobb curve > 20°, with fixation to the pelvis, from 2011-2022 were included. Risk factors for mechanical complications, defined as reoperation for proximal junctional failure (PJF), rod fracture, or pseudarthrosis, were assessed.

Results

1037 patients (Age: 46 ± 23; Levels fused 10 ± 4) were assessed (mean follow-up: 37.5 ± 8.1 months). 125 patients (12.1%) sustained a mechanical complication requiring reoperation: pseudarthrosis (42%); rod fracture (32%); PJF (26%). Reoperation occurred 31.9 ± 17.2 months after the index procedure. Patients who sustained a mechanical complication had higher BMI (28.3 vs. 25.1 kg/m2, p<0.001), were older (61 vs 44 years, p<0.001), and more frail (0.7 vs. 0.4, p<0.001). There were no differences in distribution of medical comorbidities. Patients who sustained a mechanical complication had a higher preoperative T1 pelvis angle (TPA) (29° vs. 22°, p=0.01), and greater preoperative lumbar fractional curve (13.1° vs. 11.1°, p=0.04). At early postoperative follow up (1 month), patients who went on to develop a mechanical complication had higher proximal junctional angle (PJA) (14.7° vs. 9.8°, p<0.001), greater pelvic tilt (27.9° vs. 23.4°, p<0.001), greater thoracic kyphosis (44.3° vs. 40.8°, p=0.036), and less lumbar lordosis (40° vs 44°, p=0.006), with equivalent fractional curve correction. Immediate postoperative PJA (OR 1.04, p=0.027), and greater age (OR 1.1, p<0.001) were predictive of mechanical complications at minimum 2 year follow up.

Conclusion

Mechanical complications occur at a rate of 12.1%. Greater thoracic kyphosis, PJA, pelvic tilt, and less lumbar lordosis at early follow up, and older age were associated with mechanical complications at 2 year follow up.

73. Radiographic Outcomes Following Surgical Correction for Lumbar Degenerative Kyphosis: The Impact of Supine Pelvic Tilt

Jae-Koo Lee, MD; Seung-Jae Hyun, MD, PhD; Seung Heon Yang, MD; Ki-Jeong Kim, MD, PhD

Hypothesis

If the targeted correction of pelvic tilt(PT) is optimal, the body is able to compensate within its physiologic range, resulting in decreased mechanical failure(MF).We postulated that supine radiographic measure, specifically supine PT, is the optimal target of correction.

Design

Retrospective cohort study

Introduction

Lumbar degenerative kyphosis (LDK), a flexible deformity, is a common form of sagittal imbalance in Asian countries. To achieve favorable clinical and radiographic outcomes, positional radiographs prior to surgery are becoming increasingly important in determining surgical planning. This study aims to identify radiographic characteristics of supine pelvic tilt (PT) and its relation to mechanical failure (MF) following LDK correction.

Methods

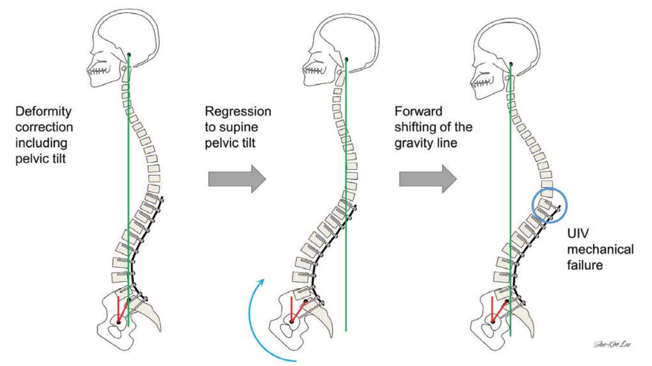
A single-center, single-surgeon retrospective analysis was performed of patients who underwent LDK correction between 2014 and 2019 with sacropelvic fixation. Patients were grouped into pelvic match and mismatch groups according to the difference between postoperative and supine PT. Demographic, surgical, and radiographic parameters were compared. Chronological change of PT was assessed by comparing preoperative, supine, immediate postoperative, and final PT.

Results

Baseline demographics and sagittal alignments were similar between PT match (n = 25) and mismatch (n = 42) groups (p > 0.05). There was a significant difference in the rate of MF between PT match and mismatch groups (4% vs. 31%, p=0.021). Multivariate analysis demonstrated that after including control variables, PT mismatch was independently associated with the likelihood of MF development (OR 68.58, p = 0.021).

Conclusion

Supine PT reflects postoperative PT changes; therefore, supine imaging may represent a tool that could be used for preoperative decision-making in LDK or possibly flexible adult spinal deformity patients. PT mismatch over 10° or under 0° is a significant risk factor for MF following correction of LDK. Measurement of supine PT would aid surgeons in optimal preoperative planning and minimizing catastrophic MF following deformity correction surgery.



A small angular change at the sacrum causes an extensive translation of the upper instrumented vertebra. Overcorrected pelvic tilt (red) returns to its 'natural' state, causing the fusion construct to tilt. The trunk and gravity line (green) shifts forward to maintain optimal balance causing mechanical failure.

Podium Presentation Abstracts

74. Incidence and Risk Factors for Rod Fractures Occurring Greater than Two Years after Adult Spinal Deformity Surgery

Karnmanee Srisanguan, BS; Thomas Errico, MD; Tina Raman, MD

Hypothesis
Patient and surgical risk factors for rod fracture occurring greater than 2 years after ASD surgery are identifiable.

Design
Retrospective review of prospectively collected single center database.

Introduction
Few studies in large single institution patient populations examine long term rod fracture and associated revision rates. We sought to identify the incidence of rod fracture occurring > 2 years postoperatively, and associated risk factors.

Methods
647 patients (Age: 63 ± 11 y; mFI: .64 ± .49; Levels fused: 10 ± 5) with > 5 levels fused, Cobb coronal angle > 30°, and fixation to the pelvis were included between 2008-2022. Outcomes evaluated were the rate of rod fracture, and associated rate of revision surgery.

Results
The rate of unilateral or bilateral rod fractures was 96/647 (14.8%). The rate of rod fractures occurring greater than 2 years postoperatively was 62/647 (9.6%). Of the 62 patients who sustained a rod fracture greater than 2 years postoperatively, 54 (87%) required revision surgery. Mean time to revision for rod fracture was 3.1 ± 2.7 years. Patients who required revision surgery for rod fracture had higher preoperative pelvic tilt (30 ± 10° vs. 23.5 ± 10.1°, p=0.001), less preoperative lumbar lordosis (29 ± 18° vs. 39 ±23°, p=0.008), and greater lumbar fractional curve measurement (14.3 ± 5.6° vs. 11.2 ± 7°, p=0.02). Age > 70 years (OR: 2.2; p=0.028) and 3-column osteotomy (OR: 2.6; p=0.045) were predictive of revision surgery for unilateral or bilateral rod fractures > 2 years after surgery. Three of the 54 patients (5.6%) required a second revision surgery for recurrent rod fracture.

Conclusion
The rate of rod fracture occurring greater than 2 years after ASD surgery is 9.6% with an associated revision rate of 8.3% at a mean of 3.1 years. Risk factors include preoperative alignment, age, and 3 column osteotomy.

75. Examining Malalignment: Persistent Compensatory Mechanisms Versus Normal Alignment in High Pelvic Incidence Patients

Julio Jauregui, MD; Thamrong Lertudomphonwanit, MD; Alekos A. Theologis, MD; Munish C. Gupta, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Michael P. Kelly, MD

Hypothesis
Persistent compensatory mechanisms increase risk of proximal junctional kyphosis (PJK) or pseudarthrosis (PSEUDO)

Design
Retrospective cohort

Introduction
Appropriate alignment is considered critical by many to achieve good outcomes in adult spinal deformity surgeries. The Roussouly classification warns against the "False Type 2" (FT2) profile where patients with high pelvic incidence (PI>55) have high pelvic tilt(PT), low lumbar lordosis(LL), and low thoracic kyphosis(TK<30). The potentially detrimental effects of this alignment is unknown with respect to mechanical failures and poor patient reported outcome measures.

Methods
A single-institution registry (two surgeons) was queried for patients with PI>55. FT2 were defined as high PT (per GAP personalized criteria) and TK < 30. FT2 patients were compared to those with normal PT and TK > 30(Nl). Reoperation for PJK was recorded. Pseudarthrosis was defined as bilateral rod fracture or surgery for confirmed nonunion. Proximal junctional angles (PJA) were measured and classified according to Glattes. SRS-22r domains were compared at baseline and at 2-years after the index surgery. Data were compared using parametric and nonparametric tests as appropriate.

Results
137 patients met inclusion criteria (Nl: 73, FT2: 64). Preoperative PT was higher in FT2 (35.8±10.2 vs 27.9±9.4, p<.001) with larger PI/LL mismatch which persisted after surgery (Nl 2.3±8.9, FT2 25.2±14.6, p<.001). Otherwise, baseline data were not different between groups. Neither baseline nor 2yr SRS-22r scores were different between groups for any domain. (2yr SRS-Pain N: 3.7 (2.9;4.2) FT2 4.0 (3.0;4.6), p=.16). Neither rates of PJK (Nl 6.8%, FT2 4.7%, p=.7) nor PSEUDO (Nl 11.0%, FT2 10.9%, p=1.0) were different. Final PJA were not different (Nl 14.3±8.7, FT2 11.4±12.4, p=.2).

Conclusion
PJK and PSEUDO are multifactorial and affected by more than alignment alone. In this study, patients with persistent compensatory mechanisms had mechanical failure rates not different from "well aligned" patients. Further work is required to determine the relationship between alignment and failure as well as determine unknown factors related to PJK and PSEUDO.

76. Upper Instrumented Vertebral Fracture in Adult Spinal Deformity Surgery can be Reduced by Increasing Occupancy Rate of Pedicle Screw in Vertebral Body over 80%

Shin Oe, MD; Yu Yamato, MD, PhD; Tomohiko Hasegawa, MD, PhD; Go Yoshida, MD, PhD; Tomohiro Banno, MD, PhD; Hideyuki Arima, MD, PhD; Koichiro Ide, MD; Tomohiro Yamada, MD; Yukihiro Matsuyama, MD, PhD

Hypothesis

Occupancy rate of pedicle screw (ORPS) over 80% can reduce upper instrumented vertebral fracture (UIVF) in adult spinal deformity (ASD) surgery.

Design

Retrospective study for patients with ASD surgery

Introduction

In long spinal fusion such as adult spinal deformity surgery, the ratio of the length of the pedicle screw to the anteroposterior diameter of the vertebral body at the upper instrumented vertebra (UIV) is defined as ORPS, and we previously reported from the results of finite element analysis that the stress on the UIV is most reduced when ORPS is greater than 80%. The purpose of this study is to investigate whether UIVF are actually reduced when ORPS is greater than 80% in patients underwent ASD surgery at our institution.

Methods

A total of 297 patients who had undergone ASD surgery since March 2010 and were available for follow-up for at least 2 years were included in the study; those with ORPS 80% were group H. The ORPS was measured from radiographic lateral images taken at the time of surgery. The incidence of UIVF, reoperation rate due to UIVF, and risk factors for UIVF in both groups were assessed.

Results

The mean age was 69 years in both groups: 198 in group L (average ORPS 70%) and 99 in group H (average ORPS 85%). The incidence of UIVF were 60 (30%) in group L and 15 (15%) in group H (P<0.01). The reoperation rate was 18 patients (9.1%) in the L group versus 1 (1%) in the H group (P < 0.01). The incidence of UIVF was NP group: P group = 7 (10%): 8 (26%) (P<0.01). In addition, it was compared the 99 patients in group H whose screws did not perforate the anterior wall of the vertebral body (68 patients in group NP) with those whose screws did (31 patients in group P). The incidence of UIVF was NP group: P group = 7 (10%): 8 (26%) (P=<0.05). Logistic regression analysis of risk factors for UIVF revealed an odds ratio of 3.9 for ORPS <80%, with a 95% confidence interval of 1.4-10.5 and P<0.01.

Conclusion

To reduce UIVF, the screw length should be set with a target ORPS of 80% or higher. On the other hand, if the screw is long enough to penetrate the anterior wall of the vertebral body, it increases the risk of UIVF.

77. Comparison of Disc and Facet Joint Degeneration and Quality of Life in Stopping Fusion at L3 versus L4 in AIS: An MRI Study with Mean 17 (15-21) years Follow-up

Hamisi M. Mraja, MD; Ayhan Mutlu, MD; Onur Levent Ulusoy, MD; Celaleddin Bildik, MD; Baris Peker, MD; Inas M. Daadour, MD; Tunay Sanli, MA; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

Hypothesis

Saving a mobile lumbar motion segment distally (L3 vs L4) will cause a decrease in disc degeneration (DD) and facet joint degeneration (FJD) grade, and will have a positive effect on clinical outcomes in the long term.

Design

Retrospective study.

Introduction

Selection of lowest instrumented vertebra (LIV) is often difficult when lumbar curve was included into the fusion (L3 vs L4). Saving L4 is believed to be beneficial for preserving motion and preventing degeneration of unfused lumbar spine. The aim of the study was to evaluate the DD and FJD of the caudal mobile lumbar spine and assess the clinical outcomes after min 15 years follow up and compare these results with healthy controls.

Methods

AIS patients treated with long posterior fusion (LIV; L3 and L4) having min 15 yrs f/up were included. Preop, postop, and final f/up radiographs were reviewed. All f/up lumbar MRIs were evaluated by two radiologists independently, and classified for each patient in terms of DD according to Phirmann classification and FJD Fujiwara classification. Clinical evaluation was done by using SRS22r and Numerical Rating Scale (NRS).

Results

L3 group included 17 pts (14F,3M) with mean age 31 (26-39). L4 group included 12 pts (8F,4M) with mean age 33 (28-39). Control group included (20F,7M) age and gender-matched healthy individuals with no spinal deformities [mean age 33(26-39)]. Mean f/up was 17.4 (15-21) yrs. Mean correction rates for lumbar curve were 78% in L3 and 79% in L4 group, with no significant correction loss at f/up. In terms of DD of L3 and control groups demonstrated similar and less degeneration rates than L4 group but this difference was not statistically significant. However, FJD was significantly greater in both L3 and L4 groups when compared to the controls. The grade of FJD was significantly higher in L4 than L3 group at the LIV+1 level (x2:8,575;p<0.05). SRS-22r and NRS scores were similar for all groups.

Conclusion

AIS pts who underwent long fusion down to L4 demonstrated higher grades of DD than L3 and control groups but this was not statistically significant. L3 and L4 group showed greater FJD when compared to healthy controls. L4 group showed significantly greater FDJ at LIV+1 than when compared to L3 group. Despite the degenerative findings, clinical outcome scores were similar for all groups at a minimum 15 years follow-up.

Podium Presentation Abstracts

78. The Reunion with my Patients. Their Journey and Experience 30 Years after Their Intervention for Adolescent Idiopathic Scoliosis (AIS) via CD Instrumentation

Francisco Javier S. Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Javier Pizones, MD, PhD

Hypothesis

Patients operated on via CD instrumentation in the 80s have lived with mild limitations

Design

Prospective qualitative cross-sectional study with an interpretative phenomenological approach

Introduction

Our objective was to understand the journey and the current situation of those patients, now adults, operated on for AIS >30 years ago

Methods

Patients operated on for AIS in a single center with CD instrumentation between 1985-1995 were contacted by phone by their original surgeon, and invited to participate. In a first semi-structured personal interview, sociodemographic and clinical data; mobility examination; clinical photographs; and quality of life questionnaires were collected. This paper summarizes this interview using the method of content, semantic and pragmatic analysis of the perioperative and postoperative experience during the years elapsed.

Results

283 patients met the inclusion criteria. We were able to contact 102; 99 agreed to participate. The mean age was 47.5 years, mean follow-up was 30.9 years after surgery. Three fundamental issues stood out: continued distorted perception of their self-image; low back pain in relation to daily activities; and lack of free spinal motion, especially in long arthrodesis. Other secondary traits were: dissatisfaction with the scar and disturbing memories of the brace experience. 65 have had offspring, although their concern, that their children would suffer the same condition, was a direct factor in not having them. One-third were single. 30 reached higher education, 8 were housewives, and most worked in administrative positions. They had limitations for load-bearing work, and 8 were receiving disability benefits. 43 were engaged in continuous physical exercise. A frequent concern was the excess of radiation over the years. 3 had breast cancer under treatment. 7 had undergone late spinal reintervention. Although some expressed doubts about the effectiveness of the treatment received, most were satisfied and appreciated the initiative of the study and the interview with their original surgeon.

Conclusion

The patients operated on during adolescence for scoliosis with CD instrumentation were dissatisfied with: their self-image, low back pain, and stiffness. In spite of this, the great majority were satisfied with the treatment received, which allowed them to lead an integrated life in society.

79. Radiographic Motion Before and After Anterior Vertebral Body Tethering Compared to Posterior Spinal Fusion for Thoracic Scoliosis.

Michelle Claire Marks, PT; Maty Petcharaporn, BS; Tracey P. Bastrom, MA; Firoz Miyanji, MD; Patrick J. Cahill, MD; John (Jack) M. Flynn, MD; Baron S. Lonner, MD; Harms Study Group; Peter O. Newton, MD

Hypothesis

Anterior Vertebral Body Tethering (AVBT) patients will have greater postoperative spinal motion than Posterior Spinal Fusion (PSF) patients.

Design

Prospective, cross-sectional, controlled comparative study

Introduction

The amount of motion preservation with AVBT compared to PSF remains in question. We aim to define radiographic spinal motion and compare changes thereof in AIS patients 2-3 years following both procedures.

Methods

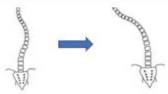
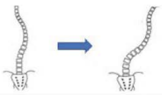
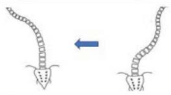
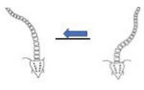
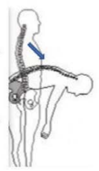
Consecutive patients from 4 sites with major right thoracic AIS who underwent thoracic AVBT (LIV:T11-L1) and presented between 2-3 years post-op were included. Pre-operative upright, and right and left coronal bend films for both cohorts were measured (no forward bend preop). Postop radiographs were acquired in neutral, maximum right, left, and forward bending positions. The AVBT patients were matched 1:1 with patients treated with PSF, for whom similar bending radiographs were captured. Matching criteria included: curve pattern and lowest instrumented vertebra (LIV).

Results

There were 28 patients in each cohort similar in age (AVBT 13± 1, PSF 14 ±2, p=0.09), preop Cobb (AVBT 48±7, PSF 49±6, p=0.5), and LIV(p=0.9). Post operative Cobb was significantly lower in the PSF cohort (AVBT 24±10, PSF 19±7, p=0.02). The loss from pre to post-op in side bending total arc of motion within the instrumented segments was 15° in the AVBT cohort (12° postop) versus 33° in the PSF cohort (2° postop) (p<0.001) (See C). Despite this difference the postop total lateral bending arc of motion from T1-S1 (64°vs63°) and from LIV-S1 (51°vs55°) (E&D) was not different between AVBT or PSF, respectively. Analysis of the forward bending arc of motion at the post-operative time point demonstrated significantly greater flexion in the instrumented region (14°vs4°) (F) as well as globally from T1-S1 (80°vs62°) for the AVBT cohort compared to PSF (p=0.007, p=0.018) (H), but no difference below the LIV (G).

Conclusion

In a cohort of thoracic scoliosis patients, AVBT patients had ~10 degrees greater side bending and flexion within the instrumented segments. Post-op global motion from T1-S1 in forward bending was greater with AVBT, but not in overall side bending. There were no differences in regional motion below the LIV between the approaches. Motion preservation after thoracic AVBT tethering is modest and appears primarily limited to sagittal plane bending.

	PRE to POST-OP CHANGES		AVBT	PSF	p
A	***Instrumented Cobb:*** Left bending – motion from upright to left bend 	Pre-op	-1 ± 6	-9 ± 6	**<0.001**
		Post-op	-4 ± 5	-2 ± 3	0.73
		change	3 ± 7	-7 ± 7	**<0.001**
B	***Instrumented Cobb:*** Right bending – motion from upright to right bend 	Pre-op	27 ± 9	29 ± 9	0.49
		Post-op	8 ± 7	-1 ± 5	**<0.001**
		change	19 ± 12	30 ± 10	**0.004**
C	***Instrumented Cobb:*** Total Lateral bending arc of motion – from right bend to left bend 	Pre-op	27 ± 13	35 ± 11	0.06
		Post-op	12 ± 7	2 ± 2	**<0.001**
		change	15 ± 14	33 ± 12	**<0.001**
	POST-OP MOTION ARC		AVBT	PSF	p
D	***LIV - S1:*** Total Lateral bending arc of motion – from right bend to left bend 	Post-op	51 ± 14	55 ± 14	0.39
E	***T1 - S1:*** Total Lateral bending arc of motion – from right bend to left bend	Post-op	64 ± 21	63 ± 17	0.96
			AVBT	PSF	p
F	***Instrumented Cobb:*** Forward bending - motion from upright to forward bend 	Post-op	14 ± 10	4 ± 3	**0.007**
G	***LIV - S1:*** Forward bending - motion from upright to forward bend	Post-op	57 ± 17	63 ± 12	0.2
H	***T1 - S1:*** Forward bending - motion from upright to forward bend	Post-op	80 ± 19	62 ± 13	**0.018**

Radiographic Motion

80. Natural History of Adult Spinal Deformity: How do Patients with Suboptimal Surgical Outcomes Fare Relative to Non-Operative Counterparts?

Peter G. Passias, MD; Rachel Joujon-Roche, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS

Hypothesis
To compare health-related quality of life(HRQL) metrics of patients with suboptimal surgical outcomes to those undergoing non-operative management, as a proxy for the natural history of ASD.

Design
Retrospective

Introduction
Management of adult spinal deformity (ASD) has increasingly favored operative intervention, however complication rates remain high.

Methods
Retrospective analysis of a single-center ASD database. All patients were offered surgery, but those who declined due to their own preferences, were eligible for inclusion in the non-operative(i.e. natural history [NH]) group. Operative patients with suboptimal outcomes, defined as any reoperation, major complication, or > 2 severe SRS-Schwab modifiers at follow-up, were selected for comparison. Groups were then propensity score matched(PSM) using BL age, deformity, SRS-22 Total, and CCI. ANCOVA and stepwise logistic regressions assessed outcomes between groups at 2 years following surgery, while accounting for confounders as appropriate

Results
441 patients were eligible for inclusion(284 SOp; 86 NH). After PSM, 142 patients remained(SOp: 71; NH: 71). At BL, groups had similar demographics, HRQLs and deformity. At 2-years, NH patients were more deformed by SVA(36.7 vs. 21.3mm,p=.025), PI-LL(11.9 vs. 2.9,p<.001), and PT(23.1° vs. 20.7°,p=.019). Furthermore, SOp patients had 4.5x higher odds of reaching MCID in ODI(OR: 4.463, [1.739, 11.452],p=.002), 3.2x higher odds of reaching MCID in SRS-22-Activity(OR: 3.233, [1.539, 6.790], p=.002), 2.8x higher odds of reaching MCID in SRS-22-Pain(OR: 2.843, [1.373, 5.887],p=.005), and 11.0x higher odds of reaching MCID in SRS-22-Total(OR: 10.982, [3.508, 34.376],p<.001).

Conclusion
Compared to the natural history of ASD, operative patients with sub-optimal outcomes still experience significantly greater improvements in deformity and HRQLs. Such divergent outcomes, highlight the progressive radiographic and functional deterioration associated with the natural history of ASD. The natural history of non-operative management should be accounted for when weighing risk and benefits of operative intervention for ASD.

81. Importance of Self-Image in Adult Spinal Deformity: Results from the Prospective Evaluation of Elderly Deformity Surgery (PEEDS)

Christopher J. Nielsen, MD; Lauren Lewis; Kristen Arnold; Thorsten Jentzsch, MSc; Colby Oitment, MD, FRCS(C)

Hypothesis
Self-image is an important consideration in patients ≥60 years of age undergoing Adult Spinal Deformity (ASD) surgery.

Design
Prospective, multicenter, multi-continental, observational longitudinal cohort study.

Introduction
The importance of self-image on outcome has been well studied in the adolescent idiopathic scoliosis population, but has been considered less important in the adult spinal deformity population. More recently, there has been evidence to suggest that self-image is an important consideration in the ASD population and that specific radiographic parameters correlate to self-image scores. The primary goal of this study is to determine the importance of self-image in ASD surgery and the significance of different coronal and sagittal spinopelvic parameters.

Methods
This study was performed of patients ≥60 years undergoing primary spinal fusion surgery of ≥5 levels for coronal, sagittal or combined deformity with 12 sites participating in this study. SRS-22r was collected prospectively as the main outcome pre-operatively, at 10 weeks, 1 year and 2 years post-operatively. 3' AP and lateral radiographs were taken pre-operatively, then 10 weeks and 2 years post-operatively.

Results
214 patients completed SRS-22r pre-operatively with 179 patients

completing 2-year follow-up. Self-image had the lowest domain baseline SRS-22r score of 2.32 (0.8) and greatest change from baseline at 24 months of 1.29 (1.15; 1.43). Radiographic changes from baseline to 2 years were thoracolumbar cobb angle was 31.9 (1.7; 102.5) to 13.1 (01; 59.7) degrees, sagittal vertical axis (SVA) 91.9 (-76.3; 327.2) to 38.4 (-108.1; 334.1) mm and pelvic tilt 28.9 (8.0; 56.6) to 22.9 (-0.2; 51.5) degrees. At baseline, SVA++ patients had lowest self-image scores 2.06 (0.75). Schwab Type D had greatest 24 month change in self-image of 1.52 (1.03; 2.02), followed by Type N 1.40 (1.17; 1.62) and Type L 1.31 (1.09; 1.52). By modifier, SVA++ had the largest change of 1.62 (1.38; 1.87) followed by PT++ 1.43 (1.19; 1.67), PI-LL++ 1.43 (1.24; 1.63) and coronal balance >4cm 1.38 (1.23; 1.53). Multivariate linear mixed effects modeling found SVA the strongest radiographic predictor of self-image.

Conclusion

This study clearly demonstrates the importance of self-image in ASD surgery in patients ≥60 years of age and identifies SVA as the strongest radiographic predictor for outcome.

82. A Prospective, Observational, Multicenter Study Assessing Functional Improvements After Multilevel Fusion for Adult Spinal Deformity (ASD): 5-Year Follow-Up Results

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Hypothesis

Improvements in specific functions including standing, sitting and walking are sustained in long-term follow-up following ASD surgery

Design

Prospective observational multicenter cohort study

Introduction

Increasing numbers of patients are undergoing surgical treatment for ASD. Multiple patient-reported health-related quality of life (HRQOL) measures are utilized to assess functional status and disability before and after surgery. Some components of these questionnaires may be more pertinent in the elderly population. Our aim were to assess which key functional outcomes were most impacted by multilevel fusion surgery for ASD and whether these improvements were maintained over time.

Methods

Patients ≥60 years of age from 12 international centres undergoing spinal fusion of >5 levels were included. Follow-up visits were assessed at 24 months and 60 months. Function was assessed using the Scoliosis Research Society 22r (SRS22r) function domain, and with the personal care, walking, sitting and standing sections from the Oswestry Disability Index (ODI) and EQ-5D-3L scores.

Results

A total of 219 patients (80.4% females) were included with a mean age of 67.5 years. The mean preoperative SRS-22r function scores were 2.71 (95% CI: 2.61; 2.80) which improved to 3.46 (3.35; 3.57) by 2 years post-surgery and were sustained at 5 years (3.40 [3.27; 3.53]). 44.9% of patients were either bedbound or had primarily no activity before the surgery which reduced to 18.1% at 2 years and 17.1% at 5-year follow-up. Similarly, the percentage of patients that could stand >30 minutes improved from 24.3% to 67.8% at 2 years and was 59.0% at 5 years. 25.7% of patients could walk for a mile or more before surgery, which improved to 62.7% at 2 years and was 57.3% at 5 years. 42.6 % had unlimited sitting pre-operatively, that improved to 65.0% at 2 years and 64.2% at 5 years. Normal social life was seen in 18.8% of patients at baseline compared to 56.0% at 2 years and 50.4% at 5 years.

Conclusion

This study provides quantifiable information regarding practical functional improvements seen in patients ≥60 years of age undergoing multilevel spinal fusions for ASD. Specifically, at 5 years post-op, about 60% of patients can expect to stand more than 30 minutes, walk more than a mile and enjoy unlimited sitting, while 50% can enjoy a normal social life.

83. Hierarchical Evaluation of Mechanically Induced Growth Modulation of the Spine in a Growing Pig Model

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Hypothesis

Mechanically induced asymmetric spine growth engenders intervertebral disc (IVD) distortion followed by physeal inhibition that results in vertebral wedging

Design

Basic Science

Introduction

IVD distortion contributes to early AIS, with subsequent vertebral wedging as deformity progresses. Spine anatomy can be modulated by manipulating the mechanical milieu during growth (Heuter-Volkmann). Using a growing pig model where a posterolateral tether produced a lateral bending moment to induce a progressive scoliosis, we investigated hierarchical tissue remodeling.

Methods

Rapidly-growing 12-wk old Yorkshire pigs (n=3) were instrumented with a subcutaneous CoCr tether spanning the thoracolumbar(TL) and lumbar(L) spine to create a lateral bending moment that incited a progressive scoliosis. Changes to vertebral body(VB) and IVD anatomy over time and space were measured by serial CT and MRI (T1-FLASH, T2-CPMG). After sacrifice @ 22 wks post-op, functional spine units were isolated at the apex of deformity for μCT and histology.

Results

Acute scoliosis (17°) was mediated by IVD wedging. From 6-12 wks deformity was shared between TL(45-38%) and L(41-47%) regions, with IVD(40-46%) and VB(60-54%) wedging contributing to overall scoliosis. By 19 wks, deformity was mainly imparted by VB wedging (Fig 1A). Asymmetric loading modulated tissue structure and function. MRI and histology (Fig 1A,B,D) demonstrate translation of the nucleus pulposus (NP) from concavity (compression) towards convexity (tension). µCT (Fig 1C) and histology (Fig.1I,J) suggest that compression inhibits physeal growth manifest by decreased epiphyseal height @ concavity and presence of bone modeling: 6.4% increase endplate thickness; and 2.4% increase in trabecular number. Cartilaginous endplate(CEP) thickening may reduce tissue diffusivity, leading to IVD degradation as shown by degeneration of annulus fibrosus(AF) by chondroid metaplasia and fibrillation of inner AF rings (Fig 1D-G). Degenerative changes within NP include multifocal loss of notochordal cells(NC) and extracellular matrix with NC necrosis (Fig 1H).

Conclusion

These multi-level, hierarchical data indicate that mechanically induced asymmetric spine growth provokes IVD distortion and degenerative processes; initially by CEP thickening that may reduce endplate diffusivity, followed by compression mediated physeal growth inhibition resulting in progressive vertebral wedging.

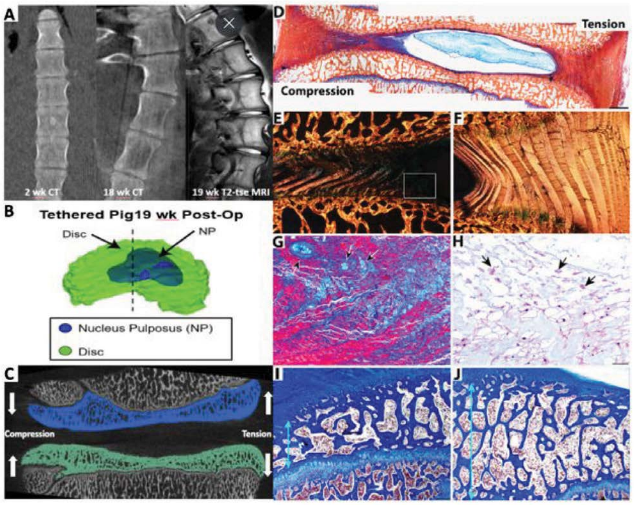

Figure 1.
CT and MRI coronal views demonstrate progressive vertebral body wedging and NP displacement towards convexity **(A)**; highlighted by 3D reconstruction of IVD geometry **(B)**.
IVD at the apex of the deformity T13-14: histology **(D-J)** and µCT **(C)** reveal narrowing of the IVD and narrowing of the endplate epiphysis @ concavity relative to the convexity.
Endplate epiphysis stained with Masson's trichrome shows relative narrowing and bone sclerosis at concavity (compression) **(I, C arrow)** relative to convexity (tension) **(J, C arrow)**.
Non-polarized **(D, G)** and polarized **(E, F)** AB-PSR stained sections of IVD demonstrate asymmetric distortion of AF fiber alignment induced by compression - fibrillation of inner AF rings at concavity and chondroid metaplasia **(G arrows)**. NP displacement from concavity (compression) toward convexity (tension) (J), corresponds to 3D reconstruction **(B)**: H&E stains show necrosis of NC cells **(H arrows)**. H&E-stained sections of the NP reveal cell necrosis **(H, arrows)**.

Figure 1.

84. Core Planar Cell Polarity Genes VANGL1 and VANGL2 in Predisposition to Congenital Scoliosis

Yongyu Ye, MD; Xin Feng, PhD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Terry Jianguo Zhang, MD; Bo Gao, PhD; Nan Wu, MD

Hypothesis

VANGL1 and VANGL2, the two highly conserved core proteins dedicated to PCP signaling, are predisposing to congenital vertebral malformations (CVMs).

Design

Genetic cohort study followed by functional assessments.

Introduction

Impaired somitogenesis leads to CVMs, which clinically manifest as congenital scoliosis (CS), a birth defect that affects 0.5-1 of 1,000 live births. Wnt/ß-catenin signaling is central to somitogenesis, whereas the role of Wnt/PCP signaling in somite development remains unclear.

Methods

First, we evaluated somitogenesis defects and vertebral malformations in Vangl mutant mouse embryos. Second, we analyzed exome sequencing data from multi-center and multi-ethnic CS patients and confirmed their loss-of-function and dominant-negative effects in cellular assays. Further, we addressed the in vivo functional significance of the most deleterious variants in both zebrafish and mouse models.

Results

Here, we show that deletion of two core PCP components, Vangl1 and Vangl2, leads to defective somitogenesis and spinal malformation that mimics the conditions of human CVMs. We identified a number of rare variants of VANGL1 and VANGL2 in CS patients and observed loss-of-function and dominant-negative effects among these variant alleles. The failure of mutant VANGL mRNA to rescue convergent extension defects in zebrafish models confirmed the variants' pathogenicity. Moreover, Vangl1 knock-in (p.R258H) mice exhibited vertebral malformations in a Vangl gene dose- and environment-dependent manner. Removal of one Vangl2 allele or perinatal hypoxia treatment significantly increased the penetrance of CVMs in Vangl1-R258H mice. A Vangl gene-environment interaction model that controls the formation of the axial skeleton was proposed.

Conclusion

Our studies revealed new critical roles for PCP signaling in somitogenesis and predisposition to CVMs in CS patients.

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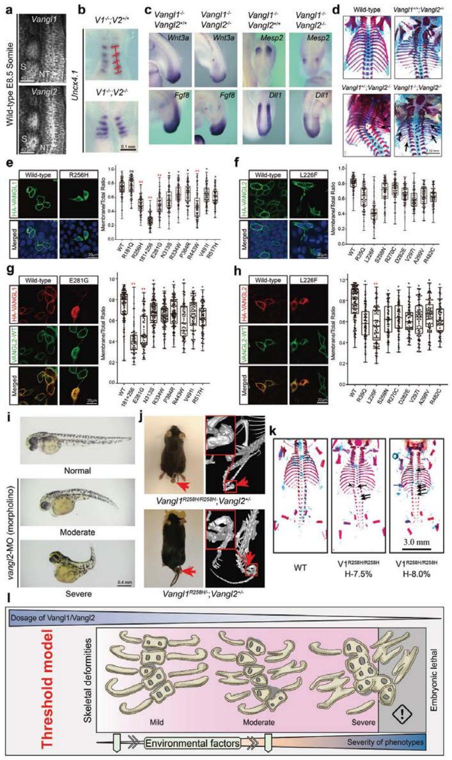

Fig 1. Functional analysis of Vangl mutant. a Vangl expression in the neural tube and somites of E8.5 wildtype embryos. b, c Whole-mount in situ hybridizations of somitogenesis markers at E9.5. d Spinal phenotypes of Vangl mutant mice. e, f, g, h Intracellular localization and co-localization of VANGL proteins. i Illustrations of convergent extension defects in vangl2 morpholino zebrafishs. j Phenotype of the Vangl KI mice. k The penetrance of vertebral defects in Vangl1 KI mice induced by mild hypoxia. l Threshold model of Vangl gene dosage in birth defects.

85. Impaired Glycine Neurotransmission Causes Adolescent Idiopathic Scoliosis

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Hypothesis
The origin of some Adolescent Idiopathic Scoliosis (AIS) is neuropathic. Variants of SLC6A9, which encodes glycine transporter 1 (GLYT1), reduce glycine transportation, impaired glycine neurotransmission, and central pattern generators (CPGs) dysfunction leading to spinal deformity.

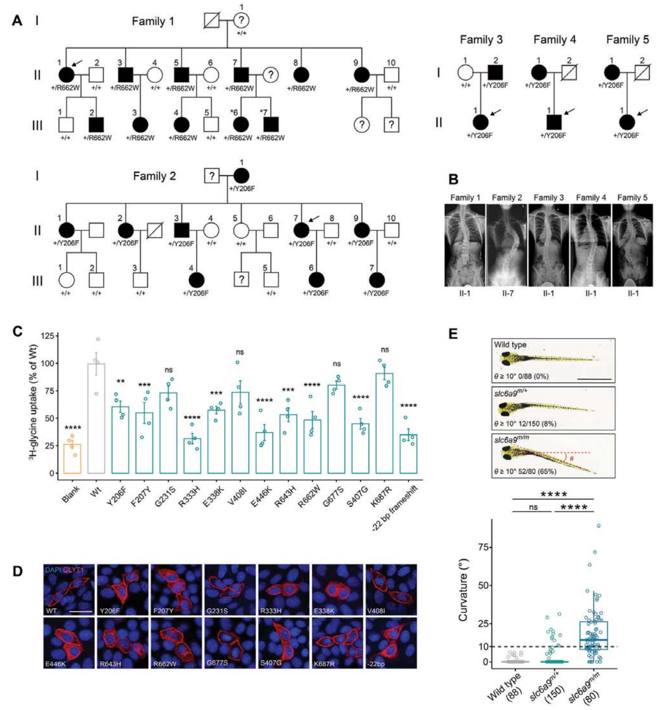
Design
Clinical investigation, genetic analysis, and functional studies.

Introduction
AIS is the most common form of spinal deformity affecting millions of adolescents worldwide, but it lacks a defined theory of etiopathogenesis.

Methods
Five multi-generation AIS families and 843 sporadic cases were identified, and along with 3219 controls, underwent genetic analyses including linkage analysis, genome sequencing, and targeted sequencing to identify pathogenic variants. Paraspinal muscle sEMG tests were performed on familial cases. Additionally, 858 patients from two additional AIS cohorts in China and US were used for validation. After identifying disease-associated variants, cellular mechanisms were studied and zebrafish models were generated to understand the underlying etiology of the spinal curvature and to test candidate treatments.

Results
Disease-causing and predisposing variants of SLC6A9 in multiple families and many sporadic cases were identified via genetic analyses. SLC6A9 variants affected subcellular localization and stability of GLYT1, leading to reduced glycine uptake activity in cells. Slc6a9 mutant zebrafish exhibited discoordination of spinal neural activities and pronounced spinal curvatures which resembles the human patients carrying the SLC6A9 pathogenic variant. Administration of a glycine receptor antagonist or a clinically used glycine neutralizer sodium benzoate partially rescued the phenotype (scoliosis phenotype dropped from 70.2% to 30.3%). Aberrant EMG bursts were found in SLC6A9 pathogenic variants suggesting an impairment of paraspinal muscle balance control.

Conclusion
Genetic variants affecting glycine transportation are strong causal risk factors of AIS. Results from patients and animal models suggest a neuropathic origin for "idiopathic" scoliosis, involving the dysfunction of CPGs, potentially a common cause of AIS. Our work suggests further avenues for early diagnosis and prevention of AIS.



(A) Dominant inherited pedigrees (B) Scoliosis x-rays of family probands (C) Glycine uptake assay for GLYT1 in HEK293T cells (D) GLYT1 Subcellular localization in MDCK cells (E) Spinal curvature of slc6a9 mutant zebrafish at 7 dpf

86. Uncovering the Role of a Genetic Variant in Adolescent Idiopathic Scoliosis: Enhanced UNCX Expression Leads to Axial Deformations in Zebrafish

Yoshiro Yonezawa, MD; Guo Long, MD, PhD; Nao Otomo, MD; Soichiro Yoshino, MD; Kazuki Takeda, MD, PhD; Yoshinao Koike, MD; Mitsuru Yagi, MD, PhD; Chikashi Terao, MD, PhD; Masaya Nakamura, MD, PhD; Morio Matsumoto, MD, PhD; Shiro Ikegawa, MD, PhD; Kota Watanabe, MD, PhD

Hypothesis

A functional variant of UNCX identified by GWAS causes Adolescent Idiopathic Scoliosis (AIS) via axial formation failure.

Design

To investigate the genetic basis of AIS, we focused on UNCX, a gene involved in axial formation and identified by GWAS as a potential susceptibility gene for AIS.

Introduction

A recent genome-wide association study (GWAS) of 79,211 individuals identified 14 new loci associated with AIS, but the biological significance of these loci remains mostly unclear.

Methods

We performed functional analysis of the 7p22.3 locus, which includes UNCX, using a combination of in silico, in vitro, and in vivo approaches. Specifically, we used in silico analysis to narrow down candidate causal variants from the SNPs located within the 7p22.3 locus. Then, we used an electrophoretic mobility shift assay (EMSA) to examine the allelic difference of the candidate SNPs. Next, we used CRISPR-dCas9-KRAB analysis to investigate the gene that the causal SNP actually have enhancer effects. In a reporter assay, we co-expressed the variant and transcription factor, and examined the activity of the UNCX promoter. Finally, we performed an in vivo experiment on zebrafish embryos by injecting UNCX mRNA to match the direction of expression shown in the reporter assay.

Results

We identified a functional SNP rs78148157 that is located in an enhancer of UNCX, a homeobox gene. The risk allele of rs78148157 upregulated the UNCX expression. A transcription factor, early growth response 1 (EGR1), transactivated the rs78148157-located enhancer and showed a higher binding affinity for the risk allele of rs78148157. Furthermore, zebrafish larvae with UNCX mRNA injection developed body curvature and defective neurogenesis in a dose-dependent manner. These results suggest that rs78148157 confers susceptibility to AIS by enhancing the EGR1-regulated UNCX expression.

Conclusion

Our study identifies a functional SNP rs78148157 and the pathological contribution of UNCX to body axis deformity in zebrafish. These findings provide new insights into the genetic basis of AIS and may inform the development of new treatments for the condition.

87. Development of a Hierarchical Approach to Surgical Planning in ACD Surgery

Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Lee A. Tan, MD

Hypothesis

To determine which hierarchical approach to cervical parameter realignment produces better 2-year HRQL metrics and decrease the risk of junctional failure during ACD surgery.

Design

Retrospective cohort

Introduction

Research has been concentrated on cervical deformity realignment thresholds for achieving desired clinical outcomes while decreasing worrisome complications, like distal junctional failure (DJF) and reoperation. This study aims to establish a hierarchical order for realignment of spinopelvic parameters during ACD surgery.

Methods

Included: Operative CD pts with up to 2-year(2Y) HRQL data. Outcome variables: distal junctional kyphosis(DJK) and failure(DJF), reoperation, and Virk et al Good Clinical Outcome: [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]. Optimal Outcome was defined as meeting Good Clinical Outcome without DJF or reoperation. Using conditional inference tree analysis, thresholds were derived based on meeting Optimal Outcome. Patients meeting the best performing threshold in terms of Optimal Outcome were isolated and the threshold derivation was repeated for the remaining parameters. ANCOVA, controlling for age and baseline

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deformity, assessed outcome rates in patients meeting the hierarchical realignment.

Results

133 (61.8±9.9yrs, 27.6±5.8 kg/m2, CCI: 1.0±1.4, CD-FI: 0.4±0.1) were included. After correction, there was a significant difference in meeting Optimal Outcome when correcting C2 Slope below 10° (85% vs. 34%, p<.001), along with lower rates of DJF (7% vs. 42%, p<.001). Next, after isolating patients above the C2 Slope threshold, correction of T1 Slope below 26° demonstrated lower rates of DJK and higher odds of meeting Optimal Outcome (OR: 4.2, p=.011). The best third step was correction of cSVA below 35 mm. This hierarchical approach (11% of cohort) led to significantly lower rates of DJF (0% vs. 15%, p<.007), reoperation (8% vs. 28%, p<.001), and higher rates of meeting Optimal Outcome (93% vs. 36%, p<.001)

Conclusion

Correction of C2 slope should be prioritized during cervical deformity surgery, with subsequent correction of T1 slope and cervical SVA below the derived thresholds. Amongst the numerous radiographic parameters used in cervical deformity, these findings help the surgeon prioritize realignment in certain parameters to achieve successful outcomes

Hierarchical Approach to Cervical Deformity	1) Correct C2 Slope below 10° 2) Then correct T1 Slope below 26° 3) Finally, correct cSVA below 35 mm

Heirarchal Approach to ACD Surgery

88. Are We Getting Better at Treating Adult Cervical Deformity? Complication Rate Trends Analysis in Adult Cervical Deformity Over 10 Years

Jamshaid Mir, MD; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; Claudia Bennett-Caso, BA; Peter Tretiakov, BS; Daniel M. Sciubba, MD; Peter G. Passias, MD

Hypothesis

Rates of complications decreased overtime.

Design

Retrospective cohort

Introduction

Adult cervical deformity patients can have significant impact on quality of life. Realignment surgery has proven to be effective in a select group of these patients, however despite advancements in the field, complications are not uncommon. Evaluation of outcomes overtime can be insightful on aspects that surgeons have been improving on and those that remain to be a nuance.

Methods

Patients with Adult Cervical Deformity with a minimum 2-year follow-up and less than 10 levels fused were included. Patients were stratified into quartiles by date of surgery, with the middle two quartiles being merged to form three categories: Early (E), Middle (M), Recent (R). Descriptive analysis of demographic data, preoperative data, surgical information, and complications was conducted. ANCOVA was used to assess complication rates and PROMs amongst tertiles controlling for age, gender, osteoporosis, CCI, mFI, TS-CL, cSVA, and levels fused. Multivariate analyses were used to assess differences in surgical, radiographic, and clinical outcomes over time.

Results

570 patients were included with enrollment from 2011-2021. Baseline demographics details: Age: 59.6± 12.4, 65% female, BMI 28.6±7.1kg/m2, CCI 0.9±1.3, mFI 2.7±1.7. Age, CCI, and mFI were highest in R cohort. No difference at baseline in Ames modifiers amongst cohorts. Controlled analysis depicted lowest rates of complications in R (E: 62.5%, M: 72.7%, R: 45.5%). Major complication rates decreased from 59.8% in E to 15.0% in last cohort. Rates of DJK decreased from M to R (39.6% to 12.7%, p=.011), with rate of DJF being lowest in R and highest in M (20% in M, 12% in E, 6.7% in R, p=0.046). Reoperation rates decreased from 18.8% in E to 12.4% in R. Neurological complications decreased as well from 38.5% in E to 2.1% in R (p=0.044). Cardiopulmonary complication rates decreased from 24.8% in M to 3.5% in R.

Conclusion

Complication rates significantly decreased over a 10 year period amongst cases, despite having higher age, frailty, comorbidities, mJOA, and no difference in baseline deformity between early and recent cases.

89. Assessing the Synergistic Impacts of Frailty, Sarcopenia, and Osteoporosis on Morbidity and Mortality in the Adult Cervical Deformity Population

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; M. Burhan Janjua, MD; Han Jo Kim, MD; Peter G. Passias, MD

Hypothesis

Frailty, osteoporosis, and sarcopenia may increase morbidity and mortality in CD surgery.

Design

Retrospective

Introduction

Mortality rates in adult cervical deformity (CD) patients remain higher than those with thoracolumbar deformity, especially among patients with notable comorbidities like frailty, sarcopenia, and osteoporosis potentially negatively impacting outcomes. However, these three significant comorbidities have not been assessed in tandem.

Methods

Inclusion criteria were operative ACD patients >18yrs with complete baseline (BL) and 2-year (2Y) radiographic/HRQL data. Two groups were created for initial comparison: those deemed frail (F) or severely frail (SF) by mASD-FI, with concurrent diagnoses of osteoporosis and sarcopenia per Ufuk et al. classification of CT-based calculation of sarcopenia per C3 paravertebral and sternocleidomastoid muscle areas (Sarc+), and those without (Sarc-) via means comparison analysis. Backstep logistic regression analysis assessed risk of mortality while controlling for each of the aforementioned factors individually.

Results

106 patients with adult cervical deformity were assessed (58.3 ± 10.7 years, 57% female, BMI 30.0 ± 7.3 kg/m2, 36% osteoporosis). Overall, 33.7% of the cohort were classified as Sarc+. At baseline, Sarc+ were older (65.33 vs 55.67, p=.041), and had a greater total Charlson Comorbidity Index scores than Sarc- patients (p=.003). Furthermore, Sarc+ patients were significantly more likely to be female (76% vs 53%, p<.001) compared to Sarc- patients. Logistic regression analysis revealed that increased frailty (p=.006) and sarcopenia (p=.043) was associated with higher risk of post-operative mortality within 2Y, though osteoporosis alone was not (p>.05). When utilizing a backstep model, the results showed similar findings, with frailty resulting in 1.3x greater odds and sarcopenia showing 1.1x greater odds of mortality in patients adjusting for age, BMI, and levels fused (p=.010, .045, respectively).

Conclusion

In the present study, we demonstrate that increased frailty and sarcopenia, but not solely osteoporosis, significantly increase the risk of mortality in CD patients. Yet, further studies must be conducted to assess the modifiability of such factors, and whether or not they can be optimized pre-operatively to reduce morbidity and mortality.

90. Analysis of Cost Utility of Distal Junctional Kyphosis Occurrence after Adult Cervical Deformity Surgery: The Benefit of Prophylaxis and Preoperative Optimization

Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Tobi Onafowokan, MBBS; Bassel G. Diebo, MD; Peter G. Passias, MD

Hypothesis

To analyze cost utility of preoperative prophylaxis in the prevention of DJK occurrence after ASD surgery

Design

Retrospective

Introduction

Prior studies have analyzed the predictive presence of distal junctional kyphosis and failure after adult spinal deformity surgery. However, there remains a gap in the cost utility of DJK and prophylactic efficacy in prevention.

Methods

Operative CD patients up to 2Y data included. Preoperative optimization for osteoporosis assessed by treatment with FDA approved drug (OptO). Preoperative rehabilitation (Prehab) assessed. Cost analysis was based on average Medicare reimbursement accounting for surgical approach and revision status. Reimbursement consisted of regression analysis of Medicare pay-scales for services within 30 days, inflation adjusted to 2022. Utility was calculated using EQ-5D as previously published. Multivariate regression noted predictive factors to DJK related to prophylaxis, adjusting for age, baseline deformity, and baseline EQ5D.

Results

136 met inclusion (57.1±9.5yrs, 60%F, BMI 28.6±6.7kg/m2, CCI: .58±1.0). 24 (22%) developed DJK within 2Y, with 6 undergoing revision. Multivariate analysis confirmed Prehab patients more likely to improve in ODI (OR .055 [CI .006-.476], p=.008) at 2Y. However, Prehab and no Prehab exhibited similar ODI rates from BL to 2Y, P<.05. Total cost for Prehab patients was $59,272 compared to $72,878 for not Prehab, P<.05. Cost effectiveness was determined via cost per QALY: Prehab = $14,463 and not Prehab = $45,515, P<.05. For osteoporosis (85.4% Opt), Opt patients had lower odds of 2Y complications (OR: 0.207 [.086, .498],p<.001) and lower cost ($28,053 vs. $33,171,p=.002) compared to non-optimized patients. Average cost of revision due to DJK within 2Y of index surgery was $50,736 ± 31,467, and average cost of index surgery was $44,418. By 2Y, NDI for DJK was (48 vs 37, p=.026) showing a greater improvement in disability for non-DJK. Total cost for DJK patients was $89,259 vs $64,973 compared to those optimized.

Conclusion

The presence of DJK after adult spinal deformity surgery leads to greater surgical cost with lower patient-reported outcomes and greater odds of revision surgery. Although preoperative optimization may increase upfront costs to primary surgery, it presents greater cost utility benefit to prevent the development of DJK and later revision.

91. Lower Hounsfield Units at the Lowest Instrumented Vertebra is an Independent Risk Factor for Distal Junctional Kyphosis After Adult Cervical Deformity Surgery

Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Robert K. Eastlack, MD

Hypothesis

The bone mineral density of the LIV, as assessed by HUs, is prognostic for the risk of DJK after CD surgery

Design

Retrospective

Introduction

The association of hounsfield units (HU) and junctional pathologies has recently emerged as a topic of interest in thoracolumbar deformity surgery. To date, the relationship between hounsfield units and distal junctional kyphosis (DJK) in corrective surgery for cervical deformity (CD) has not been elucidated.

Methods

CD patients up to 2-year(2Y) data were included. HUs were measured at the LIV, LIV+1, and C3 on all preoperative CT scans, averaging the widest region of interest (ROI) ellipse within sub-cortical bone across three axial slices for each vertebra. DJK, defined radiographically as ≥10° between the superior end plate of the LIV and the inferior end plate of the vertebra two below on a standing lateral radiograph. Means comparison test assessed differences in HUs based on occurrence of DJK, and binary logistic regression followed by conditional inference tree machine learning derived HU thresholds based on developing DJK.

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Results

107 CD patients. HU means- LIV: 272±79, LIV+1: 252±71, C3: 388±109. 9 pts (16%) developed DJK by 2Y and 2 pts (4%) developed DJF by 2Y. HUs significantly lower at the LIV for patients who developed DJK (219 vs 286, p=.018). This difference was also seen at the LIV+1 (205 vs. 262, p=.029), however there was no significant difference in DJK development between the higher versus lower HUs groups at C3 (p=.275). Upon CIT analysis, controlling for age, gender, and location of LIV, an LIV of 210 HUs (threshold) was predictive of DJK (OR: 8.2, [1.7-39.4]; p=.008). Conversely, there was no significant difference in the occurrence of DJF below this threshold (15% vs. 3%, p=.102). Patients below this threshold were older, had higher intraoperative blood loss (EBL), a longer operative time, and were more likely to have undergone a combined (anterior + posterior) surgical approach (all p<.05).

Conclusion

Low bone mineral density at the lowest instrumented vertebra, as assessed by a threshold lower than 210 Hounsfield units, may be a crucial risk factor for the development of distal junctional kyphosis after cervical deformity surgery. Preoperative CT scans should routinely be performed in at-risk patients to mitigate this modifiable risk factor.

92. Despite a Multifactorial Etiology, Rates of Distal Junctional Kyphosis after Adult Cervical Deformity Corrective Surgery Can be Dramatically Diminished by Optimizing Age Specific Radiographic Improvement

Peter G. Passias, MD; Oscar Krol, BS; Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Pawel P. Jankowski, MD

Hypothesis

Post-operative radiographic alignment influences the development of DJK in ACD patients.

Design

Retrospective

Introduction

Distal Junctional Kyphosis (DJK) is one of the most common complications in adult cervical deformity (ACD) correction. The utility of radiographic alignment alone in predicting and minimizing DJK occurrence warrants further study.

Methods

ACD patients (≥18 yrs) with complete baseline (BL) and two-year(2Y) radiographic data were included. DJF was defined as DJK greater than 15 (Passias et al.), or DJK with reop. Multivariable logistic regression (MVA) identified 3 month predictors of DJK. Conditional inference tree (CIT) machine learning analysis determined threshold cutoffs. Radiographic predictors were combined in a model to determine predictive value using area under the curve (AUC) methodology. "Match" refers to ideal age-adjusted alignment.

Results

140 cervical deformity patients met inclusion criteria (61.3yrs, 67%F, BMI: 29kg/m2, CCI: 0.96±1.3). Surgically, 51.3% had osteotomies, 47.1% had a posterior approach, 34.5% combined approach, 18.5% anterior approach, with an average 7.6± 3.8 levels fused and EBL of 824 mL. Overall, 33 patients (23.6%) developed DJK, and 11 patients (9%) developed DJF. MVA controlling for age, and baseline deformity, followed by CIT found 3M cSVA <3.7cm (OR: .2, 95% CI:.06-.6), and TK T4-T12 <50 (OR:.17, 95% CI:.05-.5, both p<.05) were significant predictors of a lower likelihood of DJK. Receiver operator curve AUC using age, T1S match, TS-CL match, LL-TK match, cSVA <3.7cm, and T4-T12 <50 predicted DJK with an AUC of .91 for DJK by 2Y, and .88 for DJF by 2Y.

Conclusion

These findings suggest post-operative radiographic alignment is strongly associated with distal junctional kyphosis. When utilizing age-adjusted realignment in addition to newly developed thresholds, a suggested post-operative cSVA target of 3.7cm and thoracic kyphosis less than 50, it is possible to substantially reduce the occurrence of distal junctional kyphosis and distal junctional failure.

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

Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Peter G. Passias, MD; D.Kojo Hamilton, MD, FAANS

Hypothesis

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

Design

Retrospective

Introduction

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

Methods

CD patients with 2-year (2Y) data included. High risk patients in need of SEV defined by increasing baseline deformity and frailty, worsening osteoporosis despite medical optimization, or existing DJK requiring reoperation. Components of SEV: LIV inclination angle above -10°, LIV at or distal to the SSV, LIV greater than 210 HUs. Patients stratify by those meeting SEV and those not meeting SEV. DJK defined radiographically as ≥10° between superior end plate of LIV and inferior end plate of vertebra two below . Means comparison test assessed differences in outcomes based on presence of SEV. SEV patients tested against those fused past thoracic apex (T10). Multivariate regression controlling for age and baseline deformity determined odds ratios for developing DJK by 2Y

Results

120 included (Age: 58.5±10 yrs, 60% Female, BMI: 28.2±6.6 kg/m2, CCI:.93). By two years, 20.6% developed DJK, 6.3% developed DJF. A total of 41 patients met SEV. Meeting SEV had average difference in NDI of 1.19 vs 4.5 for those not meeting SEV (p<.05). No SEV had greater likelihood of DJK (0% vs 40%, p<.05). The

rates of having total complication rates was overall lower for SEV patients (16.7% vs 40%, p<.001). Patients fused past T10 had increasing complications compared to SEV (25% vs 16.7%, p=.045). SEV had 72% less likelihood of DJK within 2Y (OR: .28 p<.05), 97% less likely to develop DJF (OR .03, p=.018). SEV patients were 98% less likely to undergo reoperation within 2 years (OR: .016 p<.001). Importantly, those fused past T10 had 2x higher chances of DJK occurrence (OR 2.43 p<.05) and 23% more likely for reoperation compared to SEV patients (OR 1.23 p=.022)

Conclusion

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

94. Optimizing Mental Health Conditions Prior to Adult Spinal Deformity Surgery: Does Preoperative Optimization Improve Surgical Outcomes?

Pooja Dave, BS; Peter Tretiakov, BS; Jamshaid Mir, MD; Dean Chou, MD; Peter G. Passias, MD; Justin S. Smith, MD, PhD

Hypothesis

To determine the long-term effectiveness of brief psychological intervention on psychological outcomes in cervical spine surgery.

Design

retrospective

Introduction

Cognitive behavioral therapy (CBT) works through education about pain, modification of maladaptive beliefs, and increasing patient's self-efficacy. More studies are needed to address its impact on adult spinal deformity correction.

Methods

Adult patients with symptomatic disease included. Active major depression excluded. 4 validated self-report instruments: Distress and Risk Assessment Method (DRAM), Fear-Avoidance Beliefs Questionnaire (FABQ), Pain Catastrophizing Scale (PCS), Outcome Expectation question (OEQ). Patients randomized using matched pairs: Sham (placebo group receiving six sham treatments); CBT (treatment by licensed professional). Surveys administered at enrollment. Thresholds set >17 DRAM, >49/66 FABQ, >30/52 PCS. Subjects who did not meet cutoff were assigned into control group. Those above thresholds either Sham or CBT by 1:1 randomization. Any who exceeded distress criteria assigned to DRAM observation only. Logistic regressions analyzed if disability was independent predictor of psychological burden at baseline, as well as improvements to 2 year surgical outcomes.

Results

48 patients enrolled (53.6yrs±10.7yrs, 49% female, 29.6±5.9kg/m2) 57.1% severe FABQ score, 40.8% severe PCS score, 27.7% severe NDI score. 17 (35.4%) CBT, 12 (25.0%) Sham, 10 (20.8%) Control, 9 (18.8%) DRAM. 33 (68.8%) completed 2Y follow-up. Greatest patients improved to 2Y within the CBT group by NRS Back (63% vs. 38%, p=0.014). Compared to CBT, those without intervention in the DRAM and Control groups had greater levels of distress measured by FABQ (44 vs 14.3, p<.001). Without intervention had higher odds of reoperation (50% vs. 28%, OR:1.23, p=0.03), DJK (69% vs. 45%, OR 1.44, p=0.012). Those optimized with CBT had comparatively lower NDI and lower EQ5D Pain at baseline (p<.05). Patients in CBT trended toward a higher rate of improvement in PCS (56% vs. 41%, p=0.058), VAS (63% vs. 38%, p=0.064), and NRS Back (56% vs. 38%, p=0.13)

Conclusion

We found clear trends in our cohort of operative cervical spine patients with improved psychological and functional outcomes after preoperative CBT intervention. Thus, access to appropriate mental health practitioners are an important part of preoperative surgical planning process.

95. 20-year Clinical Outcomes of Cervical Disc Arthroplasty vs ACDF: A Prospective, Randomized, Controlled Trial

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Hypothesis

Compared to ACDF, CDA has improved clinical outcomes at 20-year follow up

Design

A prospective, randomized, single-center, clinical trial.

Introduction

Anterior cervical discectomy and fusion (ACDF) has long been the standard of treatment for degenerative cervical disc disease. Complications including loss of index level motion and adjacent level disease prompted development of cervical disc arthroplasty (CDA). Prior literature demonstrates noninferiority of CDA and suggests its superiority with longer term follow up.

Methods

47 patients with single level cervical radiculopathy or myelopathy were randomized 1:1 to either BRYAN CDA or ACDF as part of an FDA IDE trial. At 20 years, one patient was deceased and 46 patients from a single center were eligible for analysis. Patient reported outcomes including visual analog scales (VAS) for neck and arm pain, neck disability index (NDI), and reoperation rates were statistically analyzed.

Results

At 20 years, VAS neck and arm pain scores, and reoperation data were available for 21/25 patients in the ACDF group (84%) and 17/21 patients in the CDA group (81%). The ACDF group had significantly worse VAS arm pain scores vs the CDA group (2.48 vs 0.67 respectively, p=0.036). VAS neck pain scores were not significantly different for ACDF vs CDA (2.73 vs 0.98 respectively, p=0.068, power=0.448). NDI scores were available for 18/25 (72%) ACDF patients and 16/21 (76.2%) CDA patients. There was no difference in NDI scores between ACDF vs CDA (19.00 vs 9.25 respectively, p=0.053, power=0.497). At 20 years, both treatments demonstrated significant improvement compared to preoperative NDI, VAS arm, and VAS neck scores (p<0.001 for all measures). Reoperation data was available for 24/25 (96.00%)

ACDF patients and 18/21 (85.71%) CDA. Reoperations occurred in 10/24 (41.67%) ACDF patients and 2/18 (11.11%) CDA patients (p=0.03). One ACDF patient had an index level reoperation, which was a posterior cervical fusion. No index level reoperations were performed in the CDA group at 20 years. Of the two CDA reoperations, one was at an adjacent level to the index site. 7/10 (70%) ACDF patients who had a reoperation, had it at an adjacent level.

Conclusion
CDA patients demonstrated significantly improved arm pain scores and less reoperations than ACDF at 20 years. There were no failures of the arthroplasty device requiring reoperation at the index level.

96. A Parameter Fixed to Poor Outcomes? A Detailed Analysis of High Pelvic Incidence in Adult Spinal Deformity Surgery

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Hypothesis
Patients with high pelvic incidence have increased risk for complications and poor radiographic outcomes following ASD surgery.

Design
Retrospective cohort study of a single-center ASD database

Introduction
Pelvic incidence (PI) serves as the cornerstone for many deformity classifications and realignment schema to create individualized realignment targets. Yet, previous literature has linked high PI to problematic outcomes following corrective surgery, including mechanical complications and hip pathologies.

Methods
ASD patients with 2-year(2Y) data were stratified into two Groups: PI >65° (HiPI) versus PI < 65° (NormPI). Means comparison tests assessed differences in demographics, surgical details, and outcomes between groups. Multivariable analysis controlling for baseline age and frailty analyzed complication rates and radiographic alignment between the cohorts. Groups were propensity score-matched (PSM) for frailty, history of prior fusion, BL PI-LL, and surgical invasiveness.

Results
445 ASD patients, with 94 patients defined as HiPI. HiPI were more likely to present with lower physical functioning scores, severe pelvic compensation (OR: 5.5, [3.4-8.9]) and global deformity (OR: 3.5, [2.2-5.6]). HiPI underwent more 3COs (OR: 1.8,[1.1-3.1]) and fusion to pelvis (OR: 2.1,[1.1-3.9]). Adjusted analysis revealed HiPI was more likely to be undercorrected in each age-adjusted parameter compared to NormPI (OR: 4.8, [2.9-7.8]). HiPI were less likely to deteriorate within in-construct PI-based alignment (OR: 0.3,[0.1-0.9]). HiPI was more likely to deteriorate in PI-based global alignment and pelvic compensation within two years (OR: 3.2, [1.6-6.5]). This translated to a higher likelihood of developing a major or mechanical complication by 2Y (OR: 1.6, [1.04-2.6]). After PSM, HiPI were still more likely to deteriorate in PI-based alignment [OR: 1.8,[1.02-5.5]), but were no longer more likely to experience a mechanical or major complication.

Conclusion
High pelvic incidence is associated with increased frailty, decreased physical functioning, and more severe lumbopelvic and global deformity upon presentation for adult spinal deformity correction. Especially when presenting for a revision, these patients are more often undercorrected by age-adjusted standards and deteriorate in out-of-construct alignment over time even when adequately corrected, leading to higher mechanical complications by 2 years.

97. Pseudarthrosis and Instrumentation Failure at the Pedicle Subtraction Osteotomy Site: Is a Multiple Rod Construct Necessary?

Karnmanee Srisanguan, BS; Tina Raman, MD

Hypothesis
The use of multiple rods spanning the pedicle subtraction osteotomy site may lower the rate of subtraction osteotomy (PSO) site failure.

Design
Retrospective review of prospectively collected single center database.

Introduction
PSO procedure in adult spinal deformity (ASD) surgery is commonly performed for severe or rigid deformities. We sought to report the impact of multiple rods spanning the PSO level on the incidence of PSO site failure, defined as pseudarthrosis or rod fracture at the PSO site based on postoperative CT scan.

Methods
Demographics, surgical variables, and radiographs for ASD patients undergoing PSO at L2 or below, > 7 levels fused, with fixation to the pelvis between 2011-2021 were analyzed. The impact of multiple rod constructs on the rate of pseudarthrosis and rod fracture at minimum 2 year follow up was assessed.

Results
117 patients (Age: 59 ± 14; Levels fused 11.7 ± 4.5) who underwent 3CO were included. Of the 117 patients, 57 (48.7%) had multiple rods spanning the PSO site including the cephalad and caudal level and 60 (51.3%) had a dual rod construct. There was no difference in age, BMI, frailty, or surgical invasiveness between the two groups. Rod material distribution was 93.8% cobalt chrome, 6.2% titanium; rod diameter was 93.8% 5.5 mm and 6.2% 6.0 mm. The average follow-up time was 44.7 ± 20.1 months. PSO site failure occurred in 40/117 patients (34%) with rod fracture at the PSO level occurring in 7/40 of the cases. The incidence of revision surgery due to PSO site failure was 24.8% at minimum 2 year follow up. There was no significant difference in rate of PSO site failure or rate of revision at two year follow-up in multiple rod versus dual rod construct groups.

Conclusion
In this study, the rate of PSO site failure was 34%, with associated revision rate of 24.8%.The use of multiple rods spanning the PSO site

was not associated with a significantly lower rate of PSO site failure or revision rate for this problem.

98. A Machine-Learned Quantitative Classification of Asymptomatic Adult Spinal Sagittal Curvature: Comparison to Roussouly Types

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Hypothesis
Roussouly's sagittal curve patterns in adult asymptomatic population can be detected using a machine learned algorithm

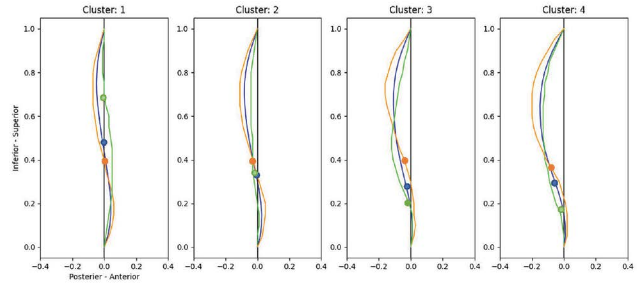
Design
retrospective

Introduction
Roussouly identified sagittal spinal alignment types in adults with a goal to guide identifying patient-specific target sagittal alignment and reduce the risk of mechanical complication after spinal surgery. We aimed to show whether variation in sagittal curve types can be identified using machine learning and how such curve types relate to Roussouly's types (RT).

Methods
A total of 431 asymptomatic volunteers 18 to 80 years old were included from a multi-ethnic cohort. Biplanar spine images were used to generate 3D reconstructions and calculate radiographic variables and the vertebral centroids. For each patient, the line connecting the T1 and L5 centroids was rotated in a way that was aligned with the true vertical line, parallel to gravity line from T1. An unsupervised clustering method classified the isotopically normalized, rotated spinal splines. The spline with the largest Euclidean distance determined the boundaries for each cluster. Clinical variables were statistically compared. The accordance between the cluster types and RT was determined using the number of true positive classifications in a confusion matrix.

Results
The cluster distributions, cluster centerlines and the boundaries associated with each cluster are shown in Figure 1. Radiographic variables were significantly different between the clusters, $p<0.05$. Cluster one was presented with the most cranial inflection point and longest lordotic section, whereas cluster 4 showed the most caudal inflection point and the longest kyphotic spine among the 4 clusters. The agreement between the automated clustering and RT was 0.77 with 82% RT 1 in Cluster 4, 69% RT 2 in cluster 3, 67% RT 3 in cluster 2, and 78% RT 4 in cluster 1.

Conclusion
We developed an automated approach for quantitative classification of the sagittal spinal alignment in an asymptomatic adult population. The relationship between pelvic and spinal parameters varied significantly between clusters and closely matched Roussouly's sagittal curve types.



The centerline and boundaries of each cluster (cases with most different sagittal curvature in each cluster) for cluster 1 to 4. The inflection point of sagittal curve is shown (Blue: centerline, Green: lower boundary, Orange: upper boundary).

99. 5-Year Outcomes of Prospective Evaluation of Elderly Deformity Surgery: A Multicenter International Study on Patients over 60 Years of Age

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Hypothesis
Older patients can have long-term benefit from multilevel fusions in the setting of adult spinal deformity

Design
Prospective observational multicenter international cohort

Introduction
The rate of multilevel fusion surgery for spinal deformity is increasing internationally. Understanding the short- and long-term outcomes and results in patient-reported health-related quality of life is important to determine the appropriateness of multilevel fusion in older adults with spinal deformity

Methods
Patients ≥60 years undergoing ≥5 levels of spinal fusion from 12 international centers were prospectively enrolled and followed at 10 weeks, 1 year, 2 years, and 5 years. Indications for surgery and surgical procedures performed were at the discretion of the treating surgeon. Patient-reported outcomes were analyzed using unadjusted mixed effects regression models. A dedicated contract research organization was hired to facilitate data collection and follow-up.

Results
219 patients of 255 enrolled met the inclusion and exclusion criteria for this study. 80.4% of patients were female with a mean age of 67.5 (60.0-83.0) years at time of index surgery. 97 (44.3%) patients were treated in North America, 86 (39.6%) in Asia, and 36 (16.4%) in Europe. 179 (81.7%%) patients completed 2-year and 118 (53.9%) completed 5-year follow-up. Comparing baseline to 2-years and 5-years, patients showed significant improvements

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in unadjusted least square means of SRS-22r (2.79 vs 3.70 vs 3.65), ODI (46.3% vs 26.9% vs 28.5%), NRS back (6.1 vs 2.7 vs 2.9), NRS leg (4.3 vs 2.3 vs 2.6), and EQ-5D (0.53 vs 0.74 vs 0.74). There were 307 recorded adverse events (AE) of which 40 occurred between 2 and 5 years. Twenty of the AEs occurring between 2 and 5 years were implant related, of which 10 were revised. There were two peri-operative deaths, and 3 patients died of unrelated causes prior to the 2-year follow-up. 3 further deaths were recorded between 2 and 5 years.

Conclusion

Greater than 50% 5 year follow up was obtained in this international prospective multicenter series of older patients, demonstrating significant benefit in multiple general and spine-specific patient-reported outcome scores at all time points following multilevel spinal fusions. This series highlights the durability of the results between 2 and 5 years with mechanical failures as the most prevalent late adverse event.

	Pre-op N=219	10 Weeks N=210	1 Year N=188	2 Years N=179	5 Years N=118
SRS – 22r Total#	2.79	3.21	3.69**	3.70**	3.65**
SRS – 22r Sub-Total#	2.72	3.12	3.65**	3.66**	3.62**
SRS – 22r Function#	2.71	2.66	3.44**	3.46**	3.40**
SRS – 22r Pain#	2.68	2.94	3.69**	3.73**	3.72**
SRS – 22r Self-Image#	2.32	3.47**	3.66**	3.61**	3.52**
SRS – 22r Mental Health#	3.18	3.36	3.81*	3.83*	3.80**
SRS – 22r Satisfaction#	3.10	4.02**	4.02**	4.08**	3.96**
Oswestry Disability Index	46.3	41.1**	28.1**	26.9**	28.5**
Numeric Rating Scale Back	6.1	3.5**	2.8**	2.7**	2.9**
Numeric Rating Scale Leg	4.3	2.4**	2.1**	2.3**	2.6**
EQ-5D Index	0.53	0.65**	0.75**	0.74**	0.74**
EQ-5D Visual Analog Score	55.7	65.8**	72.9**	70.1**	68.6**

EQ-5D: European Quality of Life 5 dimensions, SRS 22r: Scoliosis Research Society 22 revised outcome questionnaire
- $P < 0.05$ for change to pre-op; ** $P < 0.001$ for change to pre-op;
- # > 0.5 improvement in score compared to baseline at final follow-up

100. Urinary N-Telopeptide is Associated with Rod Fracture after Corrective Adult Spinal Deformity Surgery

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Hypothesis

We hypothesized that preoperative Urinary N-telopeptide (UNTX) is associated with rod fracture after corrective adult spinal deformity (ASD) surgery

Design

Retrospective Case Control

Introduction

Rod fracture following corrective surgery for ASD can result in in pain and loss of deformity correction. UNTX is an established marker of bone turnover. Low UNTX has been associated with pseudarthrosis in prior studies and may predict risk for rod fracture following corrective ASD surgery.

Methods

Adult patients who underwent ASD surgery by a single surgeon from 2015 to 2021 were identified. Corrective ASD surgery was identified based on radiographic criteria. Cases with ≥4 level fusions to the pelvis were included. All patients had at least 2 years of follow-up unless rod fracture occurred within 2 years of index surgery. UNTX was prospectively collected prior to index surgery. Potential patient demographic, comorbidity, surgical, complication, and radiographic confounders were analyzed. A multivariate model with UNTX stratified into ranges of 10 (i.e. value of 0-9=0, 10-19=1, 20-29=2) and potential confounders was created.

Results

A total of 155 patients were included in the study. There were 21 rod fractures (13.5%), of which 13 cases were revised (62%). On univariate analysis, the UNTX for rod fracture cases was 29.0±14.0, compared to 41.8±28.6 for non-rod fracture patients (p=0.002). There was no difference in UNTX based on primary (39.0±28.2) or revision fusions (41.9±26.2) (p=0.525). On analysis of potential confounders, the rod fracture cohort had more male patients, higher BMI, more diabetics, and higher incidence of high post-correction T1 pelvic angle (table 1). On multivariate analysis, lower preoperative UNTX was independently predictive of rod fracture (adjusted odds ratio 0.587, 95% confidence interval: 0.366-0.940, p=0.027).

Conclusion

Preoperative UNTX was lower in patients who developed rod fractures after corrective ASD surgery. These results suggest that UNTX can identify patients at risk for rod fracture and may guide intraoperative treatment strategies.

Table 1. Univariate Analysis of Potential Confounders

		No Rod Fracture	Rod Fracture	P-value
Demographic				
Age (years)		66.2±8.5	63.9±7.8	0.236
Gender	Male	32 (24%)	11 (52%)	0.007*
	Female	102 (76%)	10 (48%)	
Body Mass Index		27.3±5.3	30.5±6.2	0.012*
Comorbidities				
Current Smoker		6 (5%)	0 (0%)	>0.999
Diabetes		5 (4%)	4 (19%)	0.020*
Chronic Renal Disease		1 (1%)	0 (0%)	>0.999
Depression		7 (5%)	2 (10%)	0.351
Osteoporosis		24 (18%)	4 (19%)	>0.999
Parkinsons		3 (2%)	1 (5%)	0.445
Autoimmune Disease		8 (6%)	1 (5%)	>0.999
Surgical Details				
Primary		88 (66%)	11 (52%)	0.238
Revision		46 (34%)	10 (48%)	
ASA Class	I	1 (0.8%)	0 (0%)	0.919
	II	90 (70%)	15 (71%)	
	III	37 (29%)	6 (29%)	
Operative Time (minutes)		298±90	313±84	0.492
Number of Levels		8.5±3.5	9.7±4.5	0.161
Estimated Blood Loss (cc)		1341±864	1443±953	0.628
TLIF		40 (30%)	6 (29%)	>0.999
PSO or VCR		26 (19%)	4 (19%)	0.618
Number of Rods		3.2±0.8	3.4±0.9	0.244
Length of Stay		6.1±2.4	5.9±2.4	0.779
Complications				
Hematoma or Seroma managed conservatively		3 (2%)	0 (0%)	>0.999
Surgical Site Infection requiring I+D		3 (2%)	0 (0%)	>0.999
Medical		35 (26%)	7 (33%)	0.489
Dural Tear		10 (8%)	3 (14%)	0.387
PJK (with or without revision		9 (7%)	1 (5%)	>0.999
Radiographic Measurements				
Postop	PI-LL mismatch ≥10°	25 (39%)	6 (60%)	0.302
	TPA≥20°	8 (14%)	5 (46%)	0.027*

101. Improvement of Pulmonary Function and Reconstructed 3D Lung Volume After Halo-Pelvic Traction Combined with Posterior Correction for Severe Rigid Spinal Deformity: A Multicenter Study

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Hypothesis
The halo-pelvic traction (HPT) combined with posterior correction has a significant influence on lung volume and pulmonary function in patients with severe rigid spinal deformity (SRSD).

Design
Retrospective study

Introduction
SRSD not only leads to the distortion of thorax but also hinder the movement of ribs, and causes restrictive ventilation dysfunction (RVD). Previous studies have investigated the correlation between deformity correction and change of pulmonary function in patients with severe spinal deformity treated by posterior vertebral column resection (PVCR). However, few literatures reported the change of pulmonary function in SRSD patients who underwent the preoperative HPT and following posterior correction and fusion surgery.

Methods
Eighty-four adult patients with SRSD who underwent preoperative HPT and correction surgery were reviewed. Spinal parameters (main coronal cobb angel [MC], segmental kyphotic angle [SK], coronal balance [CB], sagittal vertical axis [SVA], pulmonary function test (PFT) indices (FVC, FVC%, FEV1, FEV1/FVC, TLC), and CT-based 3D lung volume were recorded and analyzed before HPT, after HPT, and at final follow-up, respectively. The correlations among the deformity correction, PFT outcomes, and lung volume was evaluated.

Results
The mean MC decreased from 102.4 ° to 60.5° after traction, and decreased to 49.3° at the final follow-up. The mean SK decreased from 66.3 ° to 41.2° after traction, and further decreased to 34.4° at the final follow-up. Absolute value of CB and SVA also significantly improved after HPT and at final follow-up. The mean CT-based lung volume significantly increased from 2.0 L to 2.4 L after traction, and further increased to 2.7 L at the final follow-up. The mean FVC improved from 1.6 L to 1.9 L after traction, and further increased to final follow-up 2.2 L. The mean FVC% increased from 51.2% to 64.5% after traction, and further increased to final follow-up 72.0%. The FEV1 increased from 1.5 L to 1.7 L after traction, and further increased to final follow-up 1.9 L. The TLC increased from 2.4 L to 2.8 L after traction, and further increased to final follow-up 3.1 L.

Conclusion
Pre-surgical HPT is a safe and effective treatment option for adult patients with SRSD. Preoperative HPT can dramatically increase the lung volume and improve preoperative pulmonary function.

102. Development of AI Algorithm for Automatic Cobb Angle Measurement in Adolescent and Adult Spinal Deformities

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Hypothesis
Our developed artificial intelligence (AI) algorism enables highly accurate automated Cobb angle measurement both in adolescent idiopathic scoliosis (AIS) and adult spinal deformity (ASD).

Design
Analytical study

Introduction
Automatic Cobb angle measurement algorisms using AI have been reported, but there is no established tool for severe deformities with both adolescent and adult pathology. We have developed an AI algorithm for automatic Cobb angle measurement that can be used commonly for AIS and ASD.

Methods
We used 1612 whole spine radiographs, including 1029 AIS and 583 ASD as a training set. The radiographs were collected from patients who underwent surgery in our hospital between 2009 and 2020 and included standing, supine, and lateral flexion positions. Our AI algorithm detected the thoracolumbar part as the region of interest (ROI) and identified the four corners of each vertebra from T1 to L5 as feature points for Cobb angle measurement. We measured both major and minor curves and defined major, minor1 and minor2 angles in order of angle magnitude. We used a Residual Network pre-trained model as a base for transfer learning in ROI detection. To evaluate the accuracy of our AI measurement, we used 285 radiographs (159 AIS and 126 ASD) as a test set and compared the results with manual measurements by four spine experts. We calculated the mean absolute error (MAE) and intraclass correlation coefficient (ICC) between AI and manual measurements.

Results
The mean Cobb angle was 33.2 ± 17.3° in manual measurement and 32.8 ± 18.0° in AI measurement. The MAE was 3.2 ± 3.4° and ICC (2,1) was 0.966. The mean Cobb angle of major, minor 1, and minor 2 were 46.7 ± 16.1°, 30.6 ± 12.9° and 19.9 ± 9.8° in manual measurement and 47.2 ± 16.4°, 30.0 ± 13.7°, and 18.7 ± 10.0° in AI measurement, respectively. The MAEs were 3.5°, 3.1° and 2.9°, and ICC (2 1) were 0.948, 0.950, and 0.908, respectively. In the AIS group, the mean Cobb angle was 30.8 ± 14.3° in manual measurement and 30.1 ± 14.5° in AI measurement. The MAE was 2.7 ± 2.7° and ICC was 0.964. In ASD group, the mean Cobb angle was 37.3 ± 20.9° in manual measurement and 37.4 ± 22.2° in AI measurement. The MAE was 4.1 ± 4.1° and ICC was 0.963.

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Conclusion
Our algorithm accurately measures the Cobb angle compared to manual measurements by spine experts in both AIS and ASD.

103. Spinopelvic Mismatch after Short Segment Lumbar Fusions Results in Increased Disability at Two Years Following Surgery

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Hypothesis
Malalignment after short segment fusion leads to increasing disability over time.

Design
Retrospective cohort from a prospectively-collected, institutional review board approved database.

Introduction
Although the relationship between pelvic incidence (PI), lumbar lordosis (LL), and patient outcomes are well established in spinal deformity surgery, this relationship in short-segment lumbar fusions for degenerative pathology unclear. We sought to examine the fate of postop spinopelvic parameters at early (3-month) and late (24-month) timepoints as well as clinical outcomes after 1-2 level lumbar fusions for degenerative pathology.

Methods
Spinopelvic parameters were measured on pre- and postoperative (3- and 24-months) standing lateral lumbar radiographs prospectively acquired from 76 patients who underwent 1-2 level lumbar fusion for degenerative pathology. Patients were categorized based on the PI-LL mismatch as aligned (AL)(PI-LL<10°) or malaligned (MAL)(PI-LL>10°) at all timepoints. Alignment was categorized postoperatively as preserved (AL to AL), restored (MAL to AL), not corrected (MAL to MAL), or worsened (AL to MAL). Oswestry Disability Index (ODI) scores were recorded at all time points.

Results
At 3 months, PI-LL matching was 61% preserved, 9% restored, 28% not corrected, and 3% worsened. PI-LL matching at 24 months was 58% preserved, 8% restored, 29% not corrected, and 5% worsened. Preoperatively patients reported equal amounts of disability regardless of alignment (aligned M=40.00, SD=15.85 and malaligned M=42.96, SD=16.03, p=.44). ODI scores improved in all patients from surgical intervention but did not significantly differ between aligned (M=20.85, SD=15.89) and malaligned (M=29.61, SD=21.89) patients at 3-months post-op, p=.05. However, at 24-months post-op, aligned patients reported significantly lower ODI scores (M=17.27, SD=16.46) compared to malaligned patients (M=27.19, SD=19.05), p=.02.

Conclusion
Spinopelvic alignment achieved at 3-months for 1-2 level lumbar fusions for degenerative pathology remains stable at 24-months. Patients report significant improvement in level of disability at 3 months after surgery regardless of alignment, however at 24 months, appropriately aligned patients have significant improvement in disability compared to the malaligned group. Surgeons may consider longer follow-up in patients where "proper" alignment wasn't initially achieved.

104. Pseudarthrosis and Rod Fracture at the Distal Levels of a Long Construct are Associated with Proximal Junctional Kyphosis after ASD Surgery

Karnmanee Srisanguan, BS; *Themistocles S. Protopsaltis, MD*; Thomas Errico, MD; *Tina Raman, MD;* Stephane Owusu-Sarpong, MD

Hypothesis
We hypothesize that lumbosacral rod fracture and pseudarthrosis may increase the risk for development of PJK after long construct ASD surgery.

Design
Retrospective review of prospectively collected single center database.

Introduction
More distal fusion levels and overall stiffness of a long fusion construct for ASD may result in larger range of motion and stress at the proximal junctional level. Stability of distal fixation, inferred by the presence of absence of pseudarthrosis and rod fracture, may confer higher risk for PJK.

Methods
We performed a review of 942 patients who underwent ASD surgery (Age: 55 ± 23 y; mFI: .41 ± .67; Levels fused: 10.1 ± 4.2; Revision: 22.3%; 3CO: 12.3%). Patients were divided into PJK and non-PJK groups based on accepted radiographic criteria using whole spine standing radiographs.

Results
The overall cohort had sagittal malalignment as demonstrated by PT 23.7 ± 12.4°, TPA 22.5 ± 26.2°, and SVA 77.8 ± 70 mm. The PJK and non-PJK groups comprised 350 and 592 cases respectively. Mean follow-up time was 48.9 months. There was no significant difference in baseline sagittal alignment, T1-pelvis angle, surgery invasiveness index, or change in sagittal alignment pre- and immediately post-operatively between the two groups. 11.1% of patients who developed PJK at final follow-up had a pseudarthrosis at the lower lumbar levels or lumbosacral junction, versus 6.4% of those who did not (p=0.011). Patients who developed PJK had a significantly higher rate of rod fracture in the lower lumbar or lumbosacral junction (15.4%) versus those who did not develop PJK (7.3%) (p<0.0001). Pseudarthrosis at the lower lumbar or lumbosacral junction (p=0.015; odds ratio 1.963, 95% confidence interval 1.14-3.38) and rod fracture at the lower lumbar or lumbosacral junction (p=0.001; odds ratio 2.27, 95% confidence interval 1.41-3.64) were significant risk factors for radiographic PJK at final follow-up by regression analysis.

Conclusion
Rod fracture at the lower lumbar levels or lumbosacral junction, and pseudarthrosis were significantly associated with development of

PJK at final follow-up. This may indicate that distal stability of a long construct has an impact on stresses at the proximal junction.

105. Decreased Bone Mineral Density is Associated with a Higher Rate of Pseudarthrosis and Unplanned Revision after Adult Spinal Deformity Surgery at Three Year Follow Up

Karnmanee Srisanguan, BS; Stephane Owusu-Sarpong, MD; Tina Raman, MD

Hypothesis

Postoperative pseudarthrosis and revision surgery rates following ASD surgery are significantly higher in patients with osteopenia and osteoporosis than in patients with normal BMD.

Design

Retrospective review of prospectively collected single center database.

Introduction

While modern spine deformity techniques and pretreatment with medications to prevent bone loss are important surgical considerations, it is unclear if they are enough to overcome the limitations posed by the osteoporotic patient. There is a paucity of data evaluating the rate of complications after ASD surgery in patients with decreased bone mineral density (BMD), particularly at long term follow up.

Methods

We performed a review of 155 ASD patients (Age: 66 11 years, mFI: 0.8 0.0.9, 10.8 4.9 levels) with baseline SVA > 5 cm, greater than 4 levels fused, preoperative dual-energy X-ray absorptiometry (DEXA) data at the proximal femur, and minimum three year follow up. We assessed the association between osteopenia and osteoporosis and the incidence of complications and rate of revision surgery long term follow up.

Results

The population analyzed included 155 ASD patients (history of osteopenia, n=61; history of osteoporosis, n=37; normal BMD, n=57). There was a significantly higher rate of rod fracture at long term follow-up in patients with osteoporosis (8.1%) versus osteopenia (3.3%) and normal BMD (1.8%)(p<0.001). Pseudarthrosis was more common in the osteoporosis group (21.6%), versus osteopenia (11.5%) and normal BMD (7.0%) (p=0.046). There were no differences seen in the rate of adjacent level vertebral compression fracture, proximal junctional kyphosis or failure, or pedicle screw pull-out. The odds of pseudarthrosis and revision surgery in patients with osteoporosis were 1.4-fold (OR 1.37, 95% CI 1.12–1.96) higher than patients with normal BMD at minimum three year follow up.

Conclusion

We found that at three year follow up, patients with decreased BMD have significantly higher rates of rod fracture and pseudarthrosis than patients with normal BMD. Decreased BMD conferred 1.4 fold increased risk for pseudarthrosis and unplanned revision at long term follow up.

106. Patients Undergoing Adult Spinal Deformity Surgery Report More Improvement with Standing than Sitting

Michael Longo, MD; Hani Chanbour, MD; Jeffrey W. Chen, BS; *Iyan Younus, MD*; Steven G. Roth, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH

Hypothesis

Certain Oswestry Disabilty Index (ODI) subdomains will improve more than others after adult spinal deformity (ASD) surgery and are influenced by preoperative and intraoperative factors.

Design

Retrospective cohort study.

Introduction

Sparse literature exists regarding which ODI subdomains improve after ASD surgery and what influences improvement in each subdomain. In a cohort of patients undergoing ASD surgery, we sought to: 1) evaluate postoperative changes in the five functional subdomains of the ODI, and 2) determine which demographic and operative factors influenced improvement in each subdomain.

Methods

A single-institution, retrospective, cohort study was conducted of patients undergoing ASD surgery from 2011-17 with 2-year follow-up. Preoperative and 2-year follow-up ODI were reported. Preoperative, operative, and radiographic parameters were analyzed with each of the five functional subdomains of the ODI (pain intensity, lifting, walking, sitting, and standing). All factors with p<0.020 after univariable analysis were included in the multivariable regression model.

Results

Among 132 patients undergoing ASD surgery, mean age was 64.0±11.6years and 108 (81.8%) were female. The upper instrumented vertebra (UIV) was thoracolumbar in 108 (82.8%) patients, and mean total instrumented levels was 10.0±2.5. Comparing preoperative to 2-years postoperative, a significant improvement was seen in the mean scores of all ODI subdomains (p<0.05), with most improvement in standing (3.5 vs. 2.4, p<0.001) and pain intensity (2.7 vs. 1.7, p<0.001), with less improvement was in lifting (3.2 vs. 2.8, p=0.008), walking (2.9 vs. 2.3, p<0.001), sitting (1.8 vs. 1.3, p<0.001). Multivariable logistic regression revealed the following predictors of improvement. Pain intensity: diabetics were less likely improve (OR=0.44, 95%CI=0.19-0.99, p=0.048). Lifting: no predictors. Walking: sacral lower instrumented vertebra (LIV) was associated with significant improvement (OR=4.3, 95%CI=1.4-12.7, p=0.010). Sitting: more instrumented levels was associated with less improvement (OR=0.88, 95%CI=0.77-0.99, p=0.047). Standing: No predictors.

Conclusion

After ASD surgery, patients reported more improvement with standing than sitting. Diabetics were less likely to improve their pain and more instrumented levels led to less improvement sitting, whereas fusing to the sacrum was more likely to improve walking.

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Table				
Dependent covariates	**Independent covariates**	**Odds Ratio**	**95% CI**	**p-value**
Question 1 - Pain Intensity				
	Female	1.3	0.61-2.90	0.470
	Diabetes*	0.44	0.19-0.99	0.048
	Thoracolumbar UIV	1.7	0.61-4.90	0.240
	Levels instrumented	0.91	0.78-1.10	0.247
Question 4 - Walking				
	Female	0.75	0.29-1.90	0.560
	LDI change	0.99	0.99-1.01	0.090
	UIV-S1 change	1.01	0.99-1.03	0.380
	Sacral LIV*	4.3	1.4-12.7	0.010
Question 5 - Sitting				
	Female	0.72	0.31-1.6	0.430
	PT change	0.94	0.80-1.10	0.450
	SS change	0.92	0.79-1.10	0.330
	LDI change*	1.01	0.99-1.01	0.054
	Total instrumented levels*	0.88	0.77-0.99	0.047
	Sacral LIV	0.45	0.17-1.20	0.120
Question 6 - Standing				
	Female	0.71	0.29-1.80	0.460
	SVA change*	0.99	0.98-1.00	0.060
	LDI change	1.01	0.99-1.00	0.190
	Diabetes	0.63	0.27-1.5	0.290

****Question 3 - Lifting (multivariate model not performed because only one covariate reached p-value <0.20*

Multivariate regression analysis

107. Combined Anterior-Posterior vs. All-Posterior Approach in Adult Spinal Deformity Surgery: Which Strategy Is Superior?

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Hypothesis

Patients undergoing a combined anterior-posterior (AP) approach for adult spinal deformity (ASD) surgery achieve better radiographic and postoperative outcomes compared to an all-posterior (P) approach.

Design

Retrospective cohort study.

Introduction

Whether a combined AP approach offers additional benefits over the P only approach remains unknown. In a cohort of patients undergoing ASD surgery, we compared the combined AP vs. P only approach in: 1) preoperative/perioperative variables, 2) radiographic measurements, and 3) and postoperative outcomes.

Methods

A single-institution, retrospective cohort study was performed for patients undergoing ASD surgery from 2009-21. Inclusion criteria were: ≥5-level fusion, sagittal/coronal deformity, and 2-year follow-up. The primary exposure was operative approach: a combined AP or P alone. Postoperative outcomes included mechanical complications, reoperation, and minimal clinically important difference (MCID) 30% of patient-reported outcomes measures (PROMs).

Results

Among 238 patients undergoing ASD surgery, the operative approach was AP 34 (14.3%) vs. P 204 (85.7%). The AP approach consisted mostly of anterior lumbar interbody fusion (ALIF) at L5-S1 (26.5%) and L4-S1 (23.5%). Preoperatively, the AP group had more previous fusion (64.7% vs. 28.9%, p<0.001), higher pelvic tilt (PT) (29.6±11.6 vs. 24.6±11.4, p=0.037), higher T1-pelvic angle (T1PA) (31.8±12.7 vs. 24.0±13.9, p=0.003), and less L1-S1 lordosis (-14.7±28.4, -24.3±33.4, p<0.001). Perioperatively, the AP approach had longer operative time (553.9±177.4 vs. 397.4±129.0 mins, p<0.001), more interbodies placed (p<0.001), and longer length of stay (8.4±10.7 vs. 7.0±9.6, p=0.026). Radiographically, the AP group had more sagittal vertical axis correction (SVA) (65.3±44.8 vs. 44.8±47.7mm, p=0.007), more T1PA correction (13.4±8.7 vs. 9.5±8.6, p=0.005), more improvement in L4-S1 lordosis (-4.7±16.4 vs. 3.2±13.7, p=0.008) and L1-S1 lordosis (-14.3±25.6 vs. -3.2±20.2, p<0.001). Postoperatively, no difference was found in mechanical complications (all p>0.05), reoperations (p=0.575), or MCID of PROMs (p>0.05).

Conclusion

Preoperatively, patients undergoing a combined AP approach had higher PT, T1PA, and less L1-S1 lordosis. The combined AP approach increased operative time and length of stay but provided a better sagittal deformity correction with no apparent impact on outcomes.

Variables	Total cohort = 238	Combined N = 34	Posterior only N = 204	p-value
Preoperative				
Age	63.4 ± 17.4	62.8 ± 9.8	63.5 ± 18.4	0.048
Female	181 (76.1%)	26 (76.5%)	155 (76.0%)	0.951
BMI	28.9±7.0	28.3±7.6	29.4±6.3	0.088
Prior fusion	81 (34.0%)	22 (64.7%)	59 (28.9%)	<0.001
Preop T1PA	25.2 ± 14.0	31.8 ± 12.7	24.0 ± 13.9	0.003
Preop L1-S1	-22.9 ± 32.9	-14.7 ± 28.4	-24.3 ± 33.4	0.039
Preop PT	25.3 ± 11.5	29.6 ± 11.6	24.6 ± 11.4	0.037
Intraoperative				
Total instrumented levels	10.5 ± 3.2	11.4 ± 3.3	10.4 ± 3.1	0.065
Operative time, min	419.9 ± 147.2	553.9 ± 177.4	397.4 ± 129.0	<0.001
Postoperative				
Mechanical complication	146 (61.3%)	22 (64.7%)	124 (60.8%)	0.664
Radiographic PJK	110 (47.8%)	18 (54.5%)	92 (46.7%)	0.404
pseudarthrosis	66 (27.7%)	7 (20.6%)	59 (28.9%)	0.315
RF	46 (19.3%)	5 (14.7%)	41 (20.1%)	0.461
LL	-5.0 ± 21.4	-14.3 ± 25.6	-3.2 ± 20.2	<0.001

Description of AP vs. P

108. The Ability of ChatGPT to Address Patient Concerns Regarding Adult Degenerative Scoliosis and the Possibility of AI-assisted Resources for Patient Education

Justin Tang, BS; Ula Isleem, MD; Eric Geng, BA; Jun S. Kim, MD; Samuel K. Cho, MD

Hypothesis

ChatGPT is able to accurately answer potential patient questions regarding the diagnosis and management of adult degenerative scoliosis surgery.

Design

Proof of concept

Introduction

Adult degenerative scoliosis (ADS) is the most common types of adult spinal deformity, defined as a spinal deformity with a Cobb angle of ≥10 as a result of spinal degeneration. In recent years, Artificial intelligence has grown in both popularity and robustness in its performance for a multitude of applications, but despite its influence in several different industries, its ability to aid in clinical care has not been rigorously studied. Patient education is one of the most vital components of a successful encounter, but at times can be difficult given the intricacies of individualized care, language barriers, and time constraints. ChatGPT is a free to use large language model that can respond to user written questions conversationally. The goal of this study was to determine if ChatGPT could appropriately answer patient questions regarding ADS diagnosis, symptoms, treatment, and recovery from surgical intervention in a variety of languages.

Methods
ChatGPT utilizes self-attention and large training data to produce conversational responses given an inputted question. The Scoliosis Research Society website provides several online resources for patient education of ADS. Questions were posed to ChatGPT based on commonly asked questions from patients found on the website.

Results
The answers ChatGPT provided regarding the management of ADS were qualitatively found to be not only accurate to current literature and guidelines but also colloquial where patients without medical backgrounds could digest and understand. Further, it provided similar answers in all languages tested. Questions were posed from general description of ADS such as etiology, pathophysiology, and symptoms to management such as imaging, medication, indications for surgery and interventions, and postop expectations. ChatGPT was able to accurately describe these components, aligning with published guidelines and clinical experience while still recommending the patient to confer with their specialist for more individualized questions.

Conclusion
ChatGPT shows profound potential for aiding clinicians in providing a resource for patients desiring further information on ADS and its management in several languages.

109. Overcorrection in Sagittal Alignment Effect on Optimal Outcomes in Adult Spinal Deformity Patients

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Hypothesis
Overcorrection past a threshold can lead to poor outcomes.

Design
Retrospective cohort

Introduction
Recent studies have suggested that overcorrection in ASD can benefit some patients without increasing the prevalence of PJK or PJF. Our research aims to investigate overcorrection of age-adjusted radiographic thresholds.

Methods
Operative ASD patients fused from at least L1 to S1 with baseline(BL) to 2 year(2Y) data were included. Frailty was calculated using Passias mFI. Good Outcome (GO+) at 2Y was defined as: no major mechanical complications, reoperations, PJF, and thoracic decompensation (TD) (>15 degree change from baseline in unfused thoracic kyphosis) and [meeting either: (1) Substantial Clinical Benefit for Oswestry Disability Index (ODI) (change >18.8), or (2) ODI<15 and Scoliosis Research Society Total>4.5]. Those that were overcorrected 1 standard deviation (O+) were evaluated. Multivariate regression controlling for covariates was used. Conditional inference tree (CIT) machine learning determined thresholds.

Results
302 ASD patients met inclusion(age 63±9yrs, 78% F, BMI 27±5kg/m2, CCI 1.9±1.7, ASD-mFI 7.2±4.7). BL radiographic deformity: mean PT 26º, PI 55º, PI-LL 21º, TPA 25º. By 2Y, 62% developed PJK, 11% PJF, 19% TD, and 69% GO. PJK, PJF, and TD was associated with greater correction in SVA, PI-LL, and PT ($p<.05$). O+ was significantly younger, had lower BMI, CCI, and frailty. O+ that were GO+ had significantly lower CCI and frailty. PJF rates were twofold higher in O+ ($p=.02$). Implant malposition and operative complications were higher in PT O+ ($p<.05$). Reoperation due to implant failure had 2x higher rate of PILL being O+ ($p=.06$). Higher CCI was the most significant patient factor that lead to PJF and GO- (PJF OR: 1.4, GO- OR: 1.3, both $p<.05$). O+ had double the likelihood of development of GO- with higher CCI ($p<.05$). Age and BMI were significant predictors for the development of PO in O1 (Age OR: 1.1, BMI OR: 1.2, both $p<.05$). Threshold for CCI in O+ of less than 1 was associated with GO+, for TD: CCI <2, and PJF: CCI <3 (all $p<.05$). Frailty threshold was <2.368 for GO ($p<.05$). Age threshold for PJK was <65.3 ($p<.05$).

Conclusion
Overcorrecting is often necessary in ASD surgery to achieve good outcomes. Our study suggests that overcorrecting in PT has the greatest impact on failure to achieve good outcomes and should be carefully considered, especially in those with greater comorbidities.

110. Association Between Elevated C-Reactive Protein and Operative Complications in Adult Spinal Deformity Surgery: An International Multicenter Study

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Hypothesis
Elevated serum C-reactive protein (CRP) may be a risk factor for operative complications in adult spinal deformity (ASD) surgery.

Design
International multicenter retrospective case series of surgically treated ASD patients

Introduction
Evidence of an association between chronic low-grade inflammation, as reflected by CRP measurements, and risk for surgical complication is equivocal. We sought to assess whether higher baseline blood biomarkers, including CRP, are associated with increased risk of surgical and medical complications in ASD surgery.

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Methods

A total of 467 (221 North American [NA] and 246 Japanese [JP]) surgically treated ASD patients who reached the 2-year follow-up point were included (US vs JP; age: 62±14 vs 52±19y, female 67% vs 92%, spinopelvic fusion: 83% vs 36%, PT: 26±12 vs 27±13 deg., PI-LL: 19±34 vs 27±23 deg., C7SVA: 7±7 vs 5±6cm, respectively; all p<.01). Commonly employed laboratory test data were obtained before surgery (white blood cell [WBC], hemoglobin [Hb], hematocrit [HCT], platelet count [PLT], albumin [ALB], creatinine [CRE], prothrombin time international normalized ratio [PT/INR]. Potential associations between baseline blood biomarkers and operative and medical complications were analyzed.

Results

Among the patient cohort, 72% (n=342) had 1 or more abnormal values in baseline laboratory tests (WBC13.3%, CRP9.4%, Hb29.6%, ALB12.8%, CRE8.1%, PT/INR6%). A perioperative complication developed in 24%, medical complication developed in 18.6%, and surgical complication developed in 28.3% of the patients within 2 years after surgery. Among the cohort, patients with elevated baseline CRP levels were more likely to develop perioperative (39% vs 21%, p=.02), surgical (34% vs 19%, p=.03), and medical complications (36% vs 13%, p<.01) within 2 years after surgery. Patients with abnormal CRE were also more likely to develop surgical and medical complications (surgical: 55% vs 26% p<.01, medical: 40% vs 17% p<.01). None of the other biomarkers were correlated with the development of operative complications.

Conclusion

This international multicenter study identified that baseline abnormal serum CRP and creatinine were significant risk factors for operative and medical complications in ASD surgery, with CRP being the most predictive biomarker for the development of operative complications.

111. The Effect of Traction and Spinal Cord Morphology on Intraoperative Neuromonitoring Alerts

Evan Fene, MD; Lydia Klinkerman, BS; Charles E. Johnston, MD; Jaysson T. Brooks, MD; Megan E. Johnson, MD

Hypothesis

Patients undergoing scoliosis correction utilizing on-table traction with type 3 spinal cords are more likely to have intraoperative neuromonitoring alerts.

Design

Retrospective Cohort Review

Introduction

Patients with type 3 spinal cords are at greater risk for intraoperative neuromonitoring (IONM) alerts when undergoing thoracic scoliosis correction. The use of intraoperative traction during deformity correction is also associated with an increased risk of IONM alerts. The purpose of this study is to examine the interplay between spinal cord morphology and intraoperative traction.

Methods

An IRB approved retrospective review of patients with major thoracic curves ≥ 70° who underwent spine fusion from 2016 to 2022 at a single institution was performed. Patients without a preoperative MRI were excluded, yielding 102 patients for review. Spinal cord morphology was determind by consensus of 4 observers using the criteria by Sielatycki et al.

Results

75 (73.5%) patients were female, with an average age of 13.7±2yrs at surgery. Mean thoracic Cobb was 85±13°. The average number of levels fused was 12±1.5, implant density 1.5±0.3, EBL 895±645mL, and total surgical time 314±112min. 87 patients had a PSF, while 15 had an ASF/PSF. 16 patients had type 1 cords, 71 type 2 and 15 type 3. There was no difference in Cobb angle, number of levels fused, EBL, surgery type, surgical time, or number of osteotomies performed based on cord type. Patients with type 3 cords were more likely to have IONM alerts than those with type 2 cords (46.7% vs. 14.1%, p=0.004), with an odds ratio of 5.3. Traction had no effect on IONM in patients with type 2 cords, however, patients with type 3 cords placed in traction (n=5) intraoperatively were more likely to have abnormal IONM alerts than those without traction (n=10, 100% vs. 20%, p=0.007).

Conclusion

Type 2 and 3 spinal cords are found in > 80% of patients with curves ≥ 70°. Patients with type 3 spinal cords are 5 times more likely than those with type 2 to have a have an IONM alert, and ALL patients with type 3 cords in intraoperative traction had IONM alerts. Based on this, we recommend that in patients with curves ≥ 70°, the use of intraoperative traction be carefully considered for significant correction efficacy when planning deformity correction methods, especially if an indicated preoperative MRI discloses type 3 morphology.

112. Vertebral Body Tethering for Lenke 1A Curves: The L4 Modifier Predicts Less Optimal Outcomes

Kenneth A. Shaw, DO; Firoz Miyanji, MD; Tracey P. Bastrom, MA; Stefan Parent, MD, PhD; Peter O. Newton, MD; Harms Study Group; Joshua S. Murphy, MD

Hypothesis

Lenke 1AR curves would have a higher rate of less optimal outcomes following VBT

Design

Retrospective cohort study

Introduction

The addition of the "AR" and "AL" lumbar modifier for Lenke 1A adolescent idiopathic scoliosis (AIS) has been shown to direct treatment in posterior spinal fusion for the minimization of distal adding on. With the growing popularity of vertebral body tethering (VBT), how this modifier influences VBT treatment outcomes have not yet been evaluated.

Methods

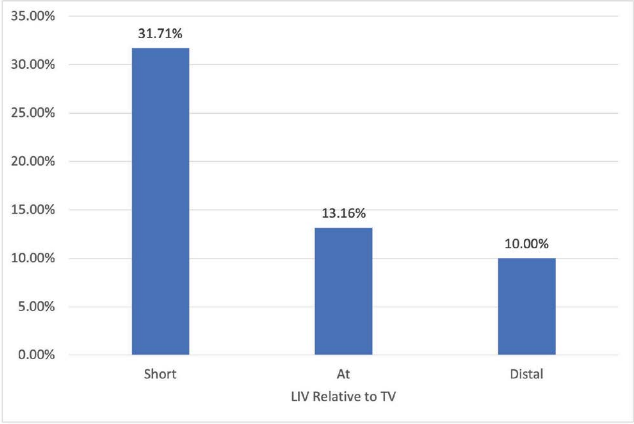
A retrospective review of a multicenter database for VBT in AIS was performed. Children undergoing VBT for Lenke 1A idiopathic scoliosis with a minimum of 2 years follow-up were isolated and categorized by their lumbar modifier (AR vs AL). Less optimal VBT outcome was defined as a final coronal curve >35°, lumbar adding-on, or revision surgery for deformity progression or adding-on. Univariate and multivariate analysis of radiographic parameters, and surgical factors were performed for study endpoint. Statistical significance was defined as P>0.05.

Results

Ninety-nine patients met inclusion criteria (81% female, mean 12.6 years), with 55.6% being AL curves and 44.4% being AR. There was a greater number of median instrumented vertebral levels for AR curves (8 vs 7; P<0.001). The mean thoracic Cobb improved from 45.8° (±8.8°) to 26.7° (±9.3°) at a mean of 2.7 years follow-up, Figure 1. Overall, there were 23 instances of tether breakage (23.3%) and 20 instances of less optimal outcome (20.2%). Failure to correct the deformity <30° on first erect radiographs was associated with less optimal outcome (41.3% failure vs 10.3%; P<0.001). This was also found with LIV selection short of the last touch vertebra (TV) (31.7% vs 10% distal to TV; P=0.04), Figure 2. Logistic regression analysis identified AR curves (Odd's ratio 3.4; P=0.04) and first erect curve magnitudes >30 degrees (Odd's ratio 6.0; P=0.002) as independent predictors of less optimal outcome.

Conclusion

There is a 20.2% rate of less optimal outcomes following VBT for Lenke 1A curves. AR curves are independently predictive of less optimal outcomes following VBT and require close attention to LIV selection. Surgeons should consider achieving an initial correction <30 degrees and extending the LIV to at least the Last Touched vertebra for AR curves.



Rate of less optimal VBT outcomes by the location of lowest instrumented vertebra (LIV) relative to the last touched vertebra (TV).

113. Radiation Exposure in Navigated Techniques for AIS: Is There a Difference for Pre-operative CT vs. Intraoperative CT?

Mikaela Sullivan, MD; Lifeng Yu, PhD; Beth Schueler, PhD; Ahmad Nassr, MD; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD

Hypothesis

Radiation dose and operative time will be lower with utilization of low-dose preoperative imaging protocol compared to low-dose intraoperative CT scanning in patients undergoing PSF for AIS.

Design

Retrospective cohort study

Introduction

Utilization of navigation improves pedicle screw accuracy in adolescent idiopathic scoliosis (AIS) and is a favorable alternative to fluoroscopic guidance. Our center switched from intraoperative CT (ICT) to an optical navigation system that utilizes a pre-operative CT (PCT). We aim to evaluate the radiation dose and operative time for low-dose ICT compared to standard and low-dose PCT used for optical navigation in AIS patients undergoing posterior spinal fusion (PSF).

Methods

A single-center matched-control cohort study of 38 patients was conducted. Nineteen patients underwent ICT navigation (O-arm) and were matched by sex, age, and weight to 19 patients who underwent PCT for use with an optical-guided navigation (7D, Seaspine). The PCT was either standard dose (N=7) or low dose (N=12). The mean volume CT dose index (CTDIvol), dose-length product (DLP), overall effective dose (ED), ED per level instrumented, and operative time per level were compared. EDs were determined by multiplying the DLP of the scan by an age-specific k-factor based on ICRP 103 tissue weighting factors.

Results

ED per level instrumented was 0.061±0.030 mSv in low-dose PCT and 0.081±0.031 mSv in low-dose ICT (p=0.123). ED per level instrumented was significantly higher in the standard PCT group (1.471±0.365 mSv vs. 0.085±0.050 mSv; p<0.0001). Mean operative time per level was 31±7 minutes for ICT and 33±3 minutes for PCT (p=0.628).

Conclusion

Low-dose PCT resulted in 0.71 mSv exposure per case and 31 minutes per level, while ICT resulted in a similar amount of exposure and operative time. Use of a standard-dose PCT involves a radiation exposure 22 times higher than either low dose strategy.

	Low Dose PCT (N=12)	Low Dose ICT (N=12)	P-value	Standard PCT (N=7)	Low Dose ICT (N=7)	P-value
CTDIvol (mGy)	0.68 ± 0.27	2.05 ± 0.48	<0.0001	18.0 ± 5.8	2.15 ± 0.25	<0.0001
DLP (mGy·cm)	32.7 ± 14.9	43.5 ± 21.0	0.160	877.1 ± 308.1	39.8 ± 16.8	<0.0001
ED (mSv)	0.71 ± 0.37	0.92 ± 0.39	0.190	17.1 ± 5.0	0.78 ± 0.34	<0.0001
ED per Level Instrumented (mSv)	0.061 ± 0.030	0.081 ± 0.031	0.123	1.471 ± 0.365	0.085 ± 0.050	<0.0001

Table 1: Comparison of radiation exposure between matched PCT and ICT patients

114. Can Use of a Stiffer Rod Obviate the Need for Posterior Column Osteotomy in Lenke I and II Curves? Prospective, Multi-center

Luke Mugge, MD; Matthew E. Cunningham, MD, PhD; Dennis R. Knapp, Jr, MD; Shyam Kishan, MD; Mark Rahm, MD; Randolph Gray, MD; Laurel C. Blakemore, MD

Hypothesis

Utilization of a novel geometry rod construct will achieve comparable coronal and sagittal correction in AIS surgery regardless of whether PCO's are performed.

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Design

Single-arm, prospective, multi-center

Introduction

The goals of surgical correction in adolescent idiopathic scoliosis (AIS) include maximal safe correction of coronal plane deformity, restoration of thoracic kyphosis and achievement of coronal and sagittal balance. PCOs are frequently utilized to increase correctability. There is conflicting evidence as to whether this is the case, and PCO's have been associated with complications.

Methods

Single-arm, prospective, multi-center study to evaluate the primary curve and TK correction in Lenke 1 and 2 AIS subjects as a function of rod stiffness. Baseline, initial post-op, and 2-year post-op radiographs were used. Pooled literature results were used for comparison.

Results

55 patients (42F, 76%) were included of which 22 had PCOs. Those with PCOs had increased blood loss (No:543 mL, PCO:718mL, p=0.0260), transfusion (No:172mL, PCO:430mL, p=0.0009), surgical time (No:266min., PCO:297min,p=0.0434), and anesthesia time (No:371 min., PCO:423 min, p=0.0021). There was no difference in proximal thoracic (No: 50.3%, PCO:48.8%, p=0.8057) main thoracic (No:70.6%,PCO:72.2%,p=0.4806) or lumbar (No:63.3%, PCO:63.9%, p=0.9246) coronal corrections. There was no difference in baseline TK (No:22.3°, PCO:20.0°, p=0.4470) or initial post-op TK (No:22.6°,PCO:24.7°,p=0.2526). This trend was observed regardless of pre-op thoracic modifier group (+, N or -). Compared to LIT, significance was found in pre-op TK (Beam:21.5°, Lit:19.8°, z=0.1041), post TK; Beam All (23.4°) and Beam PCO (24.7°) LIT (21.7°,z=0.0399 and 0.0237). Pre-op Cobb: Beam: (59.3°, Lit:54.2°,z<0.0001); Flex: Beam: (39.8%, Lit:46.1%,z<0.0001). Post-op Cobb angle (Beam:17.0°, Lit:18.5°, z=0.0194) and correction % (Beam:71.2°,Lit:65.6%,z=0.0002, Beam-No:70.6%,z=0.0073).

Conclusion

We report on a series of type 1 and 2 curves treated with and without PCO, with restoration/maintenance of primary curve and TK correction using a rod with increased rigidity. While our cohort had larger and less flexible primary Cobb and similar TK compared to the literature, relatively superior corrections were achieved regardless of PCO. This construct appears to achieve equivocal coronal and sagittal correction whether or not PCO's are performed.

115. Mental Health Components in Adolescents are Associated with Onset of Back Pain During Adulthood: A Cohort of Non-operative Idiopathic Scoliosis with a Mean Follow-up of 9.8 years

Kenney Ki-Lee Lau; Kenny Y. Kwan, MD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Karlen Law, OT; Kenneth M. Cheung, MD, MBBS, FRCS

Hypothesis

Back pain in conservatively treated idiopathic scoliosis subjects can be predicted by factors during adolescence.

Design

Retrospective analysis of prospectively collected data.

Introduction

Back pain occurs commonly in adults and is multifactorial in nature. This study aims to assess the prevalence of back pain during adulthood in subjects with adolescent idiopathic scoliosis (AIS) with long term follow up, as well as factors that may predict its occurrence.

Methods

AIS subjects aged 20-39 treated conservatively were included in this study. Patient-reported outcome measures involved episodes of back pain, and scales of self-image, depression, anxiety, and stress. Demographic and radiographic data consisted of smoking, alcohol consumption, and severity of the major curve. Additionally, self-image and mental health scores at the first clinic consultation were retrieved.

Results

101 participants were enrolled (response rate: 80.2%, mean age: 24.5±4.8 years, 77.2% females & average Cobb angle: 41.9°±13.8). The mean age at presentation was 15.8±4.7 years, and the mean duration of follow-up was 9.8±4.2 years. Prevalence of back pain in past 12 months, past 6 months, past 1 month, past 7 days, and past 24 hours were 75.2%, 72.3%, 62.4%, 52.5%, and 43.6%, respectively. Results of multivariate logistic regression models revealed that increasing depressive score was associated with 48.1%, 49.4%, and 19.2% increased likelihood of developing back pain in the past 12, 6 & 1 month(s). Conversely, increases in self-image score was associated with a 76.7% and 84.3% reduction in the likelihood of developing back pain over the past 7 days and 24 hours. Further analyses showed that lower self-image scores at presentation were characterised by participants with back pain in past 12 months, past 6 months, past 7 days, and past 24 hours compared to those without pain. Likewise, participants with back pain in past 7 days and 24 hours had significantly poorer mental health scores than individuals without pain.

Conclusion

This study demonstrated for the first time that poor self-image and mental health at presentation are strongly hinted as early signs of having back pain in adulthood among subjects with AIS. It may support that reduced psychological factors may not be consequences but aggravating factors for back pain.

Table. Psychological factors at participants' first clinic visit.

AIS adults	With back pain	Without back pain	Sig.
Self-image score at presentation in adolescence			
Past 12 months	3.49 ± 0.66	3.86 ± 0.52	0.018*
Past 6 months	3.48 ± 0.66	3.86 ± 0.51	0.012*
Past 1 month	3.50 ± 0.66	3.73 ± 0.60	0.095
Past 7 days	3.40 ± 0.65	3.81 ± 0.57	0.002*
Past 24 hours	3.39 ± 0.64	3.75 ± 0.60	0.006*
Mental health score at presentation in adolescence			
Past 12 months	4.05 ± 0.59	4.31 ± 0.48	0.067
Past 6 months	4.06 ± 0.59	4.26 ± 0.52	0.125
Past 1 month	4.04 ± 0.59	4.25 ± 0.54	0.091
Past 7 days	3.95 ± 0.58	4.31 ± 0.52	0.002*
Past 24 hours	3.96 ± 0.58	4.25 ± 0.54	0.017*

Note. * as significant.

Psychological factors at presentation

116. Vitamin D and Adolescent Idiopathic Scoliosis (AIS), Should we Stop the Hype? A Cross-sectional Observational Prospective Study Based on a Geometric Morphometrics Approach

Jose María González-Ruiz, MS; Markus Bastir, PhD; Javier Pizones, MD, PhD; Carlos Palancar, MS; Viviana Toro-Ibacache, PhD; María Dolores García-Alfaro, MD, PhD; Lucía Moreno-Manzanaro, BS; Jose Miguel Sánchez-Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; María Isabel Perez-Nuñez, MD, PhD

Hypothesis

There is an inverse correlation between variables of developmental instability in the 3D shape of the torso (fluctuating asymmetry-FA) and vitamin-D serum levels in AIS patients

Design

A prospective multicentric cross-sectional observational study

Introduction

There is strong evidence supporting the presence of FA (random deviation of an individual's shape from perfect bilateral symmetry) in the torso of AIS patients. Additionally, recent research has proved an inverse relationship between vitamin-D serum levels and Cobb magnitude. We aimed to study the relationship between vitamin D and the 3D shape of the torso in a cohort of AIS patients, evaluating the individual FA score and Cobb magnitude.

Methods

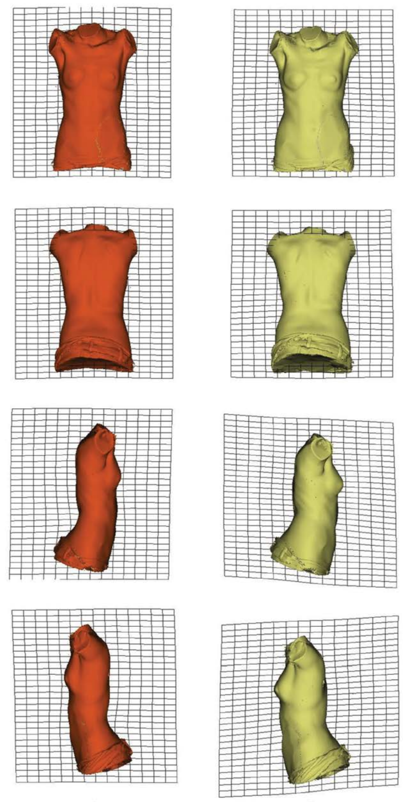
53 AIS patients were recruited in 2 hospitals from October 2021 to March 2022 with the following inclusion criteria: 10-16 years old, Cobb>20°, and Tanner <4. The exclusion criteria were: endocrine disease, vitamin supplementation, or previous fractures. We performed a surface topography scan (ArtecTM MHT-3D) of the torso and calculated the individual FA using geometric morphometric methods. Radiographs were used to measure the Cobb angle, vertebral rotation, Mehta angle, and T5-T12 kyphosis. Blood tests allowed the assessment of: vitamin D, calcium, phosphate, albumin, and PTH serum levels. Correlation analysis between vitamin D and FA was carried out to test our hypothesis. Multivariate regression analyses were performed between the surface 3D topography and vitamin D levels to analyze differences in 3D shape between vitamin D deficiency and insufficiency groups.

Results

We could not find a correlation between vitamin D and FA or Cobb angle in the cohort. A significant inverse correlation was found between vitamin D and Cobb angle only in pre-menarche AIS patients (n=7;r=-0.92). Differences in torso shape were observed between vitamin D deficiency and insufficiency groups, finding a narrower torso and a higher hypokyphosis in the deficiency group (fig).

Conclusion

Our results do not support the massive screening of vitamin D in AIS patients. We could not find a correlation between vitamin D and FA or Cobb angle, except for pre-menarche patients, which needs further investigation with more extensive samples. Shape analysis revealed differences between the torso of the deficiency and insufficiency groups related to robustness.



Grids

117. Can an Immediate Increase of Standing Height, when Wearing a Corrective Scoliosis Brace, be Predictive of In-Brace Skeletal Correction?

Anna Courtney, BSc (Hons); Sam Walmsley, BSc (Hons); Darren F. Lui, FRCS; Tim Bishop, FRCS; Jason Bernard, MD, FRCS

Hypothesis

Height change during brace fitting will equal height loss secondary to scoliosis. Height change is a useful tool at brace fitting.

Design

Retrospective quantitive analysis

Introduction

A relationship between spinal distraction and correction of a scoliotic curvature is known. Literature confirms height is lost secondary to scoliosis and that height can be gained following fusion surgery. 5 published mathematical algorithms predict expected height loss secondary to a patient's scoliosis. These are largely based on presenting Cobb angle(s). There is a paucity of literature reverse engineering this information to predict how much height should be gained in-brace at a fitting appointment if a brace is successfully correcting the scoliosis. In-brace (Cobb angle) correction is a primary indicator in predicting final success of scoliotic brace treatment and is a primary focus in conservative treatment.

Methods

Data collection was from January 2022. Each patient (n=60) had

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two standing height measurements taken on the same day – one pre and one post fitting (brace in situ). We measured two Cobb angles, one baseline and one in-brace. The relationship between these measures were evaluated. Statistical analysis was performed.

Results

Mean age 12.4 years. Mean Risser 1.49. Mean Cobb at assessment 38.1°, correcting to 10.1° in-brace. Mean in-brace correction 74.96%. Mean height change at fitting 1.1cm (range -0.2cm to 3.5cm). Those who achieved in-brace Cobb angles closest to null had the most significant increase in height. When we remove patients who had correction exceeding 100% in-brace, our linear trendline shows height change at fitting is consistent with current literature. Our R value shows moderate positive correlation between initial presenting cobb angle and height change (0.4791). Our P-value is 0.0027 ($p<0.05$). Results show all patients who had a height gain above our linear trendline demonstrated a mean correction of 78.1% (range 60-180%).

Conclusion

Limiting radiation is a priority in children. We found a positive correlation between original Cobb angle and in-brace height change. We also found that patients who had a height change above the trendline demonstrated above expected in-brace skeletal correction. We conclude that measuring height change at fitting can be used to predict brace efficacy and optimise scoliotic correction prior to the initial in-brace x-ray.

118. Starting Young: Differences in Brace Compliance Between Juvenile and Adolescent Idiopathic Scoliosis

Julianna Lee, BA; Kevin Orellana, BS; Lucas Hauth, BS; Wudbhav N. Sankar, MD; Jason B. Anari, MD; Patrick J. Cahill, MD; John (Jack) M. Flynn, MD

Hypothesis

JIS patients who begin bracing younger have higher brace compliance than patients who begin bracing after adolescence.

Design

Retrospective cohort

Introduction

Bracing has been proven to be the most effective non-operative treatment for both juvenile and adolescent idiopathic scoliosis (JIS and AIS, respectively). Skeletal immaturity and poor brace compliance are significant risk factors for treatment failure with brace management. Little is known about brace compliance in JIS, and how it compares to adolescents, for whom peer pressure has been greatly magnified in our era of ubiquitous social media. The aim of this study is to assess bracing compliance in JIS and AIS patients using an objective measurement of brace compliance.

Methods

269 patients (177 AIS, 92 JIS) met inclusion criteria including at least one measurement of time-in-brace from a temperature-sensitive button monitor. Bracing compliance was calculated as a percentage of hours worn by hours prescribed and averaged across follow-up visits per patient. Shapiro-Wilks test was performed for normality and Mann-Whitney and Fisher's Exact tests were used for comparison based on age at brace initiation and surgical progression.

Results

Among JIS patients, 52 began bracing before reaching the age of 10 years old (Juvenile Bracers). 159 patients began bracing after their 12th birthday (Adolescent Bracers). The average brace compliance was 84.7% (IQR 70.8-99.0%) for Juvenile Bracers versus 74.3% (IQR 56.8-92.4%) for Adolescent Bracers ($p = 0.016$, Figure 1). For all patients, there was a significant association between brace compliance and progression into surgical range ($p = 0.04$).

Conclusion

Patients who begin bracing before 10 years old have the best bracing compliance, and compliance decreases once patients enter adolescence (>12 years). Regardless of age, poor bracing compliance was a significant risk factor for progression to into surgical range.

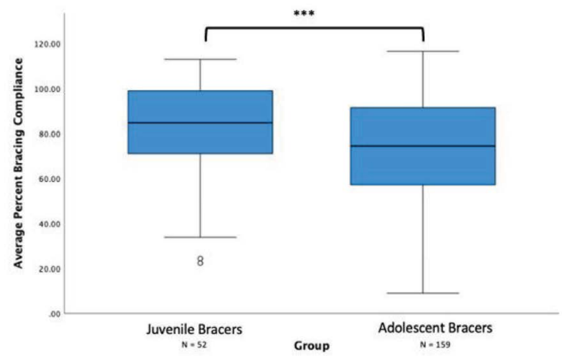


Figure 1: Distribution of average percent bracing compliance between patients who begin bracing before 10 years (Juvenile Bracers) and after 12 years (Adolescent Bracers)
***$p < 0.05$ for Independent-Samples Mann-Whitney U Test between groups

119. Long-Term (>2yr) Complications after Adult Spinal Deformity Surgery: Survivor Analysis Focused on Patients without Early- or Mid-Term Complications

Thomas J. Buell, MD; Andrew Legarreta, MD; Justin S. Smith, MD, PhD; Bassel G. Diebo, MD; Peter G. Passias, MD; Jeffrey L. Gum, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Nitin Agarwal, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Robert K. Eastlack, MD; Michael P. Kelly, MD; Alan H. Daniels, MD; Justin K. Scheer, MD; Alex Soroceanu, MD, FRCS(C), MPH; Richard Hostin, MD; Khaled M. Kebaish, MD; Robert A. Hart, MD; Stephen J. Lewis, MD, FRCS(C); Frank J. Schwab, MD; Christopher P. Ames, MD; Munish C. Gupta, MD; David O. Okonkwo, MD, PhD; D.Kojo Hamilton, MD, FAANS; Douglas C. Burton, MD; International Spine Study Group

Hypothesis

Elucidating long-term (>2yr) complications associated with adult spinal deformity surgery (ASD) may provide novel patient benchmarks.

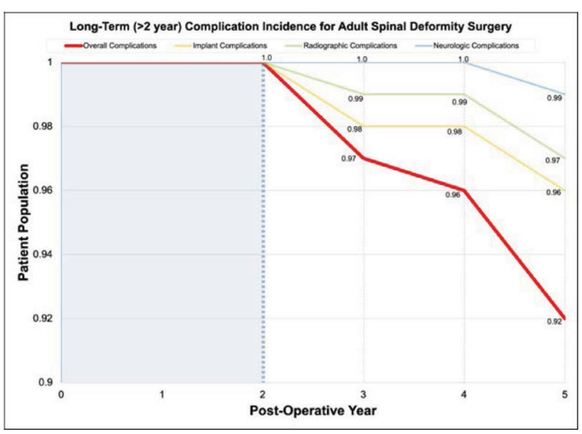
Design
Prospective multicenter consecutive series

Introduction
Operative treatment of ASD is associated with high rates of complications/reoperations with 2yr follow-up. For patients who achieve 2yr follow-up without complication, their associated long-term complication risks are not well established. In this study, we assessed long-term (>2yr) complications/reoperations in the subset of operative ASD patients without early- or mid-term complications.

Methods
Inclusion criteria was diagnosis of ASD (scoliosis≥20°, SVA≥5cm, PT≥25°, or TK≥60°) and min 2yr follow-up. Operative ASD patients who achieved 2yr follow-up without complication were analyzed, and long-term complications/reoperations were assessed. Survival curves for each complication category were plotted.

Results
Of 1359 index operative patients (age=61±15yr, 74% female, BMI=28±6), 891 (66%) had ≥1 complication/reoperation by 2yr postop. For the remaining 468 patients (34%), 351 achieved additional follow-up and were analyzed. Twenty-eight (8% [28/351]) had their first complication/reoperation after 2yr postop (mean follow-up=4.1±1.0yr). The most common complication categories (Figure) were implant failure (50% [14/28]), radiographic (43% [12/28]), and neurologic (18% [5/28]). Of these complications, 10 were considered major and 7 resulted in reoperations (reop due to implant failure [n=4], radiographic [n=3]). Implant complications were rod breakage (n=12), pain (n=1), and loose screw (n=1). Radiographic complications were proximal junctional kyphosis (n=6), adjacent segment disease (n=3), pseudarthrosis (n=2), and coronal imbalance (n=1). Neurologic complications were radiculopathy (n=2), myelopathy (n=1), and other (n=2).

Conclusion
In the subset of ASD patients who achieve 2-year follow-up without complication/reoperation, 8.0% developed complications or required reoperation after 2 years from index surgery (total follow-up duration=4.1±1.0yr). Implant and radiographic complications were the most common subtypes. We interpret these results as novel benchmarks which can facilitate surgeon-patient counseling.



120. Comparison of Multi-Level Low-Grade Techniques versus Three-Column Osteotomies in Adult Spinal Deformity Surgery: Does Harmonious Correction Matter?

Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Jamshaid Mir, MD; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Tobi Onafowokan, MBBS; Peter Tretiakov, BS; Jordan Lebovic, BA; Daniel M. Sciubba, MD

Hypothesis
To compare the complication rates, radiographic and clinical outcomes of three-column osteotomies and multi-level low-grade techniques performed in ASD corrective surgeries.

Design
Retrospective

Introduction
Recent debate has arisen between whether to use a three-column osteotomy or multiple low-grade techniques to treat more rigid deformities in adult spinal deformity (ASD) surgery. Therefore, we examined the performance of three-column (3CO) osteotomies versus multi-level low-grade (MLG) techniques in ASD patients undergoing corrective surgery.

Methods
Included: ASD pts with baseline PI-LL >30° and 2Y data. Groups: 1) 3CO or 2) MLG (3+ Smith-Peterson osteotomies or 3+ ALIF interbodies between T12-S1 with no 3CO). Groups were propensity score matched (PSM) for BL PI-LL and prior fusion. Segmental Utility Ratio (SU Ratio) assessed relative segmental correction, defined as segmental correction divided by overall correction in lordosis divided by number of thoracolumbar interventions (IBF, SPO, 3CO).

Results
111 ASD patients included. 44% underwent an MLG and 40% underwent a 3CO. MLG pts underwent significantly less revisions than 3COs (31% vs. 80%, p<.001). MLG patients accrued 43% less blood loss (p<.001), but 22% greater operative time (511 min vs. 419, p=.015). PSM for revision status and BL PI-LL (23 in each group), 3COs had greater segmental and relative correction at each level (SU Ratio means: 3CO 69% vs. MLG 23%, p<.001). However, 3COs had lordotic differences between two adjacent lumbar disc pairs (-0.5-8.4°, p=.015), while MLG was more harmonious (2.4-5.4°, p>0.6). Overall, MLG were aligned more often to age-adjusted T1PA (65% vs 26%, p=.007). MLG had lower rates of major complications (p=.042) and reoperations (17% vs. 39%, p=.1). Multivariate analysis via ANCOVA, controlling for baseline CCI and disability, revealed MLG patients more often met SCB in ODI (70% vs. 43%, p=.043).

Conclusion
For patients with a higher degree of lumbopelvic deformity, multi-level low-grade techniques showed better utility in lumbar distribution and age-adjusted global correction, while minimizing major complications and reoperation rates by two years. These findings do not underscore the unique indications for a three-column osteotomy, but during selective instances, may offer the spine

deformity surgeon a safer alternative when correcting severe adult spinal deformity.

121. Corner Osteotomy: The More Efficient Technique for Deformity Correction of Adult Spinal Deformity in Comparison to Pedicle Subtraction Osteotomy

Jung-Hee Lee, MD, PhD; Kyung-Chung Kang, MD; Ki-Young Lee, MD, PhD; Jaeho Kim, MD; Tae-Su Jang, MD; Won Young Lee, MD; Seong Jin Cho, MD; Cheol-Hyun Jung, MD; Gil Han, MD; Min-Jeong Park, PA

Hypothesis

Corner osteotomy, a modified PSO, has the advantage of obtaining a larger correction angle with a small amount of bone resection and bone-to-bone contact at the osteotomy site, preventing pseudarthrosis.

Design

A retrospective study

Introduction

Traditionally, several osteotomy techniques have been used to correct sagittal imbalance in patients with adult spinal deformity (ASD). In particular, powerful correction is possible with 3-column osteotomy such as PSO. The purpose of this study was to compare the correction angle and postoperative complications in ASD patients who underwent PSO or corner osteotomy with long segment fusion.

Methods

We retrospectively selected 108 consecutive (mean age 71.2 years) who underwent deformity correction through PSO or corner osteotomy with a minimum 2-years follow-up. Patients were classified into the PSO group (n=63) and the Corner group (n=45). For each group, patient factors, radiologic factors and osteotomy correction angle using CT scans were analyzed. A group analysis of the estimated blood loss (EBL), operation time, surgical factors, and complications was also performed.

Results

The correction angle at the osteotomy site was greater in the corner group than in the PSO group (38.64° vs. 34.98°, p<0.05). EBL was higher in the PSO group (2841 ml vs. 2466 ml, p<0.05), and operation time was shorter in the PSO group (317 min vs. 340 min, p <0.05). Rod fracture was more common in the PSO group, while the use of additional rods was more common in the Corner group. Previous spinal surgery history was more common in the Corner group.

Conclusion

In this study, we found that corner osteotomy could obtain a greater correction angle than PSO. Rod fracture was more frequent in the PSO group, but this appears to be due to the effect of additional rods, rather than the osteotomy method, itself. In the Corner group, although previous spinal surgery history was more common, the amount of blood loss was less, and there was no significant difference in complications. To that end, we believe that corner osteotomy would be more advantageous when osteotomy is needed for deformity correction in ASD.

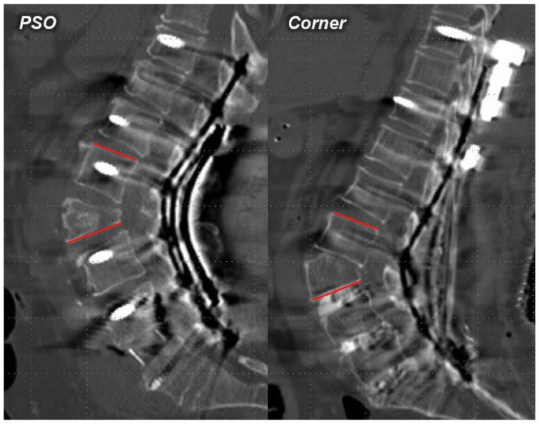


Figure. Comparison of correction angle through segmental angle measurement of osteotomy site on CT

122. Open Deformity Correction Has Greater Improvements in Spinopelvic Parameters and Lower Rates of Hardware Failure than Minimally Invasive Techniques

Elliot Pressman, MD; Kelly Gassie, MD; Molly Monsour, BS; Deborah Liaw, BS; Puya Alikhani, MD

Hypothesis

There is more risk of hardware failure with minimally invasive surgery (MIS) deformity techniques than in open correction.

Design

Retrospective cohort study.

Introduction

There has been a growing push to correct adult spinal deformity using more MIS techniques. Anterior and lateral interbody fusions (ALIFs and LLIFs) with anterior column releases (ACRs) can be used instead of open posterior fusions using three column osteotomies (TCOs).

Methods

We conducted a retrospective review of all degenerative long construct fusions at our center from 2016-2021. “Long construct” was a fusion with upper instrumented vertebra (UIV) of L2 or higher and lower instrumented vertebra (LIV) of S1 or pelvis. TCO was defined as Schwab Grade 3 osteotomy or higher. MIS was defined as a case where screws and rods were placed percutaneously. Hardware failure was defined as rod fracture, screw fracture, or screw pullout.

Results

We identified 216 patients; 36 patients (17%) underwent MIS correction. Average age was 65±2.1 years (MIS) and 61±1.6 years (open, p=0.006). Most common UIV in MIS was L2 (53%) followed by T10 (17%) and in open, T10 (46%) followed by L2 (27%). There were more levels instrumented in the open cohort (9±0.46 vs 7±0.68, p<0.001). In MIS patients, preoperative lumbar lordosis was higher (LL; 52o±3.2 vs 49o±1.3, p=0.003), preoperative sagittal vertical axis was lower (9.6o±0.72 vs 11o±0.62, p<0.001), and preoperative pelvic incidence (PI)-LL mismatch was lower (21o±4.2 vs 26o±2.1, p=0.025). Seventeen MIS patients (47%) had an ACR

(12% of open cohort; p<0.001). Thirty-one patients (17%) from the open cohort had a TCO. The open cohort had better improvement of PI-LL mismatch postoperatively (16o±1.8 vs 11o±3.2, p=0.006). Though there was no difference in rates of hardware failure in our sample, of the 12 MIS patients with UIV in the thoracic spine, there were higher rates of hardware failure (8 (67%) vs 33 (27%), p=0.007) and rod fracture (p=0.041). Average length of follow-up was 857 days.

Conclusion
Older patients and those with better baseline spinopelvic parameters were more likely to undergo MIS correction. While undergoing larger surgeries, patients with open corrections had greater improvement of PI-LL mismatch, and less chance of rod fracture and hardware failure likely due to the ability to release facet joints and minimize competitive forces against the rods.

123. Correct Now or Wait? An Analysis of Comorbidity Burden and Optimization Thresholds in Surgical Adult Spinal Deformity Patients

Peter Tretiakov, BS; Kimberly McFarland, BS; Pooja Dave, BS; Jamshaid Mir, MD; Andrew Chen, BS; Giorgos Michalopoulos, MD; Jordan Lebovic, BA; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD; Robert K. Eastlack, MD

Hypothesis
Some patients benefit from delaying surgery for optimization versus early surgical intervention.

Design
Retrospective

Introduction
Comorbidity burden is a known factor in perioperative outcomes for adult spinal deformity patients and the consequences of delaying operative treatment have been previously described.

Methods
ASD patients with available perioperative and up to 2 year data were included. Optimizable risk factors examined were BMI, frailty, osteoporosis, diabetes, and smoking status. These factors were considered optimized with BMI between 18.5-24.9, modified frailty index <7, treated or no osteoporosis, HgbA1c<7%, and non-smoker or quit >6 months ago, respectively. A "good outcome" was defined as: 1) no mechanical failure or reoperation in 2 years, 2) met MCID for ODI, and 3) improvement in at least 1 SRS-Schwab modifier. Multivariate regression modeling was used to predict achieving a good outcome based on the modifiable risk factors. For those that were predictive of a good outcome, CIT defined variables associated with optimized risk factors.

Results
234 patients were isolated (60.1±10.5 years, 52% F, BMI of 33.4±7.2 kg/m2). Severe and not severe deformity patients were similar in age, gender, BMI, operative time, EBL, and length of stay (all p>.05) but differed in levels fused (10.3±3.9 vs. 6.9±4.5, p=.012). 30.1% achieved Good Outcome. Those that achieved Good Outcome had significantly lower BMI (26.8 vs. 30 kg/m2, p=.023), less operative time (403.6 vs. 511.1 mins, p=.002), and fewer levels fused (10.3 vs. 13.2, p=.005) but were similar in age, gender, CCI, EBL, and length of stay (all p>.05). A multivariate logistic regression was significant for prehab predicting Good Outcome (OR: 18.831 [1.061-334.1], p=.045), as well as HgbA1c (OR: 2.495 [2.050-6.523], p=.003), vitamin D level (OR: 4.045 [3.999-6.480], p=.036), osteoporosis (OR: 5.001[5.000-5.901], p<.001) or smoking (OR: 9.205 [8.990-10.294], p=.040).

Conclusion
Delaying adult spinal deformity surgery for patients may decrease the relative ceiling of clinical improvement. However, for those patients who are able to tolerate delayed surgery, concurrent modification and optimization based upon conduction of prehabilitation protocols, as well as improvement in diabetes markers (HgA1C), Vit D Hydroxy, osteoporosis, and smoking can significantly increase the likelihood of achieving optimal post-operative outcomes.

Figure. Thresholds Necessitating Sagittal Correction to Achieve Good Clinical Outcome

Radiographic Parameter	Threshold	Odds Ratio for Needing Correction to Achieve Good Outcome	p-value
Thoracolumbar			
PI-LL	above 10°	17.0	<.001
PT	above 15°	3.6	.001
T1PA	above 20°	14.0	<.001
SVA	<-10 mm or > 30 mm	5.6	<.001
L4-S1	Below 40°	9.6	<.001
Cervical			
C2 Slope	Above 15°	8.1	<.001
C2-T3	Below 21°	6.6	<.001
C2-C7 SVA	Above 25 mm	4.4	<.001

124. Crossing the Bridge from Degeneration to Deformity: When Good Outcomes Necessitate Sagittal Correction in Adult Spinal Deformity Surgery

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Hypothesis
There are baseline thresholds in radiographic parameters that, when exceeded, result in dramatic clinical improvement from surgical correction.

Design
Retrospective

Introduction
Patients with less severe adult spinal deformity undergo surgical correction and often achieve good clinical outcomes. However, it is not well understood how much clinical improvement is due to sagittal correction rather than repair of degenerative disc changes.

Methods
ASD patients with BL and 2-year(2Y) data included. Parameters assessed: SVA, PI-LL, PT, T1PA, L4-S1 Lordosis, C2-C7 SVA (cSVA), C2-T3, C2 Slope (C2S). Outcomes: Good Outcome (GO):

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[Meeting either: 1) SCB for ODI by 2Y (change greater than 18.8), or 2) ODI <15 and SRS-Total >4.5 by 2Y. Binary logistic regression assessed each parameter to determine if correction was more likely needed to achieve GO. Conditional inference tree (CIT) generated baseline thresholds for each parameter.

Results

Included: 447 ASD patients. There were 223 patients achieving GO by 2Y. Logistic regression demonstrated correction of all five thoracolumbar parameters was needed to achieve GO (all p<.001). Upon CIT, thresholds were derived for each parameter, depicted in Table, with a baseline PI-LL above 10° (74% of patients meeting GO) most likely needing correction to achieve GO (OR: 17, [7.0-41.4]). Of patients with baseline T1PA above the threshold, 95% required correction to meet Good Outcome (95% vs. 54%, p<.001). All three cervical parameters were assessed and more often required correction to achieve GO (all p<.001). CIT-generated thresholds were significant for each parameter, with a baseline C2 slope above 15° necessitating correction to obtain clinical success (OR: 8.1, [4.1-16.2]). Conversely, patients above the C2-T3 threshold only required correction 11% of the time to achieve GO (vs. 45%, p<.001).

Conclusion

While degenerative thoracolumbar changes can be debilitating and require surgical intervention, our study highlighted there is a point at which sagittal correction has an exponential influence on clinical improvement, reflecting the line where deformity becomes a significant contributor to disability. These new thresholds delineate patients suitable for sagittal correction, as opposed to degenerative disc repair or replacement only, and may improve the utility gained from surgical intervention for adult spinal deformity.

125. Pelvic Non-Response is Associated with Failure to Restore Low Lumbar Lordosis and a Higher Rate of Mechanical Complications in Adult Spinal Deformity Patients

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Hypothesis

Pelvic non-responders will have inferior correction of sagittal alignment and experience higher mechanical complications than pelvic responders.

Design

Retrospective

Introduction

Despite achieving seemingly adequate sagittal alignment following fusion, compensatory retroversion of the pelvis may still fail to resolve in adult spinal deformity (ASD) patients, referred to as pelvic non-response. While linked to adverse surgical outcomes, predicting non-response is less understood. In a cohort of ASD patients undergoing surgery, we sought to: 1) identify measures associated with pelvic non-response and 2) investigate the mechanical complications associated with pelvic non-response.

Methods

A single-institution, retrospective database was queried for patients undergoing ASD surgery from 2009-2021 with minimum 2-year follow-up. Patients with baseline sagittal vertical axis >5 cm and baseline PT >7° above a pelvic incidence-adjusted ideal PT were included. Patients were grouped into "pelvic responder" (PR) and "pelvic non-responder" (PNR) groups. Pelvic response was defined as PT within 7° of ideal PT or an improvement in PT >5° maintained at >1 year, as previously defined in the literature. Risk factors for PNR were identified via multivariate logistic regression.

Results

152 patients met inclusion criteria: 86 (56.6%) PNR and 66 (43.4%) PR. Mean age was similar between cohorts (p=0.313). Preoperatively, PNR had lower PT (p=0.013) and lower PI (p=0.019), but no difference in baseline PI-LL, T1 pelvic angle (TPA), or lumbar lordosis (LL). Postoperatively, PNR had a smaller change in PT (p<0.001) and TPA (p=0.003) as well as less L4-S1 lordosis (p=0.044). In logistic regression, postoperative L4-S1 lordosis was found to be a risk factor for non-response (OR: 0.960, p=0.033). Overall mechanical complication rate (p=0.025) and proximal junctional kyphosis (PJK) (p=0.050) were greater in the PNR group.

Conclusion

Restoration of low-lumbar lordosis (L4-S1) is associated with postoperative improvement in pelvic tilt. In addition, pelvic non-responders demonstrate a significantly higher rate of PJK and mechanical complications when compared to pelvic responders. These data illustrate the importance of obtaining appropriate low-lumbar lordosis to restore overall sagittal balance and reduce mechanical complications.

Variables	Pelvic-Responders (N=66)	Pelvic Non-Responders (N=88)	P-value
Preoperative Measures, Mean±SD			
Pelvic Incidence (°)	55.6 ± 16.7	49.5 ± 14.8	**0.019**
Pelvic Tilt (°)	31.8 ± 11.7	27.5 ± 9.2	**0.013**
Thoracic Kyphosis (°)	29.6 ± 18.9	32.5 ± 17.9	0.150
L1-L4 Lordosis (°)	-1.4 ± 16.8	-1.9 ± 17.0	0.964
L4-S1 Lordosis (°)	-27.7 ± 15.8	-25.4 ± 14.5	0.063
PI-LL Mismatch (°)	29.1 ± 20.1	26.3 ± 19.5	0.391
TPA (°)	32.0 ± 13.9	29.2 ± 11.3	0.177
SVA (mm)	86.6 ± 66.1	95.6 ± 64.8	0.404
Postoperative Measures, Mean±SD			
Pelvic Tilt (°)	24.5 ± 12.4	27.4 ± 9.5	0.103
Thoracic Kyphosis (°)	38.0 ± 13.0	41.7 ± 15.7	0.150
L1-L4 Lordosis (°)	-11.6 ± 16.9	-11.4 ± 19.5	0.964
L4-S1 Lordosis (°)	-28.9 ± 12.5	-24.4 ± 12.2	**0.032**
PI-LL Mismatch (°)	13.3 ± 17.9	13.7 ± 13.8	0.879
TPA (°)	22.0 ± 15.1	25.6 ± 9.5	0.102
SVA (mm)	49.4 ± 62.4	61.3 ± 47.4	0.225
Mechanical Complications, N (%)			
Overall Mechanical Complications	36 (54.5)	62 (72.1)	**0.025**
Mechanical Complications Reoperation	20 (30.3)	36 (41.9)	0.143
PJK	27 (42.1)	48 (57.9)	**0.050**
PJF	3 (4.7)	9 (10.5)	0.180
Pseudoarthrosis	19 (28.8)	26 (30.2)	0.847
Rod Fracture	16 (24.2)	15 (21.1)	0.302

Sagittal measures and mechanical complications

126. Serum Titanium Levels Remain Elevated but Urine Titanium is Undetectable in Children with Early Onset Scoliosis (EOS) Undergoing Growth-Friendly Surgical Treatment: A Prospective Study

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Hypothesis
Children with EOS treated with distraction-based growth-friendly instrumentation (GFI) have elevated serum titanium (Ti) levels compared to control patients and serum Ti remains elevated throughout treatment. These patients have low renal excretion of titanium.

Design
Prospective case-control study.

Introduction
Elevated serum Ti levels have been found in EOS patients treated with TGR, MCGR, and VEPTR. No studies have investigated whether serum Ti remains persistently elevated and if Ti is excreted in urine in these patients. Our purpose was to compare serum Ti levels in EOS patients with GFI to age-matched controls and evaluate urine Ti and serial serum Ti levels in EOS patients.

Methods
EOS patients with TGR, MCGR, or VEPTR underwent urine Ti and serial serum Ti collection at a minimum 6-month interval. Patients with a previous spinal fusion, conversion from another GFI, separation of the actuator end cap, and indwelling implants for <6 months were excluded. Control patients did not have a history of metal implant insertion, were matched by age to EOS patients at time of first serum Ti collection, and underwent serum Ti collection prior to fracture fixation.

Results
20 EOS patients (6 TGR, 8 MCGR, 6 VEPTR) and 12 controls were analyzed. The control patients had no detectable serum Ti (0 ng/mL), whereas the EOS patients had a median serum Ti of 4.0 ng/mL (p<0.001). ANOVA showed significantly higher median serum Ti levels in the MCGR and VEPTR groups than the TGR group at timepoint 1 (5.5 vs 6.0 vs 2.0 ng/mL, p=0.01) and timepoint 2 (6.5 vs 7.5 vs 2.0 ng/mL, p<0.001) (Table). Binary comparisons showed a significant difference in serum Ti level between MCGR and TGR (timepoint 1: p=0.026, timepoint 2: p=0.011) and VEPTR and TGR (timepoint 1: p=0.035, timepoint 2: p=0.003). Although the VEPTR group had a longer time from the index surgery (p=0.001) and greater number of lengthenings at the first serum Ti collection (p=0.016), there was no difference in serum Ti level between MCGR and VEPTR (timepoint 1: p=0.399, timepoint 2: p=0.492). No EOS patients had detectable urine Ti.

Conclusion
EOS patients treated with Ti alloy GFI had elevated serum Ti levels compared to age-matched controls that persisted over time with no evidence of renal excretion, raising concerns for end organ accumulation with unknown long-term effects.

	TGR (n=6)	MCGR (n=8)	VEPTR (n=6)	*p*-value
Demographics				
Age at index surgery (years)	7.2 (6.6-9.8)	6.6 (5.6-8.6)	2.2 (1.1-4.9)	**<0.001**
Body mass index (kg/m^2)	18.3 (14.3-23.2)	16.0 (15.0-23.2)	16.9 (15.7-20.1)	0.973
Ambulatory status, n (%)				0.158
Ambulatory	4 (67%)	8 (100%)	6 (100%)	
Non-ambulatory	2 (33%)	0 (0%)	0 (0%)	
Duration of follow-up (years)	2.1 (1.6-4.4)	2.2 (1.4-4.5)	7.5 (7.2-10.9)	**<0.001**
Serum titanium level (ng/mL)				
Timepoint 1	2.0 (1.0-3.0)	5.5 (3.3-12.8)	6.0 (2.8-8.0)	**0.01**
Timepoint 2	2.0 (1.0-3.0)	6.5 (5.0-13.5)	7.5 (5.3-8.3)	**<0.001**
Surgical data				
Time from index surgery to first serum collection (months)	14.0 (7.5-44.5)	10.0 (6.9-24.2)	64.5 (60.5-109.0)	**0.001**
Time from first to second serum collection (months)	6.3 (6.0-9.6)	6.1 (6.0-8.4)	6.1 (6.0-9.2)	0.95
Number of lengthenings/patient at time of first serum collection	1.0 (0.0-4.8)	2.0 (1.3-6.8)	8.0 (6.3-12.0)	**0.016**
Number of lengthenings/patient between first and second serum collections	1.0 (1.0-1.3)	2.5 (2.0-3.8)	1.0 (0.8-1.3)	**<0.001**
Total number of rods implanted between index surgery and first serum collection	2.0 (2.0-4.5)	2.0 (2.0-2.0)	6.0 (4.8-8.8)	**<0.001**

TGR, traditional growing rods; MCGR, magnetically controlled growing rods; VEPTR, vertical expandable prosthetic titanium rib
Values are shown as median (interquartile range) unless otherwise indicated.
p-values in bold are <0.05.

Table.

127. Screening MRI in Congenital EOS; Is it Safe to Delay Advanced Imaging to Decrease Early Anesthesia?

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Hypothesis
In patients with congenital EOS, there are no significant complications from delaying MRI in the setting of a normal exam.

Design
Retrospective Chart Review

Introduction
Patients with congenital early-onset scoliosis (EOS) undergo spine MRI to rule out neural abnormalities. MRIs often require anesthesia in younger patients. Due to the uncertainty of the effects of childhood anesthesia exposure, the FDA advises elective anesthesia be delayed until after age 3. The age at which MRIs are currently obtained in congenital EOS is not well known. We set out to quantify the prevalence of neural axis abnormalities in these patients and determine if a delay in MRIs affects outcomes.

Methods
A multicenter registry with information on 2429 congenital EOS patients was reviewed. 665 patients were identified after excluding patients without information on MRIs, 2-year follow-up, and other syndromic diagnoses. Data included age and findings of first MRI, neurosurgical interventions, neurologic complications, baseline Cobb angles, and unplanned return to operating room for orthopedic complications (UPROR). We used Pearson bivariate correlations and unpaired Mann-Whitney test for statistical analysis.

Results
Data was divided into two groups; patients with an MRI < age 3 (n=282) and > age 3 (n=383). 128 abnormal MRIs were identified (19.2%). A negative correlation existed between abnormal MRI and age at time of MRI (r=-0.614, p=0.004). In patients with abnormal MRIs, no correlation existed between the age during MRI and UPROR. There were 2 neurologic complications in the <3 group.

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No neurologic complications were found in the >3 group. No significant difference was found between UPROR in patients with abnormal MRIs <3 (13/59) and >3 (23/69), p=0.9. There was a significant difference between mean baseline cobb angles of the two groups (<3 =50.6°, >3 =56.4 °), p=0.029 (Table 1).

Conclusion

The prevalence of neural axis abnormalities in congenital EOS was 19.2%. Younger patients had a higher chance of an abnormal MRI; possibly due to screening patients with positive physical exam findings. Patients after age 3 did not have more neurologic complications but did have larger baseline Cobb angles. UPROR is not significantly different between patients receiving MRIs before or after age 3. In congenital EOS, postponing MRI over age 3 can be cautiously done, given a normal exam and Cobb control.

	Cobb angle average	#Abnormal MRI	#UPROR For Abnormal MRI	Neurological Complications For Abnormal MRIs
Age range≤3	50.6	59	13	2
Age range >3	56.4	69	23	0
P value	0.029	0.08	0.9	NA

Table 1: Descriptive Data and Complications

128. Smaller Curves in Juvenile Idiopathic Scoliosis Improve with Part-Time Bracing

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Hypothesis

Part-time bracing for smaller curves would result in less progression in curve magnitude, less progression to ≥25° with clinical indication for full-time bracing, and less progression to full-time bracing.

Design

Single-center, retrospective cohort study.

Introduction

Bracing efficacy in juvenile idiopathic scoliosis (JIS) is controversial and understudied. Bracing is typically initiated for curves ≥25°, but evidence suggests part-time bracing in skeletally immature adolescent idiopathic scoliosis patients with curves <25° may prevent progression to full-time bracing. We aim to assess the short-term efficacy of part-time bracing in JIS patients with smaller curves compared with the standard-of-care observation.

Methods

Skeletally immature JIS patients 4-10 years of age with 15-24° curves and open triradiate cartilage were retrospectively reviewed. Interventions were observation or part-time bracing (10-12 hours/day). Minimum 2-year outcomes evaluated included: change in curve magnitude (≥5°); curve progression to ≥25° meeting indications for full-time bracing; actual prescription for full-time bracing.

Results

73 patients were evaluated (59% observed, 41% part-time braced) (Table 1). Age, sex, skeletal maturity, and body mass index were similar in both cohorts. Baseline curves were statistically higher for braced patients by 1.39° (p=0.05). At last follow-up, on average braced patients' curves improved by 5.63° (p<0.001), while observed patients' curves didn't change (p=0.20). 70% of braced patients improved by ≥5° compared to 21% observed (p<0.001). Braced patients' curves were 5.73° smaller than observed at last follow-up (p<0.001). Almost three times as many observed patients showed any progression ≥5° (33% vs 13% p=0.06), and over twice as many observed patients progressed to ≥25° with clinical indication for full-time bracing (47% vs 17% p=0.008). In practice, 58% of observed patients were prescribed full-time bracing, while only 17% of part-time braced patients transitioned to full-time bracing (p<0.001).

Conclusion

Early part-time bracing demonstrated curve improvement ≥5° in 70% of patients. Observed patients were almost three times as likely to progress ≥5° and more than twice as likely to progress to ≥25° compared to part-time bracing. When comparing how patients were treated at final follow-up, 58% of observed patients were prescribed full-time brace treatment (18 hours/day) compared to 17% of part-time braced patients.

Table 1. Demographics & Outcomes of Observation vs Part-Time Bracing

All Patients		Intervention Type **Observation (N=43)**		Intervention Type **Part-Time Bracing (N=30)**		P-value
Age (mean; years) (standard error)		8.66 ±0.25 [CI 95%: 8.41,8.91]		8.91 ±0.25 [CI 95%: 8.66,916]		0.48
Sex	Female (N (%))	34 (79%)		28 (93%)		0.11
	Male (N (%))	9 (21%)		2 (7%)		
Triradiate Cartilage (Missing=1)	Open (N)	42		29		0.42
	Closing (N)	0		1		
Body Mass Index (mean; kg/m²) (standard error) (Missing=4)		16.82 ±0.47 [CI 95%: 16.35,17.29]		16.56 ±0.41 [CI 95%: 16.15,16.97]		0.69
Type of Curve (Missing=7)	Thoracic (N)	29		13		0.03
	Thoracolumbar (N)	8		11		
	Lumbar (N)	1		4		
Follow-Up Time (years) (standard error)		5.08 ±0.26 [CI 95%: 4.82,5.34]		3.28 ±0.31 [CI 95%: 2.97,3.59]		<0.001
Curve magnitude at Onset of Intervention (mean; °) (standard error)		18.21° ±0.46 [CI 95%: 17.75,18.67]	p=0.20	19.60° ±0.48 [CI 95%: 19.12,20.08]	p<0.001	0.05
Curve Magnitude at Last Follow-Up or Prior to Change in Treatment (mean; °) (standard error)		19.70° ±1.26 [CI 95%: 18.44,20.96]		13.97° ±1.36 [CI 95%: 12.61,15.33]		0.003
Change in Curve Magnitude after 2 years	Progression by ≥5° (N (%))	14 (33%)		4 (13%)		0.06
	Stabilization by <5° (N (%))	20 (46%)		5 (17%)		0.008
	Improvement by ≥5° (N (%))	9 (21%)		21 (70%)		<0.001
Curve Progression to ≥25° with Clinical Indication for Bracing	Progression (N (%))	20 (47%)		5 (17%)		0.008
	No Progression (N (%))	23 (53%)		25 (83%)		
Patients for whom Full-Time Bracing was Prescribed (N (%))		25 (58%)		5 (17%)		<0.001

129. The Spring Distraction System for Growth-Friendly Surgical Treatment of Early Onset Scoliosis: Performance After >2 Years Follow-Up in a Prospective Clinical Trial.

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Hypothesis

Patients treated with the optimized version of SDS will show promising results compared to alternative treatment options after >2 years follow-up.

Design

A prospective clinical trial.

Introduction

The Spring Distraction System (SDS) was developed at our institution five years ago to treat early onset scoliosis (EOS). The system consists of standard rods and connectors that are distracted with a titanium spring. To evaluate its performance and to develop the system further, patients were enrolled in a clinical trials and followed prospectively. During this trial, we optimized the configuration, spring force and rod diameter to a standard that we have used the last three years (Fig. 1).

Methods

After IRB approval, EOS patients without a soft tissue disease, e.g. osteogenesis or Marfan, with an indication for a growth-friendly system and open triradiates, were included after informed consent. Demographics, perioperative and regular follow-up data – e.g. severe adverse events, unplanned returns to the operating room (UPRORs) and health-related quality of life (HRQoL) – were prospectively recorded every six months.

Results

Seventeen EOS patients (3 congenital, 4 idiopathic, 9 neuromuscular, 1 syndromic) with at least 2-year follow-up were included. Mean age at surgery was 9.7±2.5 years with a mean follow-up of 2.7±0.5 years. Mean surgical time was 174 minutes with 398 mL blood loss, and initial correction was approximately 50% (mean main curve decreased from 77 to 39°). During follow-up, correction was maintained, and spinal growth was near physiological (T1-S1 height increase 9.7 mm/year). Four SAEs were observed. UPRORs were needed in four patients for re-tensioning of the springs and/or when growth exceeded the rod length. This resulted in 0.09 UPRORs/patient/year. This favorable performance may be reflected by the increase in overall HRQoL scores from 57±18 to 76±14 at two years postoperatively.

Conclusion

The custom SDS implant configuration employed shows promising early results after >2 years follow-up. Especially the failure rate compared favorably to currently available alternatives. Curve control and growth are in line with alternative growth-friendly implants. We continue to work towards medical registration of this implant.

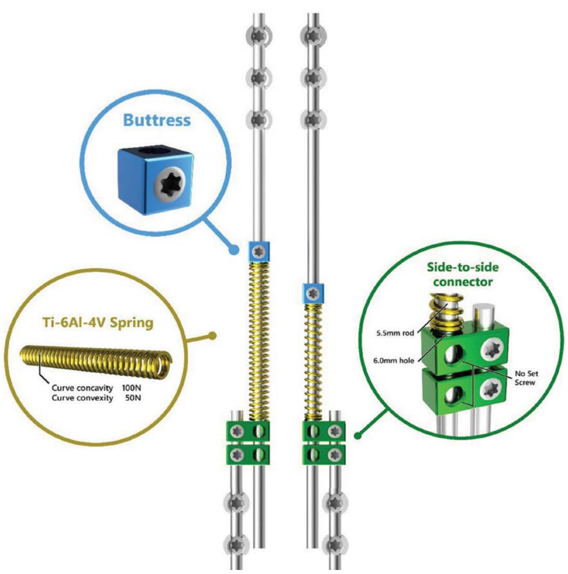

Figure 1. Typical configuration of The Spring Distraction System (SDS).

130. The Optimal Surgical Timing for Posterior-only Hemivertebra Resection in Children Younger than 10 years

Ziming Yao, PhD; Xue Jun Zhang, MD

Hypothesis

There is an optimal age group for pediatric patients to undergo posterior hemivertebra resection.

Design

Single-center retrospective

Introduction

Posterior hemivertebra resection is popular for congenital scoliosis. However, there is no consensus about when to do the hemivertebra resection for children younger than 10 years old.

Methods

Retrospective analysis was conducted for the clinical data of 104 congenital scoliosis children with thoracolumbar hemivertebra undergoing one-stage posterior-only hemivertebra resection with short-segment internal fixation and fusion, with at least a 36-month follow-up, from January 2010 to December 2017. There were 51 males and 53 females, aged 1.6~9.9 years with a mean age of 4.1 years. Standing anteroposterior and lateral radiographs of full spine were compared pre-operatively, post-operatively and at the last follow-up. Radiographic evaluation included measured changes in Cobb angle, segmental kyphosis and compensatory proximal and distal scoliosis. All children were divided into three groups: before 3 years of age group (n=47), aged 3~6 years group (n=32) and after 6 years of age group (n=25). The clinical data and spinal radiographs measurements were compared among 3 groups.

Results

The mean follow-up was 52.9 months. The mean age was 2.5 years in before 3 years of age group, 4.3 years in aged 3~6 years group, and 7.8 years in after 6 years of age group. The Cobb angle of the main curve before surgery, corrective rate of main curve, corrective rate of segmental kyphosis and compensatory proximal and distal curve after surgery were not found to be statistically different among the three groups (P>0.05). Before 3 years of age group had higher instrumentation-related complication incidence than the other groups (P<0.05); after 6 years of age group had more fixed segments than before 3 years of age group (P<0.05). The time of operation and estimated blood loss of after 6 years of age group were more than the other two groups (P<0.05).

Conclusion

Posterior-only hemivertebra resection with short-segment fixation and fusion is effective and safe for children. The corrective outcome is similar in children of different ages. However, children younger than 3 years can suffer more complications, while children older than 6 years have more fixed levels, operation time and blood loss. Thus, children aged 3 to 6 years old are proper for hemivertebra resection.

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131. Risk Severity Score (RSS) for Surgical Site Infection (SSI) is associated with Length of Hospital Stay in Growth Friendly Index Surgeries for Early Onset Scoliosis (EOS)

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Hypothesis
Higher RSS for SSI is associated with a longer hospital and/or ICU stay.

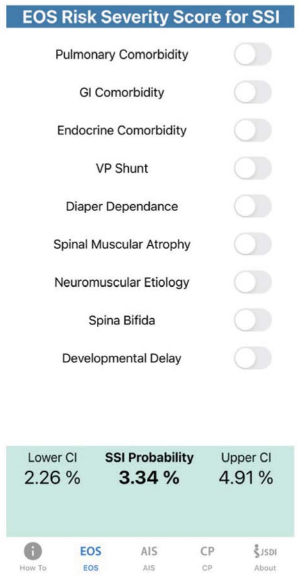
Design
Multi-center retrospective cohort study.

Introduction
Surgical site infection (SSI) is a well-recognized complication of pediatric spine surgery. The senior authors developed a risk calculator utilizing patient factors to produce a risk severity score (RSS) that predicts the probability of SSI in patients with Early Onset Scoliosis (EOS) (Figure 1). The RSS is useful for identifying high risk patients before surgery to optimize perioperative care and potentially reduce SSI incidence. Little is known about how the RSS may influence length of stay (LOS) in the hospital or Intensive Care Unit (ICU). The purpose of this study was to determine whether a higher RSS for SSI is associated with a longer hospital and/or ICU stay.

Methods
EOS patients who had undergone an index growth-friendly (GF) instrumentation were identified from a multicenter registry. Data on their hospital and ICU length of stay was extracted. Their RSS score was calculated based on patient comorbidities (Figure 1). Data was analyzed in full and stratifying by etiology.

Results
896 patients were included (Table 1). Pearson's correlation demonstrated a significant positive relationship between RSS score and hospital LOS r=0.156 (p <0.001), and a correlation between RSS score and ICU LOS, r=0.286 (p < 0.001). Spearman's correlation for patients with neuromuscular EOS showed a positive correlation between RSS and both hospital LOS rs=0.106 (p=0.05), and ICU LOS rs=0.151 (p=0.006). Threshold analysis found that an RSS >5% was associated with a 55.6% chance of a hospital stay >4 days (p=0.0001). An RSS >10% was associated with a 55.1% chance of an ICU stay >1 day (p<0.0001).

Conclusion
RSS is positively correlated with hospital and ICU LOS. A score >5% is associated with a hospital LOS >4days and a score >10% is associated with ICU LOS >1day. These results help to further validate the RSS as a measure of patient fragility.



RSS app

132. Traditional Growing Rod Lengthening Without Intra-operative Neuromonitoring: 20-year Experience with no Neurologic Deficits

Tyler D. Metcalf, BS; Gregory A. Mencio, MD; Jeffrey E. Martus, MD; Craig R. Louer, MD

Hypothesis
Lengthening procedures for traditional growing rods (TGR) can be performed safely without routine intraoperative neuromonitoring (IONM).

Design
Retrospective cohort

Introduction
In definitive fusion and other index surgeries for early-onset scoliosis (EOS), the role of IONM is well established; however, the role of IONM in TGR lengthening is poorly defined. Previous small retrospective studies have noted the paucity of IONM alerts and post-operative neurologic deficits following TGR lengthening. Disadvantages of routine IONM include anesthesia protocol modifications, prolongation of OR time, risks of IONM, and cost—all compounded by the frequency of lengthening procedures. Without clear utility in improving patient safety, the role of IONM in TGR lengthening remains unclear. In this study, we report the safety profile and cost savings of lengthening procedures without the use of IONM.

Methods
A single institution pediatric spine registry was queried (2000-2020) for patients who had undergone operative lengthening of TGR. Per institutional protocol, IONM was not routinely used for TGR lengthening. Charts were reviewed for procedure duration, IONM utilization, and postoperative complications or neurologic

deficits. Institutional cost data was obtained to estimate potential IONM charges based upon mean procedure duration.

Results

A total of 59 patients having 279 lengthening procedures were included in the study. As expected, IONM was not utilized in any of the procedures. Mean age at index surgery was 6.6 ± 2.3 years. Scoliosis etiology was distributed as follows: 19 (32.2%) idiopathic, 15 (25.4%) syndromic, 16 (27.1%) neuromuscular, 9 (15.3%) congenital. Mean major curve cobb angle prior to index surgery was 73.7 ± 21.1 degrees. Mean procedure duration was 45.2 ± 6.1 minutes. Institutional charges for 45 minutes of IONM was estimated at $6,500. No neurologic deficits were noted immediately post-op or during longitudinal follow-up.

Conclusion

279 lengthening procedures were completed without IONM and no post-operative neurologic deficits were noted. Given estimated institutional charges of $6,500 for 45 minutes of IOMN, avoidance of routine IOMN has saved approximately $1,813,500 in this patient cohort. IONM is not required during TGR lengthening in EOS.

133. Outcomes of Growth-Friendly Instrumentation in Osteogenesis Imperfecta

Daniel Badin, MD; Frederick Mun, BS; Behrooz A. Akbarnia, MD; Francisco Javier S. Perez-Grueso, MD; Paul D. Sponseller, MD, MBA; Pediatric Spine Study Group

Hypothesis

In patients with Osteogenesis Imperfecta (OI) and early-onset scoliosis (EOS), growth-friendly instrumentation (GFI) can achieve similar trunk elongation compared to idiopathic EOS patients, but with higher complication rates.

Design

Retrospective Comparative

Introduction

There is limited literature on the outcomes of OI patients undergoing GFI. The purpose of this study was to report the outcomes of GFI in patients with EOS and OI.

Methods

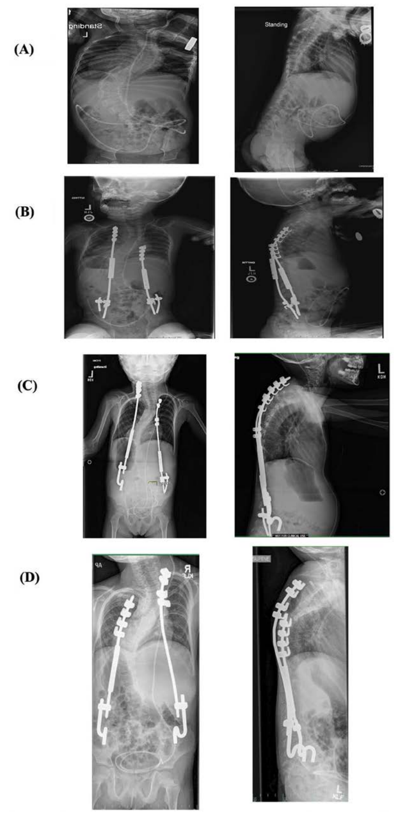
A multicenter database was studied for patients with EOS and OI etiology who had GFI from 2005 to 2020, with a minimum 2-year follow-up. Demographic, radiographic, clinical, and patient-reported outcomes data were collected and compared to an idiopathic EOS cohort matched 2:1 for age, follow-up duration, and curve magnitude.

Results

15 OI patients underwent GFI at a mean age of 7.3±2.1 years, with an average follow up of 7.3±3.9 years. OI patients had a mean preoperative coronal curve of 78.1±14.5 and achieved 35% correction after index surgery. There were no differences in major coronal curves and coronal percent correction between the OI and idiopathic groups at all time points. T1-S1 length (cm) was lower for the OI group at baseline (23.3±4.6 vs 27.7±7.0; P=0.028) but both groups had similar growth (mm) per month (1.0±0.6 vs 1.2±1.1; P=0.491). OI patients had a significantly increased risk of proximal anchor failure, which occurred in 8 OI patients (53%) vs 6 idiopathic patients (20%) (P=0.039). OI patients who underwent preoperative halo traction (N=4) had greater T1-S1 length gain (11.8±3.2 vs 7.3±2.8; P=0.022) and greater percent coronal cobb angle correction (45±11 vs 23±17; P=0.042) at final follow-up vs patients with no halo traction (N=11). At final follow-up OI patients had a non-statistically significant increase in early-onset scoliosis questionnaire (EOSQ) scores. Staged foundation fusion was performed in 2 cases.

Conclusion

Compared to matched idiopathic EOS patients, OI patients undergoing GFI achieved similar radiographic outcomes but sustained greater rates of anchor failures, likely due to weakened bone. Preoperative halo traction was a useful adjunct and may improve final correction. Staged foundation fusion is an idea to consider for difficult cases.



3-year-old with type 1 OI (A) preoperative radiographs, (B) 1 month after index surgery, and (C) 2 years after index surgery. Plowing and displacement of the proximal rib anchors can be noted. (D) This was revised successfully.

134. Outcomes from Surgical Treatment in Idiopathic Early-Onset Scoliosis: A Minimum 25-year Follow-up

Patrick McCabe, MD; Martin Kelly, FRCS (Tr & Orth); Flavia Alberghina, FEBOT; Patrick J. Kiely, FRCS (Tr & Orth); Patrick O'Toole, FRCS (Tr & Orth); Jacques Noel, FRCS (Tr & Orth); David P. Moore, FRCSI MCh; Caroline Goldberg, MD; Esmond E. Fogarty, FRCSI,

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FRACS; Frank E. Dowling, FRCSI, BSc; James F. Kennedy, MD, FRCS

Hypothesis

Patients with idiopathic early onset scoliosis managed surgically will maintain satisfactory patient reported outcome measures at long term follow up

Design

Retrospective Cohort Study

Introduction

The aim of this study was to investigate the long-term surgical outcomes in idiopathic early onset scoliosis (IEOS).

Methods

We identified all patients who had undergone surgical treatment for IEOS at our institution. Medical records at time of discharge from pediatric services were evaluated for surgical management and radiographic outcomes. The national register of deaths was examined for mortality. Those patients who were at least 25 years from index surgical treatment were invited to complete a questionnaire which assessed for further unplanned return to the operating room (UPROR), healthcare utilisation, health related quality of life (EQ5D-5L) and function (SRS-22, Oswestry Disability Index (ODI)).

Results

47 patients with at least 25 years follow-up were identified. 26 patients were excluded due to incomplete data or were lost at follow-up. 3 patients (6%) were known to be deceased. The remaining 18 patients completed all study components. The average follow-up was 34.4 years (25-48.7). The mean age at diagnosis was 4.8 years (1.03-9.1 yrs) and 9.6 years (1.4-14.4 yrs) at index surgical intervention. 12 patients (67%) underwent primary fusion, and 6 patients (33%) underwent growing rod treatment followed by definitive fusion. The mean thoracic height was 20.1 cm (15.5-27 cm) and average thoracic height to thoracic width ratio was 0.99 (0.73-1.37) at completion of surgical treatment. At the time of review 2 patients (11%) were under the care of a respiratory physician. 10 patients (55.5%) graduated from university, the remainder had all graduated from high school. 14 patients (77.7%) worked outside the home. The average EQ5D-5L was 7.2 (5-20). The mean SRS-22 for the cohort was 4.1 (1.4-4.8) and ODI was 10% (0-66%). Since transfer to adult services 3 patients (17%) are known to have undergone further unplanned reoperation.

Conclusion

At a minimum follow-up of 25 years surgical treatment for IEOS demonstrates low rates of UPROR. However, functional and health related quality of life outcomes were variable with some patients experiencing significant disability.

135. What has Changed in the Last Ten Years for Spine Surgery Training? Residency and Spine Fellowship Program Directors Response to A Nationwide Survey 2013 vs 2023

Alan H. Daniels, MD; Daniel Alsoof, MBBS; Bassel G. Diebo, MD; Christopher L. McDonald, MD; Andrew S. Zhang, MD; Craig P. Eberson, MD; Carl B. Paulino, MD; Eren Kuris, MD; William F. Lavelle, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Robert A. Hart, MD

Hypothesis

Over the last decade, there has been significant change in orthopedic (ORTH)/neurosurgery (NSG) residency and fellowship director's responses regarding spine training.

Design

Cross-sectional anonymous survey study emailed to all US Residency Program and Spine Fellowship Directors (382 in 2013, 468 in 2023).

Introduction

Training spine surgeons has been a point of debate for the past decade. In 2013, a survey of spine program directors was reported potentially contributing to changes in training.

Methods

Anonymous questionnaire distributed to all PDs of ORTH and NSG surgery residencies and spine fellowships in the US. Chi-squared tests of association was used to compare answers over the years.

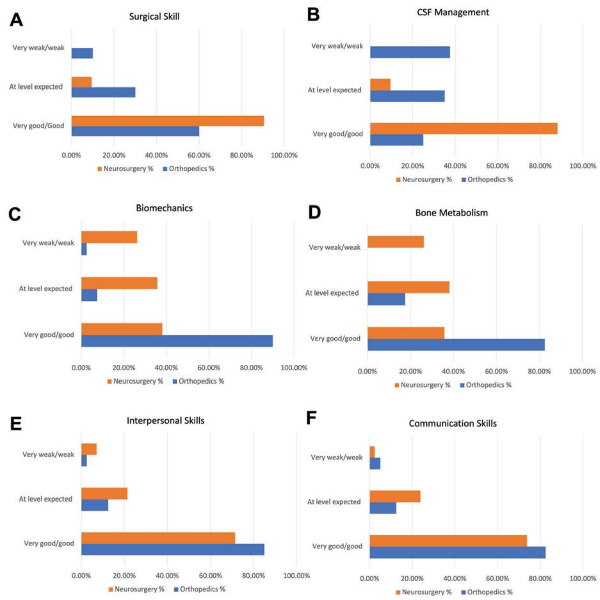
Results

241 PDs completed the survey. From 2013-2023, there was no change in months on spine service (2-4 months for 58% of ORTH vs >1yr for 80% of NSG programs, $p>0.05$). NSG improved % of residents with >300 cases from 86% in 2013 to 100% in 2023, while ORTH remained with >90% of residents <225 cases. There was an increase in % of NSG PDs who encourage spine fellowship for community spine surgery practice (0% agreed in 2013 vs. 20% in 2023, $p<0.05$); this continued to be significantly different from ORTH PDs (~88% agreed, $p<0.05$). 100% of NSG PDs remained confident in their residents performing spine surgery, whereas ORTH confidence decreased from 43% (2013) to 25% (2023). Currently, 95% of ORTH PDs and 94% of neurosurgery PDs recommended that ORTH and NSG trainees should complete a fellowship if they desire to perform spinal deformity surgery ($p<0.001$). 59% of ORTH PDs agreed navigation is important for training, compared to 100% of NSG PDs. 67% of ORTH PDs agree minimally invasive surgery should be a component of residency, compared to 92% of NSG PDs. In 2013 and 2023, 44% were satisfied with the training model. In 2013, 24% believed we should have dedicated spine residency, compared to 41% in 2023 ($p<0.05$).

Conclusion

Spine surgery training has evolved yet ORTH and NSG training remain different in case volumes and educational strengths. Similar to 2013, nearly 100% of respondents believe all trainees should complete a spine fellowship if performing spinal deformity surgery. In both 2013 and 2023, under 50% of program directors were satisfied with the current spine training model, and a growing minority believe spine surgery should have its own residency.

Fig 1. Rating of skill domains between ORTH and NSG.



Fig

136. The Surgical Correction of Severe Scoliosis (SS) with Asymptomatic Syringomyelia (AS): with Traction-assistance without Neurosurgical Intervention

Zhi Zhao, MD; Yingsong Wang, MD; Jingming Xie, MD; Tao Li, MD; Quan Li, MD; Zhibo Song, MD; Tingbiao Zhu, MD; Ying Zhang, MD

Hypothesis

SS with AS could be safely corrected by one-stage posterior spinal correction (OSPSC) under traction-assistance.

Design

Single-center retrospective.

Introduction

For the SS with AS patients, the significance of neurosurgical intervention in reducing the neurological risk of followed spinal correction is still controversial. The superpositions of the hazards and risks from repeated anesthesia and multiple surgeries must be considered carefully. The purpose of this study was to investigate the safety and efficacy of traction-assisted OSPSC in these patients.

Methods

28 patients of SS with AS without previous surgical intervention undergoing traction-assisted OSPSC at one center with > 2 years follow up were included. The clinical and imaging data before traction, after traction and operation (OP) were reviewed. Based on preop MRI, patients were divided by two ways: 1. AS with Chiari 1 malformation and idiopathic AS (CS vs IS); 2. moderate and large syringomyelia (MS vs LS, syrinx/cord ratio 0.6 being set as the division). The contributions of traction and OP were calculated. The contributions of traction/OP between groups (CS vs IS, MS vs LS) were compared respectively. Traction contribution=(initial scoliosis-posttraction scoliosis)/initial scoliosis. OP contribution=(posttraction scoliosis- postop scoliosis)/initial scoliosis.

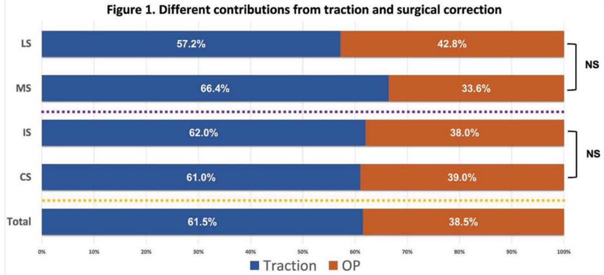
Results

In the 28 patients, 16 were male and the mean age was 19.0 years. Before traction, the mean main scoliosis was 101.0 degrees with a mean flexibility of 21.4%. In the process of traction and OP, the mean scoliosis was reduced by 37.5, 25.2 degrees respectively. After OP, a mean scoliotic correction rate of 63.9% were achieved in total. In which, the mean contributions of traction and OP were 61.5% and 38.5%. None underwent postop neurological deficits. Through the comparisons of CS vs IS and MS vs LS, there was no difference among age, inital main scoliosis and flexibility, postop correction rate (P>0.05); moreover, similar contributions of traction were found in them (61.0% vs 62.0%, and 66.4% vs 57.2%, P>0.05) with similar contributions of OP (P>0.05).

Conclusion

Traction-assisted OSPSC is a feasible choice to safely and effectively correct SS with AS. More than half of the final correction of scoliosis and similar corrective effects can be achieved by traction before surgery even the patients with diverse syringomyelia.

Figure 1. Different contributions from traction and surgical correction



137. Experimental Study of the Asymmetric Growth of Vertebral NCS Modulated with MWA under CT-guided in Immature Porcine

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

Hypothesis

Microwave ablation (MWA) of the NCS can result in asymmetric growth of vertebral body, thus inducing scoliosis in immature porcine.

Design

Prospective randomized controlled study

Introduction

The NCS may play a role in the formation and progression of scoliosis in younger patients. Most of the experimental studies on the modulation of NCS were epiphysiodesis through pedicle screw with greater trauma. There is no report of minimally invasive intervention on the NCS.

Methods

Fifteen six-week-old pigs were assigned to three groups. In the NCS group, five animals were treated with microwave ablation of

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the NCS on the left side under CT-guided; In the sham group, the same sided NCS were punctured under CT-guided in five animals, then the puncture needles were pulled out; In the control group, nothing was done in the other five animals. Radiographs and axial computed tomography images of the spine were obtained every month post-op.

Results

A scoliotic curve was not seen in any of the animals in the sham and control group. All of the five animals in the NCS group formed a structured scoliosis at the first month post-op and the deformity progressed every month. All curves were located at the operated levels with the convexity toward the unablated side. The coronal angle was 13.1±2.19°, 15.49±1.51° and 19.24±3.02°in the NCS group at the first, second and third month post-op separately. The height of the vertebral body and the pedicle length on the left side in the NCS group decreased significantly than the other two groups and contralateral side. The spinal canal area in the NCS group was smaller than the sham and control group. Vertebral rotation occurred slightly in the NCS group.

Conclusion

Unilateral ablation of the NCS minimal invasively under CT-guided in a growing-pig model can precisely modulate asymmetric growth of the synchondrosis to create scoliosis with the convexity on the unablated side. The ablation of the NCS can adversely affected the growth of the vertebral height, pedicle length and spinal canal in immature pigs.

138. Selecting "SSV-1" as Lower Instrumented Vertebra in Scheuermann's Kyphosis: A Prospective Study with a Minimum of 2-year Follow-up

Dongyue Li; Zezhang Zhu, PhD; Yong Qiu, PhD; Zhen Liu, PhD

Hypothesis

To investigate whether one level proximal to the sagittal stable vertebra (SSV-1) could be a valid lowest instrumented vertebra (LIV) for Scheuermann kyphosis (SK) patients with different curve patterns.

Design

A prospective study

Introduction

The proper selection of LIV remains a controversial in the treatment of Scheuermann's disease and there is a paucity of study investigated the clinical outcomes of selecting SSV-1 as LIV.

Methods

This was a prospective study on consecutive SK patients surgically treated with posterior surgery between January 2018 and September 2020, in which the distal fusion level ended at SSV-1. The LIV was selected at SSV-1 only in patients with Risser > 2 and with LIV translation less than 40mm. All of the patients had a minimum of 2-year follow-up. Patients were further grouped based on the sagittal curve pattern as thoracic kyphosis (TK, n=23) and thoracolumbar kyphosis (TLK, n=13). Radiographic parameters were measured and the intraoperative and postoperative complications were recorded. The Scoliosis Research Society (SRS)-22 scores were performed to evaluate clinical outcomes.

Results

A total of 36 patients were recruited in this study, with 23 in the TK group and 13 in the TLK group. In TK group, the GK was significantly decreased from 80.8±10.1° to 45.4±7.7° after surgery, and was maintained at 45.3±8.6° at the final follow-up. While in the TLK group, GK was significantly decreased from 70.7±9.2°to 39.1±5.4° after surgery (P<0.001) and to 39.3±4.5° at the final follow-up. Meanwhile, despite presenting with different sagittal alignment, significant improvement was observed in LL, SVA and LIV translation for both TK and TLK groups (P<0.005). Self-reported scores of pain and self-image in TK group and scores of self-image and function in TLK group showed significant improvement at the final follow-up (all P<0.005). Distal junctional kyphosis (DJK) was observed in two patients (8.7%) in TK group, and one patient (7.7%) in TLK group. No revision surgery was performed.

Conclusion

Selecting the SSV-1 as LIV can achieve satisfactory radiographic and clinical outcomes for SK patients with different curve patterns without increasing the risk of DJK. This selection strategy could be a favorable option for SK patients with Risser sign >2 and LIV translation less than 40mm.

139. Adding Satellite Rods to Standard Two-rod Construct in Posterior Correction of Scheuermann Kyphosis: Can it Promote Vertebral Remodeling?

Xu Sun, MD; Yong Qiu, PhD; Zezhang Zhu, PhD; Sinian Wang, MD

Hypothesis

Patients treated with S-RC had greater vertebral remodeling and less correction loss.

Design

A retrospective cohort study of patients with SK was performed. In total, 26 SK patients aged 10–20 years at surgery were included. All patients received at the least 24 months of follow-up and had Risser sign greater than grade 4 at latest follow-up.

Introduction

This study aimed to investigate reversal of vertebral wedging and to evaluate the contribution of adding satellite rods to correction maintenance in patients with adolescent Scheuermann's kyphosis (SK) after posterior-only instrumented correction.

Methods

Patients receiving placement with a standard 2-RC construct composed the 2-RC group, and those with enhanced instrumentation with satellite rods adding to 2-RC via duet screws were assigned to the S-RC group. Radiographic data and patient-reported outcomes were collected preoperatively, immediately postoperatively, and at the latest follow-up, and compared between the two groups.

Results

There were 13 and 13 patients in the S-RC group and the 2-RC group, respectively. No significant difference was found between groups in preoperative patient's baseline data and surgery related facotrs (osteotomy levels, and fused levels). Remarkable postoperative correction of global kyphosis was observed in both groups, with higher correction rate in the S-RC group had than the 2-RC group (53.8%±6.8% vs. 47.5%±6.5%, P =0.02). The correction loss was slightly but significantly less in the S-RC group during follow-up (1.0°±0.7° vs. 2.3°±1.2°, p < 0.001). The ratio between anterior vertebral body height (AVBH) and posterior vertebral body height (PVBH) of deformed vertebrae notably increased in SK patients from postoperation to the latest follow-up (p < 0.05). Loss of correction of global kyphosis was significantly and negatively correlated with increased AVBH/PVBH ratio. Compared with the 2-RC group, the S-RC group had significantly greater increase in AVBH/PVBH ratio during follow-up (p < 0.05).

Conclusion

Reversal in wedge deformation of vertebrae was observed in SK patients. Patients treated with S-RC had greater vertebral remodeling and less correction loss. The biomechanical benefits of stress dispersion, coupled with increased stability and weight bearing ability, make it a powerful technique promoting structural remodeling and protecting against correction loss.

140. Independent Variables Determining the Outcome Of Halo Gravity Traction (HGT) in Rigid Severe Spinal Deformities - A Multi-centric Study of 65 Patients

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Hypothesis

Age, Duration of HGT, Etiology of spinal deformity, m-JOA score, preoperative cobb, and flexibility are independent variables in determining the outcome of HGT in severe spinal deformities.

Design

Retrospective, Multicentric Study

Introduction

HGT is a standard treatment method for Severe and Rigid spinal deformities (Cobb > 90, Flexibility < 20%) - the variables which determine outcome has not been studied extensively.

Methods

Electronic medical records from 3 centers doing high volume deformity surgery were obtained - age, genderr, duration of HGT, etiology of the spinal deformity, the preoperative coronal and sagittal cobb angle, curve flexibility and the JOA scores for myelopathy (if present) were collected. These independent variables were tested for correlation with the post halo and the final postoperative correction of cobb angle. Complications and intraoperative monitoring data were also collected.

Results

65 patients with a minimum follow-up of 2 years, with mean age 16.6 years (3-74), with mean duration of HGT of 37.2 days (14-135 days) were analyzed.Mean preoperative, post-halo and post final surgery cobb was 95.05, 76.67 and 52.16 degrees respectively . Multivariate regression analysis was done - age, duration, etiology, mJOA score, preoperative sagittal and coronal cobb and flexibility as independent variables were tested for post-Halo and post-operative cobb correction. Flexibility was found to be the only statistically significant variable determining the outcome (r value 0.0026(post-halo),/ 0.114 (postop). Subgroup analysis was done for Congenital, Neuromuscular, Adolescent Idiopathic Scoliosis and Post tubercular Kyphosis. Preoperative flexibility was again a significant variable on post halo (r value 0.312) and post op correction (r value 0.115) in both Congenital and Neuromuscular groups. Mean preoperative neurology (mJoa score) improved from 16.9 (preoperative)to 16.95 (post-Halo) and to 17.19 (post-operative). Intraoperative monitoring changes were seen in 7 patients (10.7%) - none had permanent neurological deterioration. 11 patients (16.9%) had post operative complications including wound healing problems, implant prominence and PJK

Conclusion

Curve flexibility is the single independent variable which is predictive of the efficacy of HGT for severe spinal deformities.

HGT-Neuromscular Scoliosis

141. Chronic Absenteeism in Scoliosis Care: An Analysis of Missed Work and School

Christina M. Regan, BS; Charles P. Nolte; Todd A. Milbrandt, MD, MS; Anthony A. Stans, MD; William J. Shaughnessy, MD; A. Noelle Larson, MD

Hypothesis

Children and parents of children undergoing spinal deformity treatment miss a significant amount of school and work as a result of their medical care. Patients undergoing halo gravity traction or multistage surgery will miss more school and work than their fusion and non-fusion counterparts.

Design

Retrospective comparative study

Introduction

The true burden of scoliosis care extends beyond the cost of treatment and includes loss of income for the parent and missed educational time for the patient. Days of missed school and work have yet to be evaluated for families with a child receiving scoliosis treatment. Chronic absenteeism is defined as more than 18 days of missed school and has a significant impact on a child's educational progression.

Methods

As part of routine clinical practice since 2014, patients/parents presenting for spinal deformity treatment have been queried at a single

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large tertiary center regarding missed days of work or school in the past year due to the child's treatment. The number of reported days missed was compared with the type of surgery.

Results

2877 surveys were completed by 1197 patients/parents. A total 1285 visits (45%) or 658 unique parents (55%) responded that they had missed work, with a mean 13 days, for the treatment of their child's spine condition (SD, 19 days). Similarly, a total of 692 respondents (24%) or 421 patients (35%) reported missing school. Mean reported missed school was 12 days (SD, 18 days). 191 patients responded that they had missed school after having scoliosis surgery. When looking at the effect of surgical type, 38 children undergoing fusion missed a mean of 14.3 days of school while 26 children undergoing non-fusion surgeries missed a mean of 11.8 days of school (p = 0.37). In contrast to those undergoing routine scoliosis procedures, patients undergoing halo gravity traction or multistage surgery missed a mean of 50 days of school, and parents missed a mean of 41 days of work (P < 0.05).

Conclusion

Caregivers and patients miss a significant amount of work and school due to scoliosis treatment. As predicted, patients and parents with multiple surgeries or a halo gravity traction missed more days of school and work when compared to patients and parents of kids receiving fusion and non-fusion surgeries. Further efforts are needed to reduce the burden of scoliosis care on families.

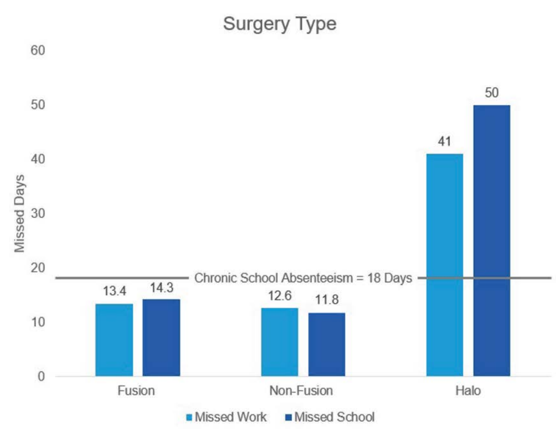

Figure 1: Missed Days according to Surgery Type

142. Assessing the Economic Benefit of Enhanced Recovery After Surgery (ERAS) Protocols in Adult Cervical Deformity Patients: Is the Initial Additive Cost of Protocols Offset by Clinical Gains

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Jordan Lebovic, BA; Pawel P. Jankowski, MD; Peter G. Passias, MD; Thomas J. Buell, MD

Hypothesis

Enhanced Recovery After Surgery (ERAS) protocols may increase cost-effectiveness in cervical deformity corrective surgery.

Design

Retrospective

Introduction

The economic benefit of ERAS protocols, nor the heterogeneous components that make up such protocols, has not been established.

Methods

Operative CD patients ≥18yrs with pre-(BL) and up to 2-year(2Y) postop radiographic/HRQL data were stratified by enrollment in Standard-of-Care ERAS beginning in 2020. Differences in pre, peri-, and post-operative factors were assessed via means comparison analysis. Costs were calculated using PearlDiver database estimates from Medicare pay-scales. QALY was calculated using NDI mapped to SF6D using validated methodology with 3% discount rate to account for residual decline to life expectancy.

Results

270 patients were included (58.11 ± 11.97 years, 48% female, 29.13 ± 6.89 kg/m2. Of these patients, 54 (20.0%) received ERAS protocol recovery treatment post-operatively. Peri-operatively, ERAS+ patients also reported lower mean LOS overall (4.33 vs 5.84, p=.393), and were more likely to be discharged directly to home (χ^2(1) = 4.974, p=.028). Per cost analysis, ERAS+ patients reported a significantly lower mean total 2Y cost of 33,829 USD compared to ERAS- patients at 36,951 (p<.001). Furthermore, ERAS+ patients trended towards greater life-expectancy 2Y QALYs gained versus ERAS- patients (.423 vs .368, p=.051), and demonstrated significantly lower costs at reoperation by 2Y (7050 USD vs 8110, p<.001). Controlling for age, surgical invasiveness, and deformity per BL TS-CL, ERAS+ patients below 70 years old were significantly more likely to achieve a cost-effective outcome by 2Y compared to their ERAS- counterparts (OR: 1.011 [1.001 – 1.999, p=.048].

Conclusion

Patients undergoing Enhanced Recovery After Surgery (ERAS) protocols experience lower operative times, length of stays, as well as lower rates of peri-and and post-operative complications. Subsequently, this study demonstrates that ERAS programs in ACD surgery demonstrate improved cost-effectiveness and reduced total cost by 2Y post-operatively. Due to the potential economic benefit of ERAS for patients, physicians and instutions should consider incorporation of ERAS into practice for eligible patients.

Table 1. Enhanced Recovery After Surgery (ERAS) Protocols Utilized

Pre-Operative	Nutritional optimization (eg. Diabetes, dietary management)
	Specialist consult: ENT (dysphasia risk), cardiology (cardiac stress test)
	Psychological assessment, goal setting, setting recovery expectations
Peri-Operative	Opioid-sparing multimodal approach
	Early mobilization with physical therapists
	Intensive care unit avoidance or minimization
	Enhanced wound care protocol and expedited catheter/drain removal when possible
	Expedited discharge
Post-Discharge	Care team virtual follow-up (discharge day +1)
	Pain-management consultation
	In-office consolation (2-3 weeks post-discharge)

Fig 1. ERAS Protocol

143. Learning Curve for Navigated Screw Placement for Vertebral Body Tethering: 3D Imaging Analysis

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Hypothesis
CT-guided navigation for vertebral body tethering allows for accurate screw placement which improves with surgeon experience.

Design
Retrospective review.

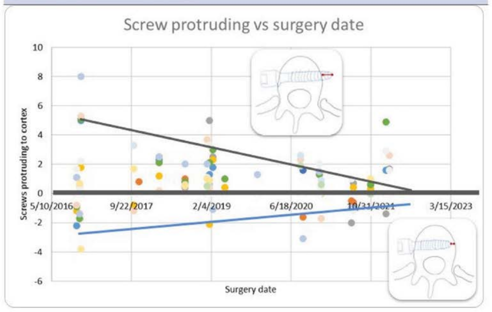
Introduction
Vertebral body tethering (VBT) is increasingly used for the treatment of scoliosis in skeletally immature patients to preserve the spinal motion. O-arm guided navigation is routinely used in our institution to ensure accurate screw placement to avoid intrusion into the spinal canal or excessive prominence or impingement on the major vessels in the thoracic cavity. The accuracy of navigation and the learning curve of navigated screw placement have not yet been evaluated by axial imaging.

Methods
Our institution routinely uses intraoperative CT-guided navigation to place VBT screws (O-arm, Stealth, Medtronic, Minneapolis, MN). From 2016-2022, 133 patients underwent VBT with intraoperative CT-guided navigation. Twenty-two patients had incidental post-operative CTs. The patients were then divided into the early group and the late group according to the surgical date for evaluating the accuracy of navigated VBT. Images of screws were assessed for appropriate screw length (within 2.5 mm of the far cortex), placement within the vertebral body (middle 1/3), and screw head impingement on the rib head.

Results
A total of 169 VBT screws were placed in 22 patients, with a mean of 8 screws per patient (range, 6-12). 144 screws were imaged on incidental postoperative CT. There were 69 screws in the early group and 75 screws in the late group. Rate of ideal screw length (protruding within 2.5 mm of the far cortex) were 56/69 (81%) in the early group and 69/75 (92%) in the late group ($p<0.01$). The mean screw lengths protruding from the cortex were 1.51 mm in the early group and 0.81 mm in the late group ($p<0.01$). There were two screws located too anteriorly in the early group whereas all screws located in the middle of the vertebral body in the late group. The rib head impingement rate was 5/69 (7%) and 0/75 (0%) ($p<0.05$), respectively. There were no major vascular injuries or cerebral spinal fluid leaks in either group.

Conclusion
Navigated VBT results in accurate screw position and length. Accuracy of navigated screw placement improved with surgeon experience.

Total 144 screws, 22 patients	Before 5/2019	After 5/2019	
Number of screws	69	75	
Ideal screws (<2.5 mm away from cortex)	56 (81%)	69 (92%)	p<0.001
Screw Length away from cortex	1.51 mm	0.81 mm	p<0.01
Rib Head Impingement	64/69 (93%)	75/75 (100%)	p<0.05
Ideal Location in Vertebral Body (in the middle of vertebral body)	2/69 (2%)	75/75 (100%)	p=0.22



144. Delayed Onset Neurologic Deficit Following Spinal Fusion for Pediatric Spinal Deformity

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Hypothesis
Transient hypotension may be associated with Delayed onset neurologic deficits (DOND) after spinal deformity surgery.

Design
Retrospective multicenter case review

Introduction
While the management of intraoperative neuromonitoring changes has continued to improve, delayed onset neurologic deficits (DOND) are poorly understood but often devastating.

Methods
Retrospective case review from 8 hospitals was performed evaluating clinical and radiographic parameters of patients who suffered a new neurologic change after spinal deformity correction.

Results
14 pts were included. 9 patients had presumed AIS, 2 had syndromic, 2 had neuromuscular, 1 had congenital scoliosis. Preoperative Cobb measured 73+/-25 and C-DAR was 10+/-4. No patient had preoperative traction and 12 had intraoperative posterior column osteotomies. 3 patients had temporary intraoperative neuromonitoring changes. 13 patients (93%) had new neurological changes within 24 hours post operatively (range 3-24 hrs). 7 of the 14 (50%) patients had at least one episode of hypotension (MAP<60mmHg) surrounding the change in neurologic status. Axial imaging was used in all patients and showed implants to be contained in bone. 4 patients sustained a spinal cord infarct, all in the cervical spine proximal to instrumentation, and did not show any neurologic recovery. One patient showed pontine demyelination in the spinal cord and brain on POD#5. 10 patients (72%) were treated with vasopressors to maintain MAP>24 hours. 12 patients

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returned to the operating room and underwent an average of 2 additional procedures. Of 9 patients with some (6 complete, 3 partial) neurological return, no infarct was seen on axial imaging and treatment included elevation of MAP +/- hardware removal.

Conclusion

Delayed neurological change is a rare but dreaded complication of spinal deformity correction surgery. This represents the largest documented series comprising 8 high volume spine centers and highlights the multifactorial and still poorly understood nature of this condition. The primary modifiable risk factor appears to be hypotension in the post operative period as 50% of patients sustained a documented hypotensive episode (MAP<60mmHg) around the time of neurological change. Patients with spinal cord infarct did not show any neurologic recovery while those without infarct did recover function. Management included elevation of blood pressure with hardware removal in most cases.

145. Does Custom Instrumentation Reduce the Risk of Implant Failure in Adult Cervical, Spinal Deformity, or Degenerative Lumbar Pathology Patients?: A Multi-Center Predictive Analysis

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Hypothesis

Custom, pre-operatively constructed instrumentation may decrease risk of instrumentation failure in adult spinal deformity (ASD), cervical deformity (CD), or lumbar degenerative (Degen) surgery.

Design

Retrospective, multi-center

Introduction

Custom pre-contoured instrumentation has been increasingly utilized and studied due to the potential for decreased material strain and possible decreased risk of instrumentation failure. Yet, there remains a paucity of literature assessing long-term failure rates with such technologies.

Methods

Operative CD, ASD, and lumbar degenerative patients ≥18yrs with pre-(BL) and two-year (2Y) postop data were assessed. All patients were implanted with pre-contoured custom rods. Patients were categorized as having suffered mechanical failure (rod fracture, screw failure) [Failed] or not [Not Failed] at any point after index surgery. Bonferroni-adjusted ANOVA assessed differences in demographics and radiographics. Conditional backstep binary regression and Conditional Inference Tree (CIT) analysis identified thresholds of predictors of mechanical failure.

Results

171 patients were included (mean age: 59.3±12.7 yrs., 33% F, BMI:27.9±6.0 kg/m2); 43.3% were ASD, 18.7% were CD, and 38.0% were Degen. By 2Y, 4.7% of the cohort suffered instrumentation failure, with 8.1% of ASD, 3.1% of CD, and 1.5% of Degen patients failing (p=.171). The number of rods implanted and undergoing PSO were comparable between Failed vs Not Failed cohorts (p=.105, .580). Adjusted for age and gender, ANCOVA revealed no differences in risk of failure by surgery type (p=.155), nor in time between index surgery and date of fracture (p=.428). Adjusted for gender, pelvic fixation, and magnitude of planned correction, logistic regression revealed Degen patients with BL PT > 27.9° (p=.004) and ASD patients with BL thoracic kyphosis > 39.3° (p<.001) were significantly more likely to experience instrumentation failure by 2Y.

Conclusion

Across adult spinal deformity, cervical deformity, and degenerative lumbar patients implanted with custom pre-contoured instrumentation, failure rates remain well below literature values. For patients who do suffer instrumentation failure, increased baseline thoracic kyphosis in ASD patients, and moderate-severe pelvic tilt in lumbar degenerative patients are predictive of failure by two-years post-operatively.

146. Patient Financial Burden in Surgical Treatment of Adolescent and Adult Spinal Deformity

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Hypothesis

We sought to quantify OOPC for surgical treatment of both adolescent and adult spinal deformity in commercially insured patients.

Design

Retrospective cohort study.

Introduction

Out-of-pocket costs (OOPC) associated with medical and surgical care can cause significant financial burden for patients.

Methods

This retrospective cohort study utilized a large database of commercial insurance claims. Patients undergoing surgery from 2015 – 2020 for adolescent idiopathic scoliosis (AIS) and adult spinal deformity (ASD) were identified using CPT and ICD-10-CM codes. Patients were stratified into cohorts based on age, with patients 10 – 25 years-old classified as AIS, and patients ≥40 years-old classified as ASD. The surgical care episode was considered from 180 days pre-operative to 30 days post-operatively. The primary outcome variable was OOPC, calculated as the sum of deductibles, copayments, and coinsurance, and adjusted to 2020 dollars.

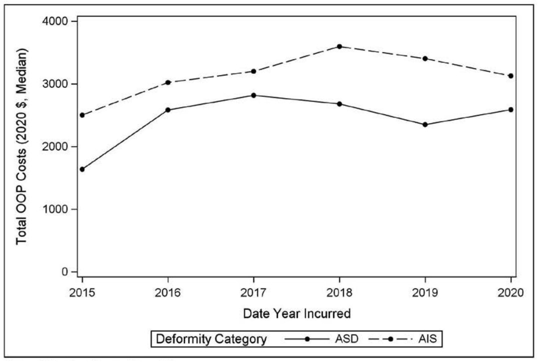
Results

2,869 AIS and 1,528 ASD patients who received surgery between 2015 and 2020 were included in the analysis. The median age in years was 15.0 (SD 2.5) for AIS patients, and 58.0 (SD 6.2) for ASD patients. The majority of patients in both cohorts were female (AIS 75.1%, ASD 64.5%). Of the commercial insurance types, the majority of patients had PPO insurance (AIS 52.4%, ASD 58.0%), with smaller proportions of CHDP (AIS 13.7%, ASD 12.2%), HMO (AIS 11.8%, ASD 8.7%), and HDHP (AIS 11.8%, ASD 8.1%). OOPC were median 2.6% and 1.8% of total net payments for AIS and

ASD surgery, respectively. The median total OOP cost for AIS surgery was $3,231 (SD 2,615) and for ASD surgery was $2,559 (SD 2,803). The total net payments from commercial insurance were $119,493 (SD 71,480) for AIS surgery, and $140,822 (SD 112,060) for ASD surgery. In comparison, national average payment for DRG 456 (spinal fusion for curvature with major comorbidity/complication) in 2020 from Medicare was $50,655. There was significant variation between commercial insurance types, with HDHP plans exhibiting generally the highest OOPC. Total OOPC as well as the total net payments from insurance did not significantly increase from 2015 – 2020 for either AIS or ASD surgery (both p>0.1).

Conclusion

Total OOPC for patients undergoing surgery for AIS and ASD were relatively high. Out-of-pocket costs did not significantly increase over time for either surgery.



Out-of-Pocket Costs Over Time

147. Compliance with the Best Practice Guidelines for Preventing Surgical Site Infections (SSI) in High-risk Pediatric Spine Surgery

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Hypothesis

There will be higher compliance among BPG authors, surgeons with more than 10 years of experience, high yearly case volume, and awareness of the BPGs. There will be no compliance difference between North American and European surgeons or between members of the Pediatric Spine Study Group (PSSG), HARMS Study Group (HSG), and the European Spine Study Group (ESSG).

Design

Cross-sectional survey study.

Introduction

The senior authors published Best Practice Guidelines (BPGs) in 2013 for surgical site infection (SSI) prevention in high-risk pediatric spine surgery. We evaluated compliance to these guidelines.

Methods

We developed an anonymous electronic survey for North American and European surgeons, authors and non-authors, and members of PSSG, HSG, and ESSG. Responders provided years in practice, yearly case volume, adherence to BPG recommendations, and knowledge of the guidelines. Knowledge of the BPGs was assessed, since surgeons could be using the practices as standard-of-care. The survey had 18 Likert scale questions. We developed a mean compliance score to assess adherence ranging from 0 to 3 (0=no compliance, 1=weak to moderate, 2=high, 3=perfect).

Results

Of the 136 surgeons who responded, 73.7% reported high or perfect compliance (all or most of the time). Table 1 shows compliance per guideline, with less than average compliance (<60%) flagged. Mean compliance for all responders was 2.22 +/- 0.41. There were significantly different compliance scores between North American and European surgeons (2.32 vs 1.81 p<0.001), authors and non-authors (2.49 vs 2.19 p=0.023), and surgeons with and without knowledge of the BPGs (2.26 vs 1.81 p<0.001). We found a weak correlation between BPG awareness and compliance (r=0.34 p<0.001) and no correlation between years in practice or case volume with compliance (r=0.03 p=0.37; r=0.15 p=0.78, respectively).

Conclusion

73.7% of surgeons reported high or perfect compliance with BPGs for preventing SSI spine surgery. North American surgeons, BPG authors, and surgeons aware of the BPGs showed higher compliance. Study group, years in practice, and yearly case volume did not affect compliance. BPG recommendations with low compliance should be emphasized, highlighting training opportunities for preventing SSIs in high-risk pediatric spine surgery.

TABLE 1. Best Practice Guidelines compliance breakdown

Questions	All the time		Most of the time		Sometimes		Not at all	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1. Do you have patients use a Chlorhexidine skin wash/wipe at home the night before surgery?	96	67.6	20	14.1	4	2.8	22	15.5
2. Do you obtain pre-operative urine cultures in patients that are incontinent, diaper dependent, or have a history of UTI?	51	35.9*	21	14.8	34	23.9	36	25.4
3. Do patients in your practice receive a pre-operative Patient Education Sheet?	91	64.1	21	14.8	13	9.2	17	12.0
4. Do patients in your practice receive a preoperative nutritional assessment?	28	19.7*	28	19.7	78	54.9	8	5.6
5. When you must remove hair, do you clip instead of shaving the patient?	110	77.5	5	3.5	7	4.9	20	14.1
6. Do your patients receive peri-operative intravenous Cefazolin?	120	84.5	16	11.3	3	2.1	3	2.1
7. Do your patients receive peri-operative intravenous prophylaxis for gram negative bacilli (e.g., Escherichia, Enterobacter, Klebsiella, etc)?	69	48.6*	16	11.3	47	33.1	10	7.0
8. Do you monitor adherence to peri-operative antimicrobial regimes (agent, timing, dosing, re-dosing, cessation)?	118	83.1	14	9.9	5	3.5	5	3.5
9. Do you try to limit operating room access during scoliosis surgery?	85	59.9*	34	23.9	14	9.9	9	6.3
10. Do you use ultraviolet lights in the operating room?	15	10.6*	2	1.4	2	1.4	123	86.6
11. Do you practice intra-operative wound irrigation?	130	91.5*	5	3.5	4	2.8	3	2.1
12. Do you use vancomycin powder in the bone graft and/or the surgical site?	109	76.8	8	5.6	5	3.5	19	13.4
13. Do you use impervious dressings post-operatively?	120	84.5*	8	5.6	9	6.3	5	3.5
14. Do you minimize or avoid post-operative dressing changes prior to discharge?	109	76.8	8	5.6	9	6.3	5	3.5

*Questions with less than average compliance.
*Questions with very high compliance.

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148. Selection of the Lowest Instrumented Vertebra and Odds Ratio of Distal Complications for Lenke Type 5 Curves in Adolescent Idiopathic Scoliosis Using a Posterior Approach: A Systematic Review and Meta-analysis

Esteban Quiceno Restrepo, MD; Amna Hussein, MD; Michael Prim, MD; Ali A. Baaj, MD

Hypothesis

L3 LIV has more adding on

Design

Meta-analysis

Introduction

Lenke classification was published in 2001 but there aren't standardized criteria to select the lower instrumented vertebra (LIV) in Lenke 5 curves when treated with a posterior surgical approach, most of the thoracolumbar/lumbar curves have the lower end vertebra (LEV) at L3 or L4, and there is not consensus about ending the construct at the LEV LEV+1 or LEV -1 due to the risks of disc wedging and chronic lumbar pain vs the risk of sagittal malalignment and decompensation.

Methods

Using electronic databases, studies reporting on LIV selection in AIS Lenke type V curves and associated complications were identified. Studies were excluded if they had patients treated with an anterior approach. A meta-analysis was done to compare the rate of complication between the 357 patients that were instrumented to L3 and L4

Results

Six studies were identified reporting on 381 patients, with an average follow up of 29.9 months (2-117) the number of patients with LIV at L2, L3, L4 and L5 were 2, 241, 116 and 22 respectively. Regardless of radiological criteria 50% of the papers recommended fusing the Lenke V curves to L3. Rotation of less than grade II in the Nash Moe scale, CSVL crossing through the pedicles of the LIV, tilt less than 25° and reverse of the LIV tilt during the bending films were the most common criteria used by the authors to select the LIV. The rate of misalignment in patients instrumented to L5 was reported to be as high as 100%. A meta-analysis was done to compare the overall rate of complication in terms of post op misalignment, adding on, junctional failure and reoperation between 357 patients that were instrumented to L3 and L4. A fixed model was used due to lack of heterogeneity (I2<70% and p0.26). The pooled rate of complication in the L3 and L4 group was 17% and 12% respectively but there wasn't a significant difference between groups (OR 1.55; 0.78,3.09; p0.31).

Conclusion

L3 should be selected as the LIV in most of Lenke V curves, the results of this study show that there was not a significant difference in terms of misalignment, adding on, junctional failure or reoperation between the L3 or L4 groups. Stopping at L3 could save mobile lumbar levels favoring motion preservation in young patients.

149. Spinopelvic Failure After Adult Spinal Deformity Surgery: Incidence and Predictors

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Hypothesis

In adult spinal deformity (ASD) surgery, spinopelvic failures affecting L4-ilium occur at a high rate and are impacted by preoperative demographics, intraoperative factors, and surgical correction.

Design

Retrospective cohort study.

Introduction

Long segment fusions in ASD surgery rely heavily on pelvic fixation, yet spinopelvic failures remain understudied. In a cohort of patients undergoing ASD surgery, we sought to: 1) report the rate of spinopelvic complications and 2) determine predictors of spinopelvic complications.

Methods

A single-institution, retrospective cohort study was undertaken for patients undergoing ASD surgery from 2009-21. Inclusion criteria were: ≥5-level fusion, fusion to ilium, having a sagittal/coronal deformity, and at least 2-year follow-up. The independent variables included demographics, comorbidities, intraoperative factors, and radiographic measurements. The primary outcome was spinopelvic failure, defined as rod fracture or pseudarthrosis from L4- S1, S1 screw failure, iliac screw failure, set plug dislodgment, sacral fracture, iliac screw loosening, or iliac screw prominence. Secondary outcome was spinopelvic failure requiring reoperation. Bivariate statistics were performed.

Results

Of 238 patients undergoing ASD surgery, 191 (80.2%) were instrumented to the ilium. Mean age was 68.3±11.3 and 45 (23.6%) were males. Spinopelvic failure occurred in 67 (35.0%) patients, with 48/67 (71.6%) requiring reoperation. Diabetes was significantly higher in patients with spinopelvic failure (28.4% vs. 19.9%, p=0.031), yet no difference was found in basic demographics, comorbidities, or previous fusions (p>0.050). Intraoperatively, spinopelvic failure was associated with the absence of interbody graft at any level (77.6% vs. 62.9%, p=0.037) and operating surgeon (p=0.015). Regarding failures requiring reoperation, diabetes (29.2% vs. 15.3%, p=0.039), operating surgeon (p=0.002), and the absence of an interbody (79.2% vs. 62.9%, p=0.041) were associated with reoperation.

Conclusion

Spinopelvic failure occurred in 35% of patients undergoing ASD surgery who were instrumented to the ilium, of which 72% required reoperation. Diabetes, absence of an interbody graft, and operating surgeon were significantly associated with major spinopelvic failures requiring reoperation.

Variables	Total Cohort N=191	With spinopelvic complication N = 67	p-value
Preoperative			
Age, mean± SD	68.3±11.3	67.7±11.7	0.660
Female, n (%)	146 (76.4%)	52 (77.6%)	0.779
BMI, mean± SD	29.5±6.3	28.6±5.6	0.205
Comorbidities, n (%)			
Diabetes	38 (19.9%)	19 (28.4%)	0.031
COPD	57 (29.8%)	24 (35.8%)	0.184
CHF	27 (14.1%)	10 (14.9%)	0.818
HTN	138 (72.3%)	50 (74.6%)	0.590
Osteoporosis	37 (25.3%)	12 (23.1%)	0.640
Prior fusion, n (%)	75 (39.3%)	22 (32.8%)	0.181
Intraoperative			
Total instrumented levels	10.5±3.2	10.7±2.8	0.178
Interbody graft at any level, n (%)	46 (37.1%)	15 (22.4%)	0.037
Units of blood received	2.4±2.7	2.4±2.9	0.740
Operative time, min	443.5±143.5	452.9±147.7	0.441
EBL, mL	1,638.5±1,301.7	1,798.4±1,401.5	0.738
Discharged home n (%)	80 (44.7%)	30 (48.4%)	0.760

table

150. Outcomes for Nighttime Bracing in Adolescent Idiopathic Scoliosis Based on Brace Wear Compliance

Karina A. Zapata, PT, DPT; Megan E. Johnson, MD; Donald Virostek, LPO/CPO; Anne-Marie Datcu, BS; Chan-Hee Jo, PhD; McKenzie Gunselman, CPO; John A Herring, MD

Hypothesis

Patients in nighttime braces are compliant with brace wear, and brace wear compliance lowers the risk of curve progression in adolescent idiopathic scoliosis (AIS).

Design

Prospective cohort study

Introduction

The effect of brace wear compliance on outcomes in AIS has been evaluated for full-time brace treatment but is unknown for nighttime bracing. We measured brace wear compliance using temperature sensors for patients treated with nighttime bracing (Providence brace) and evaluated the effect of brace compliance on curve progression.

Methods

134 patients with AIS treated with nighttime bracing were prospectively enrolled and followed until skeletal maturity or surgery. Inclusion criteria were age 10 to 16 years, Risser stage 0 to 2, major Cobb <45° and females <1 year post menarchal. Brace compliance was measured using iButton temperature sensors.

Results

Average Risser stage was 0.4 ± 0.7 (70% premenarchal; 32% open TRC) with average major Cobb of 24.6 ± 4.4° at brace prescription. Curve types were single thoracolumbar/lumbar (58%, n=78), double (36%, n=48), and thoracic (6%, n=8). Curves progressed 2.2 ± 9.8° at skeletal maturity or surgical magnitude. Brace compliance averaged 7.7 ± 2.3 hours after 3 months and 6.7 ± 2.6 hours at brace discharge. Brace duration averaged 2.0 ± 0.8 years. 22% (n=29) of curves improved ≥6°, 49% (n=66) remained stable, and 29% (n=39) progressed ≥6°. 8% (n=11) transitioned to full-time braces. 5% (n=7) progressed to surgery, all of whom were Risser 0 at brace prescription. There was no significant difference in curve progression between Risser 0 and Cobb <25° (1.0°, n=60) versus Risser 0 and Cobb ≥25° (4.7°, n=39, p=0.092) at brace prescription. Curves that progressed ≥6° had decreased brace compliance after 3 months than curves with no progression ≥6° (7.0 hrs vs. 8.0 hrs, p=0.034), but not at brace discharge (p=0.065). Curves that improved ≥6° had higher brace compliance after 3 months than curves with no improvement ≥6° (8.6 hrs vs. 7.5 hrs, p=0.0025), but not at brace discharge.

Conclusion

Nighttime bracing is effective at limiting curve progression in AIS single thoracolumbar/lumbar and double curves. Patients treated with nighttime bracing have a high rate of brace compliance. Curve progression is significantly associated with decreased initial brace wear.

	Total curve change (°)	p-value	90-day Brace Wear (hrs)	p-value	Overall Brace Wear (hrs)	p-value
Risser 0 <25° (n=60) ≥25° (n=39)	1.0 ± 10.0 4.7 ± 11.2	0.092	7.7 ± 2.1 6.8 ± 2.3	0.079	8.5 ± 2.3 7.0 ± 3.0	0.82
Risser 1 & 2 <25° (n=11) ≥25° (n=24)	2.1 ± 5.8 1.3 ± 7.8	0.75	7.1 ± 3.2 6.4 ± 2.9	0.67	6.7 ± 2.1 6.3 ± 2.4	0.90

151. The Addition of Daytime Schroth-based Physical Therapy to AIS Nighttime Bracing Reduces Curve Progression

Karina A. Zapata, PT, DPT; Chan-Hee Jo, PhD; Donald Virostek, LPO/CPO; Amy L. McIntosh, MD

Hypothesis

Physiotherapeutic scoliosis-specific exercises (PSSE) in patients Risser 0 with single thoracolumbar or lumbar adolescent idiopathic scoliosis (AIS) curves treated with nighttime braces will reduce curve progression compared to nighttime bracing alone.

Design

Prospective cohort study

Introduction

The effectiveness of adding PSSE (Schroth-based Physical Therapy [PT]), to nighttime bracing is unknown. The aim of this study was to evaluate PSSE in skeletally immature patients with AIS treated with nighttime braces (PSSE group) compared to the standard-of-care of nighttime bracing alone (Control group).

Methods

Patients with AIS thoracolumbar or lumbar primary curves <35°, Risser 0, and < 1 year post menarchal who donned night-time (Providence) braces were prospectively enrolled into the PSSE or Control group. A temperature sensor recorded the number of hours of brace wear. The PSSE group underwent ≥8 hours in-person PT and performed a home exercise program for 75 minutes/week for 1 year. Exercise adherence was tracked using a paper log initialed by the caregiver in addition to a weekly e-mail.

Results

Seventy-four patients (37 PSSE, 37 Controls) were followed until final visit of skeletal maturity or surgery averaging 2.9 ± 1.0 years. Self-reported exercise adherence in the PSSE group averaged 64% ± 35% at 6 months and 51% ± 36% after 1 year. The PSSE and Control groups had similar baseline Cobb angles (24.0° vs

24.5°), average hours of brace wear (8.0 hours vs. 7.3 hours) and growth at final visit (10.2 cm vs 10.1 cm). The PSSE group had a decrease in curve magnitude after 1 year compared to the Control group (-1.9° vs 1.5°, p=0.03), and no change at final visit compared to curve progression in the Control group (0.5° vs. 7.0°, p=0.01). Furthermore, the PSSE group had a lower incidence of curve progression >5° at final visit (14% vs. 43%, p<0.01). Surgical recommendation did not differ between groups (5% PSSE vs 14% Controls, p=0.43).

Conclusion

The addition of Schroth-based PT reduces curve progression after 1 year and at skeletal maturity in nighttime braced AIS patients with primary thoracolumbar and lumbar curves. Active corrections to the spine during the day from PSSE may enhance passive corrections from the brace at night.

Table. Characteristics and curve magnitude of patients

	Control Group (n=37)	PSSE Group (n=37)	*P*-value
Initial age*	12.1 ± 1.0	12.7 ± 1.3	0.066
Gender	32 girls	31 girls	0.99
	5 boys	6 boys	
Race	29 White	25 White	0.66
	2 Hispanic	5 Hispanic	
	4 Asian	3 Asian	
	2 Black	3 Black	
	0 Native American	1 Native American	
Initial body mass index (kg/m^2)*	17.0 ± 3.4	18.7 ± 4.1	0.40
Initial menarche	25 pre	20 pre	0.51
	7 post	11 post	
	5 male	6 male	
Initial triradiate cartilage	20 open	14 open	0.22
	16 closed	19 closed	
	1 Unknown	4 Unknown	
Initial curve pattern	22 Lumbar	23 Lumbar	0.99
	15 Thoracolumbar	14 Thoracolumbar	
Initial curve magnitude*	24.5° ± 4.0°	24.0°± 3.5°	0.50
1 yr Risser stage*	1.6 ± 1.4	2.3 ± 1.7	0.033**
1 yr menarche	5 pre	9 pre	0.44
	25 post	21 post	
	4 male	6 male	
1 yr triradiate cartilage	2 open	1 open	0.99
	34 closed	35 closed	
1 yr growth (cm)*	6.2 ± 2.5	6.5 ± 3.2	0.98
1 yr curve magnitude*	25.9° ± 8.6°	22.2° ± 8.4°	0.035**
1 yr curve change*	1.5° ± 7.8°	-1.9° ± 6.6°	0.034**
1 yr, curve progression >5° (yes/no)	31% (11/36)	14% (5/36)	0.16
1 yr, curve improvement >5° (yes/no)	8% (3/36)	31% (11/36)	0.035**
Final curve magnitude*	31.5° ± 13.5°	24.5° ± 11.0°	<0.01**
Final curve change*	7.0° ± 12.3°	0.5° ± 9.9°	<0.01**
Final curve progression >5° (yes/no)	43% (16/37)	5% (2/37)	<0.01**
Final curve improvement >5° (yes/no)	16% (6/37)	27% (10/37)	0.26
Surgery recommended (yes/no)	14% (5/37)	5% (2/37)	0.43
Final risser stage*	4.0 ± 0.6	4.1 ± 0.4	0.64
Final age*	15.0 ± 1.4	15.6 ± 1.3	0.16
Final body mass index (kg/m^2)*	19.7 ± 3.0	20.7 ± 4.5	0.64
Final growth (cm)*	10.1 ± 4.8	10.2 ± 5.2	0.99

*Data are mean ± SD. **Indicates statistical significance. PSSE=Physiotherapeutic scoliosis-specific exercises.

Characteristics and curve magnitude of patients

152. Femoral Neck Version in the Spinopelvic and Lower Limb 3D Alignment. A Full-body EOS® Study in 400 Healthy Subjects.

Marc Khalife, MD, MS; Claudio Vergari, PhD; Guillaume Rebeyrat, MS; Emmanuelle Ferrero, MD, PhD; Pierre Guigui, MD; Ayman Assi, PhD; Wafa Skalli, PhD

Hypothesis

Pelvic retroversion is associated with higher femoral version angle

Design

Multicentric retrospective

Introduction

The goal of this study was to better understand the role of femoral neck version in the spinopelvic and lower limb 3D alignment using biplanar X-Rays in standing position.

Methods

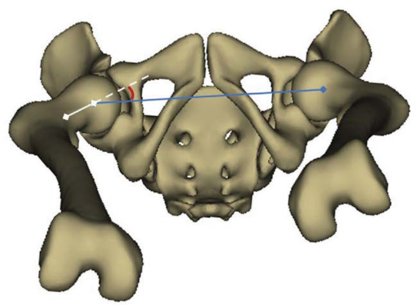
This multicentric study retrospectively included healthy subjects from previous studies who had free-standing position bi-planar radiographs. Subjects were excluded if they presented spinal or any musculoskeletal deformity, and reported pain in the spine, hip or knee. Age, sex, and the following 3D-reconstructed parameters were collected: spinal curvatures, pelvic parameters, Sagittal vertical axis (SVA), T1 pelvic angle (TPA), spino-sacral angle (SSA), Femoral torsion angle (FTA), Sacro-femoral angle (SFA), Knee flexion angle (KA), Ankle angle (AA), Pelvic shift (PS) and ankle distance. Femoral neck version angle (FVA) was calculated between horizontal plane projection of the bicoxofemoral axis and the line passing through the femoral neck barycenter and femoral head center. Analysis according to age subsets was performed.

Results

400 subjects were included (219 females), mean age was 29±18 years (range: 4-83). FVA decreased from childhood to adolescence and young group (p=0.001), and increased to middle-aged and senior group (p=0.007). Subjects with high pelvic tilt presented higher FVA than average and low-PT individuals, respectively 7.8±7.1°, 2±9° and 2.1±9.5° (p<0.001). These subjects also presented lower lumbar lordosis values and higher acetabulum anteversion in the horizontal plane than the two other groups. SVA correlation with FVA was weaker (r=0.1, p=0.03) than SSA and TPA (r=-0.3 and r=0.3 respectively, p<0.001). A strong correlation was found with FTA (r=0.5, p<0.001). SFA (r=-0.3, p<0.001), pelvic shift (r=0.2, p<0.001) and ankle distance (r=0.3, p<0.001) were also significantly correlated. Multivariate analysis confirmed significant association of age, pelvic tilt, lumbar lordosis, pelvic shift, ankle distance and FTA with FVA.

Conclusion

Femoral neck version presents significant relationships with the spinopelvic complex: lower lumbar lordosis, pelvic retroversion, and higher pelvic shift were associated with higher FVA values. Higher age, male gender and increased femoral torsion were also correlated with higher FVA. Normative values are given according to gender and age subsets.



FVA

153. Lumbar Lordosis Redistribution and Segmental Correction in Adult Spinal Deformity (ASD): Does it Matter?

Bassel G. Diebo, MD; Alan H. Daniels, MD; Renaud Lafage, MS; Mariah Balmaceno-Criss, BS; D.Kojo Hamilton, MD, FAANS; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Richard G. Fessler, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Stephen J. Lewis, MD, FRCS(C); Breton G. Line, BS; Pierce D. Nunley, MD; Gregory M. Mundis, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Jeffrey P Mullin, MD; Alex Soroceanu, MD, FRCS(C), MPH; Christopher P. Ames, MD; Lawrence G. Lenke, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis
Correction of lumbar lordosis to segmental ideals restores spinal shape and prevents mechanical complications.

Design
Retrospective review of prospectively collected data

Introduction
Spinal realignment for ASD is an evolving science. Recent data outlining ideal targets for each lumbar lordosis segments has been published, however, little is known whether those targets impact clinical outcomes.

Methods
510 patients who underwent ASD surgery with UIV between T4-L1, LIV at ilium and baseline (BL) and 2-year follow up (2yr) radiographs and PROMs. PI adjusted segmental lordosis were extracted from recent literature, Charles and Pesenti et al (Table). Post-op offset from normative values were calculated. Patients were grouped based on offset to overcorrected (OVER), (MATCH) within 10% of mean offset, and undercorrected (UNDER). OVER/UNDER at L4-S1 and T10-L2 also examined. Surgical strategies (3CO, IBF), PROMs (ODI, VR12, and PROMIS), radiographic and implant related complications, and revisions across groups compared.

Results
Post-op, L4-L5, L5-S1, and L4-S1 were OVER in 38%, 34%, and 35% of pts. T10-L2 and L2-4 were OVER in 45% and 46% of pts. Overall, 14.9-33.5% of pts were matched to ideal segmental lordosis at any level. At 2yr, PJK rate in the T10-L2 groups were 28.9% for OVER, 9.3% in MATCH and 13.2% of UNDER, $p<0.001$. Similarly, L2-L4 groups (25.2 vs 12 vs 15.9%, $p<0.05$). Patients who were UNDER vs OVER in both T10-L2 and L4-S1 had greater rate of revision for implant related complications 18.6 vs 7.8%, $p<0.05$; specifically rod breakage 21.6% vs 12.7%. Pts who were OVER in proximal lordosis and T10-L2 segments had greater junctional zone posterior inclination (-12.5 vs -8.3 vs -7.2°, $p<0.05$) with 76% of proximally OVER patients having UIV posterior inclination of > -10°. 59.4% of patients with laterally placed IB were OVER at T10-L2 vs 42.3% in ALIF, $p<0.05$. PROMs were comparable between correction groups at 2yr. OVER at L4-S1 did not achieve better outcomes vs MATCH, but both had better outcomes vs L4-S1 UNDER (ODI: 25 vs 27.5 vs 32.1, $p<0.05$).

Conclusion
Overcorrection of segmental lordosis based on PI-adjusted ideas led to higher rates of PJK at 2yr. Undercorrection led to more revisions for implant failure (i.e. rod breakage). Proximally and laterally placed interbodies were more likely to overcorrect the thoracolumbar junction; these groups were more likely to sustain a PJK.

PI Category	PI	T10-L2	L1-L2	L2-L3	L3-L4	L4-5	L5-S1
Low	40	-6.9	1.4	5	10	15	20
Avg	50	-4.3	2.3	6.5	10	15	17.5
Avg	60	-4.3	2.3	6.5	10	15	17.5
High	70	2.1	4.9	9.6	12	15	18
High	80	2.1	4.9	11.2	14	17.5	21
HIGH	90	2.1	4.9	12.8	16	20	24

154. Three-Column Osteotomy for The Surgical Treatment of Dropped Head Syndrome Due to the Cervicothoracic-Upper Thoracic Proximal Junctional Failures Following Adult Spinal Deformity Surgery: Radiologic and Clinical Outcomes

Baris Peker, MD; Ali T. Evren, MD; Hamisi M. Mraja, MD; Halil Gok, MD; Cem Sever, MD; Tunay Sanli, MA; Meric Enercan, MD; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

Hypothesis
Severe proximal junctional failures (PJF) located at cervicothoracic-upper thoracic (CT-UT) spine can be treated successfully with three-column osteotomies (3CO). Anterior column lengthening at the level of osteotomy following PVCR procedure enables greater and safer deformity correction

Design
Retrospective

Introduction
Severe PJF following adult spinal deformity surgery can result in Dropped head syndrome (DHS) is characterized by severe kyphotic deformity at the CT-UT spine. Severe kyphotic deformity causes significant sagittal imbalance, horizontal gaze difficulty and chin-on chest deformity. Surgical treatment of the severe kyphotic deformity requires 3COs for correction. The aim of this study is to analyze the efficacy and safety of 3COs in the management of dropped head syndrome due to severe CT-UT PJFs

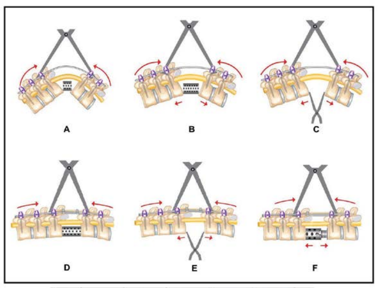
Methods
13 pts (6M,7F) pts who had undergone revision surgery with 3CO for dropped head syndrome were included. These patients had undergone their primary ASD surgeries at different centers and admitted our clinic for revisions. Pre-revision, post-revision and f/up whole spine standing x-rays were evaluated for cervical and global sagittal alignment parameters. Clinical assessment was done with ODI

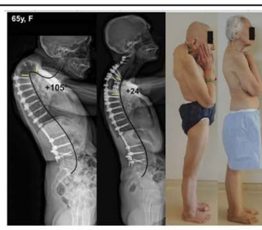
Results
Mean age was 42 (18-79) yrs and mean f/up was 5 (2-15) yrs.

3COs were performed between T2-T4 levels. 3 pts had PSO, 2 pts had Bone-disc-bone resection and 8 pts had PVCR for deformity correction. Preop mean LKA of 66° improved to 14° (79%). All global and cervical sagittal alignment parameters improved postoperatively. Gradual anterior column lengthening technique following PVCR provides proper sagittal alignment restoration both regionally and globally and also avoids iatrogenic neurologic deficit by preventing dural bucking. 7 pts who had preop neurologic deficit had at least one grade improvement at final f/up. Most common complication was dural tears in 3 pts (23%) during PVCR. ODI decreased from 63 to 17. Solid fusion was achieved in all pts

Conclusion

3CO enabled significant correction of severe proximal junctional failures causing kyphotic and rigid deformity, improved neurological deficit and provided proper global and regional sagittal alignment. Anterior column lengthening at the level of osteotomy following PVCR procedure enables greater and safer deformity correction.





155. Does Preoperative Optimization of Psychiatric Conditions Improve Perioperative Outcomes in Adult Cervical Deformity Patients?

Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Lee A. Tan, MD; Peter G. Passias, MD

Hypothesis

To describe psychological burden among cervical deformity surgical patients

Design

Retrospective

Introduction

Previous studies have utilized psychological questionnaires to identify the baseline effects that spine region disability has on psychological distress. Still, there remains a paucity of literature regarding the psychological status of patients undergoing cervical spine surgery.

Methods

Adult patients with symptomatic disease were included. Active major depression excluded. 4 validated self-report instruments: Distress and Risk Assessment Method (DRAM), Fear-Avoidance Beliefs Questionnaire (FABQ), Pain Catastrophizing Scale (PCS), Outcome Expectation question (OEQ). Patients randomized using matched pairs: Sham (placebo group receiving six sham treatments); CBT (treatment by licensed professional). Thresholds were set >17 DRAM, >49/66 FABQ, >30/52 PCS. Subjects not meeting cutoff assigned to control. Those above any thresholds placed Sham or CBT by 1:1 randomization. Any who exceeded psychological distress criteria assigned to DRAM observation only. Logistic regressions analyzed improvements to perioperative 90 day surgical outcomes.

Results

47 enrolled (53.6years, 49% female, 29.4 kg/m2). 57.1% severe FABQ score, 40.8% severe PCS score, 27.7% severe NDI score. Without intervention had greater psychological distress by FABQ (40 vs 17.55; p<0.001) and PCS (27.4 vs 19.25; p<0.001). Those with higher baseline NDI had greater odds of increasing PCS, independent levels fused and diagnosis (OR:1.76 [1.5,2.5]; p=0.019). This trend was similar for FABQ (OR: 1.25; p<0.05). Out of CBT group, thus optimized preoperatively, reoperation rates were lower and less likely to occur compared to not optimized (11% vs 32%, p<.001). Similar relationship was found for FABQ scores in optimized patients compared to not optimized (18.2 vs 40; p<0.001). Optimized patients had lower DJK (7.4% vs 18.9%, OR: .55) and lower length of stay (2.4 vs 7.2; all p<0.05). Patients optimized preoperatively had improved EQ5D Pain and Anxiety Scores compared those not optimized (OR:1.8; [1.33, 1.76] p<0.001).

Conclusion

Degenerative cervical patients without preoperative psychiatric intervention were found to have an overall greater levels of psychological distress. Preoperative optimization of mental health conditions may help mitigate perioperative outcomes after adult spinal deformity correction.

156. Surgery for Neuromuscular Scoliosis Is Associated with Reduced Pulmonary Mortality in Children with Cerebral Palsy

Matti Ahonen, MD, PhD; Ilkka J. Helenius, MD, PhD; Mika Gissler, PhD; Ira Jeglinsky-Kankainen, PhD

Hypothesis

Aim of this study was to compare mortality and causes of deaths in scoliotic children with CP with and without spinal deformity surgery. We hypothesized that scoliosis surgery reduces respiratory causes of deaths in this patient population.

Design

Retrospective national population-based cohort study.

Introduction

Severe neuromuscular scoliosis leads to decreased health-related quality of life (HRQoL) and pulmonary compromise, which scoliosis surgery aims to prevent. It is crucial to assess how scoliosis surgery affects lifespan of children with cerebral palsy (CP) and scoliosis.

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Methods
In this population-based national registry study we identified 4571 children born between 1987 and 2020 who had been diagnosed with CP between 1996 and 2022 from national registries, of these 474 children with CP had been diagnosed with scoliosis. Two hundred and thirty-six had not been operated and 238 were operated for scoliosis during the follow-up median 17.8 (IQR 11.7-25.7) and 23.0 (IQR 18.4-28.2) years, respectively.

Results
Children with CP and scoliosis with non-surgical and surgical treatment were diagnosed with scoliosis at the age of 12.1 and 12.5 years, respectively. Length of gestation and birth weight was similar in both groups. Surgically treated patients had been treated with brace more commonly than non-surgically treated patients (p<0.001), but both groups had similar rate of pneumonia, epilepsy and gastrostomy. During the follow-up mortality was higher in the non-surgically treated group than in the surgically treated group (n=38/236, 16% vs. n=29/238, 12%, p=0.047) (Fig. 1.). Cause of death was respiratory in 76.3% (29/38) in patients with non-surgical treatment and 37.9% (11/29) surgical treatment of scoliosis (OR 5.27, 95% CI 1.83 – 15.21, p=0.002). Neurological causes of death were significantly more common in surgically treated patients than in non-surgically treated patients, 44.8% (13/29) and 15.8% (6/38), respectively (OR 4.33, 95% CI 1.39 – 13.53, p=0.009).

Conclusion
Surgical treatment of scoliosis associates to reduced mortality due to respiratory causes in children with cerebral palsy and scoliosis.

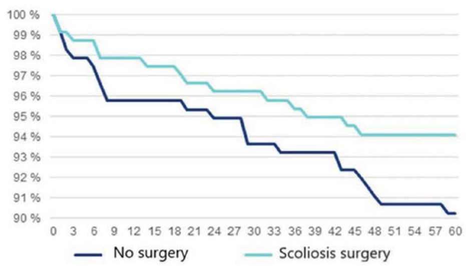


Fig.1 Survival function showing risk of death in non-surgically treated and surgically treated scoliosi patients with cerebral palsy starting at the age of surgery (median 12.8(IQR 9.2-15.2)) years of age (p=0.047).

157. Risk for Reoperation 10-years Following Spinal Fusion for Neuromuscular Scoliosis Associated with Cerebral Palsy

Christopher Seaver, BS; Candice Legister, BS; Sara Morgan, PhD; Casey Palmer, BS; Eduardo C. Beauchamp, MD; Tenner Guillaume, MD; Walter H. Truong, MD, FRCS(C), FAOA; Steven E. Koop, MD; Joseph H. Perra, MD; Daniel J. Miller, MD

Hypothesis
Patients will continue to require reoperation throughout the 10-year follow-up period, reinforcing the need for long-term follow-up.

Design
Retrospective review of consecutive patients with cerebral palsy (CP) who underwent primary spinal fusion at a single specialty care center with a minimum of 10 years from their index surgery.

Introduction
Data on long-term outcomes after spinal fusion in pediatric patients with CP and scoliosis are limited. Our aim was to describe the incidence of reoperation and factors contributing to surgical revision within a minimum of 10 years after spinal fusion.

Methods
Charts for eligible patients were reviewed. Time intervals were defined as 0 - <3 mos, 3 mos - <1 yr, 1 - <2 yrs, 2 - <5 yrs, 5 - <10 yrs, and 10+ yrs. Causes of reoperation were classified as implant failure/pseudoarthrosis, surgical site infection (SSI), proximal junctional kyphosis, and/or prominent/symptomatic implants. Reoperation rate with 95% confidence interval was calculated and a Kaplan-Meier survival curve generated (SAS v9.4). Survival was defined as the percentage with no reoperation on the spine after the index procedure, adjusting for loss to follow-up.

Results
153 patients met inclusion criteria (mean age=14.5±2.7 yrs, 62.0% male); 82.4% had 5-year follow-up and 58.8% had 10-year follow-up. Most (94.1%) were non-ambulatory (GMFCS IV: 28.1% or V: 66.0%) with an average primary curve magnitude of 74±23 degrees. Reoperation rate increased throughout the study follow-up period (Figure 1). Estimates suggest that 80.1% (95% CI: 72.6%, 85.8%) did not undergo reoperation by 5-years post-surgery, and 79.0% (95% CI: 71.2%, 84.9%) did not undergo reoperation by 10-years post-surgery. Indications for reoperation included implant failure/pseudoarthrosis (n=11, 36.7%), SSI (n=10, 33.3%), and prominent/symptomatic implants (n=8, 26.7%).

Conclusion
To our knowledge, this study is the largest long-term follow-up of patients with neuromuscular scoliosis who underwent spinal fusion. Approximately 20% of patients required reoperation 10 years after their index surgery, primarily due to implant failure/pseudoarthrosis, SSI, and prominent/symptomatic implants. Reoperations continued throughout the 10-year period after index surgery, reinforcing the need for long-term follow-up as patients transition into adulthood.

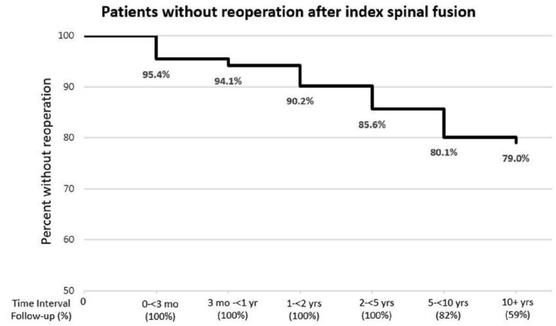


Figure 1. Percentage of patients without reoperation at each time interval.

Podium Presentation Abstracts

158. 15 Years of Spinal Fusion Outcomes in Children with Cerebral Palsy: How Are We Doing?

Daniel Badin, MD; Majd Marrache, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Burt Yaszay, MD; Patrick J. Cahill, MD; Joann Hunsberger, MD; Paul D. Sponseller, MD, MBA; Harms Study Group

Hypothesis
Outcomes of spinal fusion for cerebral palsy (CP) related scoliosis have improved over the past 15 years

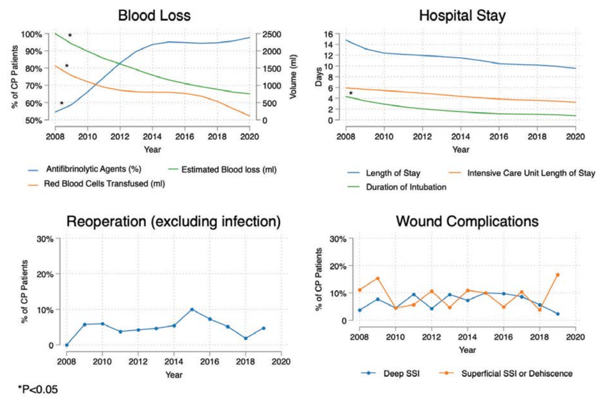
Design
Retrospective cohort study

Introduction
Over the past 2 decades, significant efforts have been placed to improve outcomes of spinal fusion for CP-related scoliosis. We assessed 15-year trends in operative factors, outcomes, and complication rates in this population.

Methods
We retrospectively reviewed a North American multicenter registry for pediatric CP patients who underwent spinal fusion from 2008 to 2020. We evaluated baseline and perioperative data, as well as radiographic and quality-of-life outcomes at a minimum 2-year follow-up.

Results
638 patients were included. Mean estimated blood loss and transfusion volume declined from 2.7 ± 2.0 L in 2008 to 0.71 ± 0.34 L in 2020 and 1.0 ± 0.5 L in 2008 to 0.5 ± 0.2 L in 2020, respectively, with a concomitant increase in antifibrinolytic use from 58% to 97% (all, $P<0.01$). Unit rod and pelvic fusion use declined from 33% in 2008 to 0% in 2020 and 96% in 2008 to 79% in 2020, respectively (both, $P<0.05$). Mean postoperative intubation time declined from 2.5 ± 2.6 days to 0.42 ± 0.63 days ($P<0.01$). No changes were observed in pre- and post-operative coronal angle and pelvic obliquity, operative time, frequency of anterior/anterior-posterior approach, and durations of hospital and intensive care unit stays. Postoperative improvements in the Caregiver Priorities and Child Health Index of Life with Disabilities did not change significantly over the study period. Complication rates, including reoperation, superficial and deep surgical site infection, and gastrointestinal and medical complications remained stable over the study period (Figure 1).

Conclusion
Over the past 15 years of CP-scoliosis surgery, surgical blood loss, transfusion volumes, duration of postoperative intubation, and pelvic fusion rates have decreased. However, the degree of radiographic correction, the rates of surgical and medical complications, and health-related quality-of-life measures have broadly remained constant. These results suggest that, despite our substantial efforts, some of the challenges faced in CP-related scoliosis have been difficult to overcome.



Trends in blood loss, hospital stay, reoperation and wound complications for our cohort. Significant changes were observed for blood loss and hospital stay but not for reoperation and complications.

159. Spinal Fusion in Patients with Classic Amyoplasia and General Arthrogryposis

Dietrich Riepen, MD; Emily Lachmann, BS; Brian Wahlig, MD; Karl E. Rathjen, MD

Hypothesis
Surgical management of scoliosis in patients with arthrogryposis has a high complication rate.

Design
Retrospective Review

Introduction
Arthrogryposis multiplex congenita (AMC) is a group of conditions characterized by joint contractures affecting two or more joints. This study describes results of spinal fusion in patients with classic amyoplasia and general arthrogryposis.

Methods
IRB approved retrospective review of patients with a diagnosis of classic amyoplasia and general arthrogryposis who had a primary definitive posterior spinal fusion between 1990 and 2017 at a single pediatric institution. Patients with distal and syndromic arthrogryposis were excluded as well as patients treated with growth-sparing spinal instrumentation. The Modified Clavien-Dindo-sink (MCDS) classification system was used to describe post-operative complications.

Results
342 patients were diagnosed with amyoplasia and general arthrogryposis, 60 (18%) had scoliosis, and 22 (6% of the cohort and 37% of those with scoliosis) were treated surgically. 6 patients had growth sparing techniques or initial fusion elsewhere, leaving 16 patients. 10 (63%) had a PSF and 6 (37%) had a combined ASF/PSF. The ASF/PSF group was significantly younger at surgery, had a greater ASA status, longer surgery duration, and lower implant density. The average pre-operative coronal Cobb angle for ASF/PSF patients (108 degrees) was greater than patients treated with PSF alone (88 degrees). There were 11 complications in 7 patients, with the most common being deep infection requiring reoperation (5/11, 45%). There was one instance (1/11, 9%) of each: prolonged ICU

admission (>72 hours), superficial wound dehiscence, symptomatic implants requiring removal/revision, coronal plane progression requiring extension of fusion, recurrent pneumothorax requiring return to OR, and pseudoarthrosis leading to implant failure (without revision). Complications occurred in 1/10 (10%) PSF only patients and 6/6 (100%) ASF/PSF patients with all 6 ASF/PSF patients requiring at least one reoperation. The average coronal correction was 49% in the PSF-only group and 28% in the ASF/PSF group.

Conclusion

Complication rates after spinal fusion for scoliosis in AMC patients are high, especially in patients undergoing ASF/PSF, deep infection is common, and major coronal plane curve correction is modest.

Modified Clavien-Dindo-Sink for Post-Operative Complications

Grade	Specific Complication	Overall N = 11 in 7 pts.	PSF Only N = 2 in 1 pt.	ASF/PSF N = 9 in 6 pts.
Grade 1	No patient with a grade 1			
Grade 2	Prolonged ICU Admission (>72 hours)	1 [9%]	1 [9%]	-
Grade 3	Deep Infection requiring reoperation	5 [45%]	-	5 [45%]
	Superficial wound dehiscence	1 [9%]	-	1 [9%]
	Symptomatic implants requiring removal/revision	1 [9%]	-	1 [9%]
	Coronal progression requiring extension of fusion	1 [9%]	-	1 [9%]
	Recurrent pneumothorax requiring reoperation	1 [9%]	-	1 [9%]
Grade 4	Pseudoarthrosis leading to implant failure	1 [9%]	1 [9%]	-
Grade 5	No patient with a grade 5			

160. Prospective Natural History Study of Idiopathic-like Scoliosis in Patients with 22q11.2 Deletion Syndrome, Starting Before its Pathological Onset

Peter Lafranca, MD; Steven de Reuver, MD; Abdiqani Abdi, BS; Moyo C. Kruyt, MD, PhD; Keita Ito, MD, PhD; René M. Castelein, MD, PhD; Tom P. Schlösser, MD, PhD

Hypothesis

A longitudinal database on spinal development in patients with 22q11.2 deletion syndrome (22q11.2DS) can be used for identification of the age of scoliosis onset and differentiation of curves with and without significant scoliosis progression.

Design

Prospective epidemiological study.

Introduction

Previous studies have shown that ±50% of children with 22q11.2DS develops an idiopathic-like scoliosis. In our national 22q11.2DS referral center, patients are biennially radiographically screened for scoliosis from age 6 to adulthood. The purpose of this study is to test whether this longitudinal database can be used to inventory the natural history of scoliosis development in 22q11.2DS patients and to explore whether this can be used for predictive modelling on scoliosis development and progression.

Methods

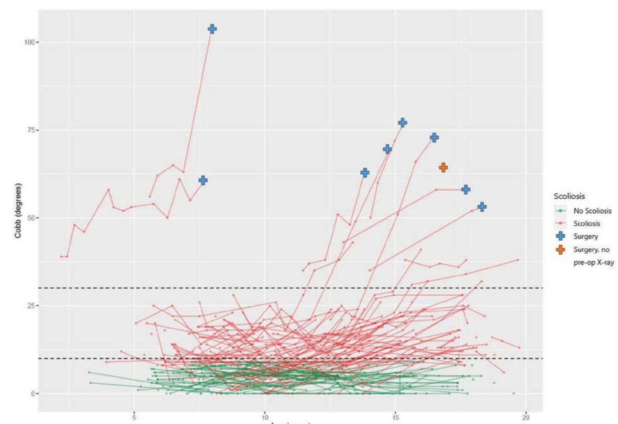
From the prospective registry, which includes radiographs before the onset of scoliosis, 775 full-spine radiographs of 297 patients with 22q11.2DS were included. Coronal Cobb angles were measured and scoliosis development was defined as the first radiograph with a curve >10°, according to SRS guidelines. Age of onset, risk of significant progression to >30° and need for treatment were evaluated.

Results

141 (47%) of the patients developed scoliosis >10°, 15 (5%) progressed to >30°. Nine (3%) required surgical treatment (see figure). Girls to Boys ratio for scoliosis development was 1.1. For scoliosis patients, 33 had radiographs taken before the onset of scoliosis. The mean age of progression into a scoliosis (>10°) was 12.5±2.3 years and ranged from 7.4 – 15.8 years. A total of 69 patients with scoliosis had radiographic follow up until 16 years or older: 45 (65%) had scoliosis with a Cobb>10°, 12 (17%) Cobb>30° and 7 (10%) needed surgery.

Conclusion

This is the first prospective natural history study that describes the course of scoliosis development, starting before the development of the deformity. It demonstrates the exact age of onset and is able to differentiate patients without scoliosis development, patients with scoliosis that remains mild, and patients with severe progressive deformities. This provides the opportunity for future risk-profiling to distinguish between mild and stable versus progressive scolioses.



Longitudinal Cobb angle changes in 22q11.2DS patients with and without scoliosis development. Dashed lines at 10° and 30°.

161. Defect in Extrinsic Pathway Impacts Clotting Efficiency in Neuromuscular Scoliosis

Gregory Benes, BS; William G. Elnemer, BS; Amit Jain, MD; Dolores Njoku, MD; Paul D. Sponseller, MD, MBA

Hypothesis

We hypothesize that patients with neuromuscular scoliosis (NMS) develop reduced clotting efficiency triggered by incision that correlates with the development of increased blood loss.

Design

prospective

Introduction

Children with NMS experience greater intraoperative blood loss than all other types of scoliosis. Interestingly, excessive blood loss

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in NMS is recognizable as early as incision. While mechanisms responsible for these increases have not been completely elucidated, inherent coagulation efficiency likely drives these increases. Our study aims to investigate clotting efficiency via activation of the intrinsic and extrinsic coagulation pathways.

Methods

Blood samples were prospectively collected to compare TEG at pre-incision and 30 minutes following incision in patients with idiopathic and neuromuscular scoliosis undergoing PSF. Both classic and rapid TEG, which activate the intrinsic and extrinsic pathways, respectively, were used to study the effect of neuromuscular conditions on coagulation pathways. Normalized blood loss (NBL) was calculated by dividing blood loss by number of levels instrumented and by patient's weight.

Results

92 children were included consisting of 57 AIS and 35 NMS patients. NMS patients had significantly higher NBL than AIS patients (p=.048). No differences in baseline or at 30 minutes post incision were detected in classic TEG parameters between the two groups. Regarding rapid TEG utilizing the extrinsic pathway, no differences were found at baseline between the two groups. However, at 30 minutes post incision, NMS patients had longer durations in time taken to achieve clot strength amplitude (K) (2 min vs. 1.41 min, p=.03) and less clot lysis at 30 minutes (0.03% and 0.52%, p=.04). Additionally, NMS patients had a greater positive change in K (+0.32 min vs. -0.21 min, p=.01) and decrease in alpha angle (-1.85 deg vs. +1.11 deg, p=.02) after incision compared to AIS patients.

Conclusion

Significant differences in TEG K times, clot lysis and alpha angles were evident in children with NMS when compared to AIS at 30-minutes post incision, although baseline TEG values within normal limits. Our preliminary study suggests that variations in the quantity of extrinsic pathway factors, such as tissue factor pathway inhibitor protein, could promote increased blood loss observed in patients with NMS.

Rapid TEG (normal range)	Pre-Incision			30 Minutes Post Incision			Delta		
	NMS (n=10)	AIS (n=15)	P value	NMS (n=10)	AIS (n=15)	P value	NMS (n=10)	AIS (n=15)	P value
Clot formation rate (min) (0.4-0.8)	0.62 ± 0.2	0.52 ± 0.2	0.12	0.53 ± 0.1	0.8 ± 0.9	0.20	-0.09 ± 0.17	0.27 ± 1.0	0.14
K (min) (0.8-2.2)	1.68 ± 0.6	1.59 ± 0.4	0.33	2 ± 1.1	1.41 ± 0.3	**0.03***	0.32 ± 0.75	-0.21 ± 0.26	**0.01***
A (deg) (65-82.2)	71.14 ± 4.9	71.88 ± 3.8	0.34	69.29 ± 6.9	72.71 ± 3.5	0.06	-1.85 ± 4.4	1.11 ± 2.1	**0.02***
MA (mm) (56.2-78.1)	60.66 ± 6.7	61.91 ± 4.6	0.29	59.61 ± 10.6	63.01 ± 2.7	0.13	-1.05 ± 8.2	1.14 ± 4.1	0.20
LY30 (%) (0-6)	0.34 ± 1.1	0.81 ± 1.2	0.16	0.03 ± 0.09	0.52 ± 0.8	**0.04***	-0.31 ± 1.1	-0.28 ± 1.4	0.48

Table 1: Rapid thromboelastography (TEG) values for neuromuscular and idiopathic scoliosis patients at pre-incision and 30 minutes post-incision. NMS = neuromuscular scoliosis; AIS = adolescent idiopathic scoliosis; R = clot formation rate; K = firm time; A = alpha angle; MA = maximum amplitude; LY30 = Clot lysis at 30 minutes

Regular TEG (normal range)	Pre-Incision			30 Minutes Post Incision			Delta		
	NMS (n=25)	AIS (n=42)	P value	NMS (n=25)	AIS (n=42)	P value	NMS (n=25)	AIS (n=42)	P value
Clot formation time (min) (4-9)	4.31 ± 1.0	4.25 ± 0.8	0.39	3.68 ± 0.7	4.07 ± 1.2	0.07	-0.64 ± 1.3	-0.36 ± 1.8	0.22
K (min) (1-3)	1.24 ± 0.3	1.14 ± 0.5	0.08	1.11 ± 0.2	1.17 ± 0.3	0.17	-0.14 ± 0.3	-0.003 ± 0.5	**0.02***
A (deg) (57-76)	72.85 ± 7.1	73.18 ± 7.7	0.42	74.18 ± 2.9	73.11 ± 3.8	0.12	1.32 ± 7.5	0.74 ± 12.5	0.36
MA (mm) (52-75)	65.5 ± 5.3	63.04 ± 7.9	0.09	65.5 ± 5.3	62.83 ± 9.2	0.10	-0.004 ± 3.7	0.026 ± 13.9	0.49
LY30 (%) (0-10)	1.6 ± 1.4	4.62 ± 14.6	0.16	1.68 ± 1.3	1.62 ± 1.2	0.43	0.08 ± 1.4	-3.11 ± 14.6	0.15
Coag Index (-3-4)	2.44 ± 1.3	2.47 ± 1.3	0.46	3 ± 1.2	2.52 ± 1.2	0.06	0.56 ± 1.6	0.26 ± 1.3	0.19

Table 2: Regular TEG values for neuromuscular and idiopathic scoliosis patients at pre-incision and 30 minutes post-incision. NMS = neuromuscular scoliosis; AIS = adolescent idiopathic scoliosis; R = clot formation rate; K = firm time; A = alpha angle; MA = maximum amplitude; LY30 = Clot lysis at 30 minutes

Rapid and Regular TEG values for patients with NMS and AIS at baseline and 30 minutes post incision

162. Greater Implant Density Does Not Improve Pelvic Obliquity and Major Curve Correction in Neuromuscular Scoliosis

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Hypothesis

Greater implant density in posterior instrumented fusions (PIF) to the pelvis in neuromuscular scoliosis (NMS) patients will achieve better coronal and sagittal correction with long-term durability.

Design

Retrospective review of prospectively collected multicenter NMS registry database.

Introduction

The influence of implant density has received significant attention in the idiopathic scoliosis literature. The NMS population present unique challenges with larger curves and associated pelvic obliquity (PO), osteopenia and more comorbidities. It is unknown how implant density affects initial and long-term correction in NMS.

Methods

All NMS patients undergoing upper thoracic to pelvis PIF with a minimum follow-up of 2 years were included. Implant density was defined as the number of screws per level fused. Patients were divided into two groups, low density (LD) [<1.6 screws/level] and high density (HD) [>1.6 screws/level]. Demographic and radiographic data were collected to perform independent sample t tests with Bonferroni correction between groups.

Results

A total of 236 patients (134 LD, 102 HD) were included. Baseline demographic characteristics were similar between cohorts (Table 1). Likewise, preoperative major curve magnitude and pelvic obliquity were similar between LD and HD (Table 1). Perioperative data was comparable between LD and HD, with greater blood loss in the HD group (P<.001). Two-year postoperative coronal plane measurements revealed a statistically significant reduction in both the major curve 24 (71% correction) versus 32 degrees (64% correction) [p=0.017] and residual pelvic obliquity of 7.1 (76.3% correction) versus 11.6 degrees (58.7% correction) [p=.035] favoring LD over HD. Sagittal plane measurements demonstrated no statistically significant difference between LD and HD at all timepoints. Similarly, no functional outcome differences as measured by CPCHILD were present at any time point in either group.

Conclusion

Low-implant density in NMS demonstrates improved major curve correction and pelvic obliquity correction over higher-implant density constructs at two-years postoperatively with reduced operative time, blood loss and equivalent functional outcomes. Efforts to maximize correction while minimizing operative time, blood loss and cost are imperative in NMS management.

Table: Demographics and coronal plane measurements

Variable	LD, n	LD Mean (± SD) [% Correction]	HD, n	HD Mean ± (SD)	P-Value
Preoperative Characteristics					
Gender (M:F)	134	75:59	102	65:37	.143
Age (years)	134	14.3 (2.8)	101	13.8 (2.8)	.142
Height (cm)	86	142 (12.7)	40	139.4 (15.1)	.316
Weight (kg)	86	34.4 (9.5)	40	34.7 (9.2)	.868
Operative Time (minutes)	134	371 (148)	97	456 (154)	**<.001**
Blood Loss (mL)	134	1356 (1180)	102	1301 (862)	.693
Length of ICU Stay (days)	122	4.6 (7.0)	85	5.0 (4.9)	.654
Length of Hospital Stay (days)	128	9.7 (7.9)	85	10.5 (7.3)	.457
Coronal Plane Measurements					
Preoperative Major Cobb Angle (Degrees)	134	81.7 (22.6)	102	88.7 (24.5)	.123
First erect Major Cobb Angle	132	23.8 (14.3) [71%]	99	32.3 (16.5) [64%]	**.017**
2-Year Major Cobb Angle	134	24.5 (13.9) [70%]	102	35.9 (17.4) [59.5%]	**<.001**
5-Year Major Cobb Angle	73	23.9 (11.5) [70.8%]	47	32.3 (13.5) [63.6%]	.546
Preoperative Major PO (Degrees)	119	29.9 (14.8)	90	28.1 (16.0)	1.000
First erect PO (Degrees)	131	5.9 (6.3) [80.3%]	98	7.1 (6.88) [75.3%]	1.000
2-Year PO (Degrees)	134	7.1 (6.6) [76.3%]	102	11.6 (9.6) [58.7%]	**.035**
5-Year PO (Degrees)	73	6.5 (6.2) [78.3%]	47	9.9 (9.0) [64.8%]	1.000

LD: low density (<1.6 implant density); HD: high density (>1.6 implant density); SD: standard deviation; n= number of patients; first erect: first postoperative image; 2-year = 2-years postoperatively; 5-year= 5-years postoperatively; PO = pelvic obliquity

Table: Demographics and coronal plane measurements

163. What is the Optimal Curve Correction for Cerebral Palsy Patients Undergoing Posterior Spinal Fusion?

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Hypothesis
Cerebral palsy (CP) patients undergoing posterior spinal fusion (PSF) for scoliosis will have significantly improved patient reported outcomes measures (PROM) that directly correlate with pelvic obliquity (PO) and curve correction.

Design
Retrospective review of prospectively collected multicenter database.

Introduction
Previous studies have demonstrated significant improvements in PROMs, assessed using CPCHILD, after PSF for CP patients with scoliosis. However, no studies exist to evaluate the correlation of pelvic obliquity and curve correction on PROMs, or a goal correction to maximize patient outcomes after PSF for CP patients.

Methods
243 CP patients (87% GMFCS IV/V) with a minimum 2-year follow-up after PSF for scoliosis were identified. A more homogenous subset of nonambulatory patients with scoliosis and no hip pathology were separately evaluated (n=116). Preop and 2 year postop surgical and radiographic data were analyzed, while PROMs were evaluated using the CPCHILD questionnaire.

Results
Curve magnitude and PO significantly improved from preop to 2 years postop ($p<0.001$). Patients exhibited significant improvements in all CPCHILD domains at 2 years postop ($p<0.001$) in both cohorts. The majority of patients had PO<10° at 2 years (mean: 8.7°, range: 0-48°) with a mean 44% PO correction. No significant correlation was found with CPCHILD scores and 2 year postop PO or PO correction ($r2<0.1$). There was no correlation with coronal/sagittal curve magnitude or percent curve correction and CPCHILD scores ($r2<0.1$). Results were consistent for the entire group and the subset of nonambulatory patients without hip pathology. Complication rates did not correlate with PO or curve magnitude at two years.

Conclusion
All CP patients demonstrated significant improvements in PROMs following PSF for scoliosis. However, there was no correlation or target minimum curve or pelvic obliquity correction to achieve that resulted in significant improvements in CPCHILD scores regardless of patients' ambulatory or hip status. These results suggest a modest intraop correction may be acceptable to patients vs. performing additional intraop maneuvers to achieve maximal deformity correction, which may needlessly increase surgical time and blood loss.

CPCHILD Domains	Preop	2 years postop	p value
Activities of Daily Living	39.8	46	<0.001
Positioning, Transfer, & Mobility	35.4	44.9	<0.001
Comfort & Emotions	74.9	84.2	<0.001
Communication and Social Interaction	54	57.9	<0.01
Health	55.4	62.2	<0.001
Overall QOL	62.7	72.2	<0.001
Total Score	51.9	58.9	<0.001

		CPCHILD MDC	N	Mean	SD	P value
2 year Postop	Major Curve Cobb Angle(°)	Not improved	190	27.1	14.6	0.07
		Improved	53	31.4	17.4	
		Total	243	28.0	15.3	
	Kyphosis T2-T12(°)	Not improved	187	35.7	14.3	0.11
		Improved	51	31.9	17.7	
		Total	238	34.9	15.2	
	Major Coronal Cobb Correction (%)	Not improved	190	65%	16%	0.18
		Improved	53	62%	19%	
		Total	243	65%	17%	
	Sagittal T2-T12 Cobb Correction (°)	Not improved	166	-7.7	20.4	0.32
		Improved	42	-4.2	21.8	
		Total	208	-7.0	20.7	
	Pelvic Obliquity(°)	Not improved	190	7.6	6.9	0.09
		Improved	53	9.6	9.9	
		Total	243	8.0	7.6	
	Pelvic Obliquity correction (%)	Not improved	188	50%	91%	0.64
		Improved	52	56%	55%	
		Total	240	52%	84%	
	Change in PO (°)	Not improved	190	-17.5	15.1	0.68
		Improved	53	-18.5	16.4	
		Total	243	-17.7	15.3	

CHCHILD MDC: patients that reached minimal detectable change (11.6) in CPCHILD total score

164. Why are we Giving Additional Parenteral Antibiotics to Non-ambulatory Cerebral Palsy Patients with Isolated Acute Post-operative Fevers Following Posterior Spinal Fusion?

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Hypothesis
Isolated, post-operative fevers after spinal fusion for scoliosis in non-ambulatory CP patients is not associated with acute, post-operative infection within 90 days of surgery.

Design
Retrospective review

Introduction
Children with neuromuscular scoliosis secondary to cerebral palsy are at a heightened risk for complications following surgical treatment. The purpose of this study is to evaluate post-operative fevers in non-ambulatory (GMFCS IV and V) CP patients after posterior spinal fusion for scoliosis.

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Methods

Retrospective review in a single-center. Chart review was performed to characterize maximal temperatures during the hospital stay. Post-operative fever defined as temperature >38°C. Patient, surgical, and postoperative variables were collected including additional imaging studies, labs, antibiotics, and antibiotic related complications. Univariate and multivariate analyses were performed.

Results

122 non-ambulatory CP children were included in the study (82% GMFCS V, mean 14.3 years (+/- 3.4 years)). Post-op fever was documented in 92 patients (75.4%) reaching a mean 38.5°C on post-op day 1.67 (+/- 1.3 days). Fever resulted in 138 additional CBC panels, 88 chest x-rays, 47 CRP, 28 blood cultures, and 6 urine cultures. 100% of cultures were negative. Twelve children were administered additional or new parental antibiotics for a mean of 7 days after completion of peri-operative antibiotics. One patient sustained an acute renal injury from Vancomycin toxicity. Presence of a post-operative fever resulted in longer length of hospital stay trending significance (4.8 days vs 7.3 days, p=0.08). Readmission within 90 days occurred in 15.6%, at mean 27.6 days and most commonly associated with pulmonary complication (47.4% vs 24.3%, P=0.039), which was independently predictive of readmission (odd's ratio 2.8, P=0.044). Five (4%) patients underwent repeat surgery within 90 days of primary surgery (3 persistent wound drainage, 2 surgical site infections).

Conclusion

GMFCS IV and V CP patients undergoing posterior spinal fusion have a 75% rate of developing isolated fevers in the acute post-operative period. In the setting of an immediate post-operative fever in isolation, reflexive work-up and empiric antibiotics provide limited utility but can expose the patient to antibiotic related complications.

Table 1. Summary of univariate analysis for variables associated with postoperative fever development following PSF for children with non-ambulatory CP.

Variable	Post-op Fevers (N=97)	No Fevers (N=25)	P-Value
Mean Age at Surgery	14.0±3.5	14.6±3.3	0.2
GMFCS	IV – 61.9% V – 83.2%	IV – 38.1% V – 16.8%	**0.03**
GMFCS V Subclassification	<5.2 - 84.9% ≥ 5.2 - 81.2%	<5.2 – 15.1% ≥ 5.2 – 18.8%	0.62
Underlying Seizure Disorder	Seizure-79.2% No Seizure-81.0%	Seizure-20.8% No Seizure-19%	0.86
Pre-existing Feeding Tube	Feeding Tube-75.4% Without-83.6%	Feeding Tube-24.6% Without-16.4%	0.26
PICU Admission	PICU-88.9% Floor-72.1%	PICU-11.1% Floor-17.9%	**0.02**
Pulmonary Complication	With-90.9% Without-75.3%	With-9.1% Without-24.7%	0.08

*Bold font indicates statistical significance, P<0.05

Univariate analysis results

165. Is Long-Term Follow-Up Required for Low-Grade Spondylolisthesis? A Prospective Study of 247 Children Followed until Skeletal Maturity

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Hypothesis

Long-term follow-up until skeletal maturity is not required for children with low-grade spondylolisthesis

Design

Single-site prospective observational study of 247 children with low-grade spondylolisthesis

Introduction

Low-grade spondylolisthesis is a common spine diagnosis, but there is no large prospective study pertaining to its natural history. Consequently, there are still no guidelines on the requirements for follow-up in this population, and most clinicians will follow patients until skeletal maturity to ensure that there is no slip progression or development of neurological deficits that would require surgery. The objective of this longitudinal study is to document the clinical and radiological changes observed from initial presentation to skeletal maturity for low-grade spondylolisthesis in children.

Methods

A prospective observational cohort of 247 children referred to a single pediatric clinic for a low-grade isthmic spondylolisthesis was followed for a minimum of 2 years until reaching a Risser sign of at least 4. There were 108 boys and 139 girls with a mean age of 13.0±2.7 years at initial presentation, and a mean follow-up of 4.7±2.3 years. The percentage of slip was assessed from x-rays and pain was measured using the SRS-22 outcome questionnaire.

Results

The initial percentage of slip was 14.8±9.0% (maximum 49%). There were 4 patients with a slip percentage between 40-50% that remained unchanged at final follow-up. Slip progression by at least 10% was observed in 7 children (2.8%), but these patients had a slip less than 40% at final follow-up. There was no evidence of neurological deterioration. A small proportion of patients (19%) had worsened pain (0.5 or more decrease in SRS-22 pain subscore) at final follow-up. Surgery was performed in 2 patients due to persisting axial pain after failed conservative treatment.

Conclusion

Progression of low-grade isthmic spondylolisthesis is unlikely during growth. Progression to a high-grade slip or development of neurological deficit was not observed in our cohort. While 19% of patients had worsened pain at final follow-up, surgery is rarely necessary for intractable pain despite conservative management. Although short-term follow-up can be advised to rule out rapid progression of spondylolisthesis, this study suggests that long-term follow-up until skeletal maturity is unnecessary in the majority of cases.

166. The Effect of Antibiotic-Impregnated Calcium Sulfate Beads and Medical Optimization Clinic Attendance on Surgical Site Infection Rate in High-Risk Scoliosis Patients

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Hypothesis

Patients attending a preoperative medical optimization clinic (MOC) and receiving antibiotic-impregnated (Abx-I) calcium sulfate beads will have lower infection rates than those without these interventions.

Design
Prospective Cohort Study of Quality Improvement (QI) processes

Introduction
Neuromuscular and syndromic (NMS) scoliosis patients are at increased risk of acute surgical site infections (SSIs). This study sought to examine the synergistic effects of two QI infection prevention projects. Preoperatively, a medical optimization clinic (MOC) for high-risk patients was created. Intraoperatively, Abx-I beads were used to improve the elution profile for locally delivered abx.

Methods
Patients with NMS scoliosis that underwent PSF between 2016-2022 were prospectively enrolled at a single institution. During this enrollment, two QI processes were implemented sequentially – creation of a preoperative MOC and use of Abx-I beads. Only patients with ≥ 2 of the following risk factors were included: 1) BMI <18.5 or >25 kg/m2 2) bowel/bladder incontinence 3) fused to pelvis 4) non-verbal status 5) GMFCS IV or V. Acute SSI was defined as deep infection within 90 days.

Results
283 patients were included (Mean age at surgery 13.7 ± 3.1 years, 63.1% female, mean major Cobb 81.5° ± 27.1). The overall infection rate was 4.2%. The most common organisms were MRSA, MSSA, and E. coli. Higher GMFCS (p=0.018), non-verbal status (p=0.003), and longer fusions (p < 0.001) were independently associated with higher infection rate. The cohort that both attended the MOC and received Abx-I beads had higher GMFCS scores (4.5), higher ASA class (3), and fusion to the pelvis (85%). Despite these increased risks, the group with both MOC and Abx-I had the lowest SSI rate (2.3%) compared to groups that received neither (4.2%) or only one intervention (5.7%, 4.6%) (p=0.854) (Table 1). This did not reach statistical significance.

Conclusion
This study examined the infection rate of high-risk, NMS scoliosis patients. We implemented two QI interventions (MOC and Abx-I) which appeared to drive acute SSI rates to low levels (4.2%). Patients that attended MOC and received Abx-I had the highest GMFCS scores, ASA class, and % fusion to the pelvis. Regardless of these increased risks, they demonstrated the lowest rate of infection.

	No Additional Interventions	MOC only	Abx-I Beads only	MOC and Abx-I Beads	p-value
Patients (n)	144	22	70	47	
Infection rate	4.2%	4.6%	5.7%	2.13%	0.8537
Age	13.6 ± 3.0	14.4 ± 4.2	14.1 ± 3.2	13.5 ± 2.8	0.494
Percentage Female	63.6%	63.6%	55.7%	72.3%	0.336
ASA	2.72± 0.55	3.09 ± 0.43	2.89 ± 0.40	3.00 ± 0.36	<0.001
Major Cobb Angle	77.12° ± 24.85	74.7° ± 24.5	88.6° ± 31.1	87.7° ± 25.5	0.006
GMFCS	2.70± 1.69	3.68± 1.67	3.96± 1.35	4.53± 0.88	<0.001
Verbal	72.2%	36.4%	58.6%	25.5%	<0.001
Total Levels Fused	13.9± 3.2	15.9± 2.2	15.8± 2.3	16.3± 1.8	<0.001
Percent Fused to Pelvis	35.4%	40.9%	68.6%	85.1%	<0.001

Table 1: Patient Demographics and SSI Rates

167. Does Laminectomy Adjacent to Instrumented Fusion Increase the Risk of Adjacent Segment Disease?

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Hypothesis
Patients who underwent an additional laminectomy adjacent to a fusion will develop ASD at an increased rate

Design
A retrospective review

Introduction
The increased mechanical forces at a laminectomy adjacent to instrumented fusion may lead to more adjacent segment disease (ASD). Few studies have examined the development of ASD with regards to laminectomy performed adjacent to instrumented fusions.

Methods
794 patients at a single institution underwent instrumented lumbar fusion and laminectomy at the same level(s) or instrumented fusion and laminectomy with additional adjacent level laminectomy with minimum 2-year follow-up. Excluded were prior lumbar surgery, fusion without laminectomy, tumor and trauma. 670 patients had instrumented fusion without adjacent laminectomy (group C) and 124 patients had laminectomy adjacent to instrumented fusion (group L). Primary outcomes included timing and development of ASD as well as revision surgery. ASD was determined using X-ray criteria. Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores were collected pre and post operatively. Baseline demographic data was recorded for each patient.

Results
Group L developed ASD at a significantly higher rate of 56.5% (n=70), compared with 35.2% (n=236) in group C (p < 0.001). There was no significant difference in time to ASD (L 30 mo vs C 33.5 mo, p=0.39), revision surgery rate (L 34.3% vs C 30.1%, p=0.56) or time to revision (L 37.9 mo vs C 48.2 mo, p=0.18). ODI and VAS scores did not differ between groups at any time. There were no differences in average levels fused (L 1.75 vs C 1.74, p=0.20), or in baseline demographics except for age (L mean age 67.6 vs. C 62.3, p<0.001). However, age was not found to be an independent predictor of ASD development (p=0.44).

Conclusion
Performing a laminectomy adjacent to an instrumented fusion significantly increased the rate of radiographic ASD but did not result in inferior clinical outcomes or increased revision surgery at 2 years follow-up

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200. Optimal Choice of Lower Instrumented Vertebra Can Prevent Distal Junctional Kyphosis after Posterior Fusion for Thoracic Adolescent Idiopathic Scoliosis

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Hypothesis
Optimal selection of lower instrumented vertebra (LIV) can reduce risk of distal junctional kyphosis (DJK)

Design
Retrospective review of prospective patients followed a minimum of 2 years

Introduction
Previous studies propose ending a fusion at the sagittal stable vertebra (SSV) to prevent DJK, often requiring longer fusion in patients with AIS. This study aimed to describe risk factors for developing DJK, optimal LIV selection, and distal junctional angle (DJA) to prevent DJK. A secondary objective was to define effect of DJK on sagittal alignment, patient-reported outcomes (PROs), and reoperations.

Methods
Patients with Lenke 1 or 2 curves underwent posterior thoracic fusion (PTF) with LIV above or equal to L1. Patients were divided into those who developed DJK (≥10° of DJA) and those who did not. We used a ROC curve to detect cut-off value of DJA and multiple logistic regression to ascertain risk factors for DJK. A mixed effect model was also used to determine if a time-by-group interaction existed in changes in radiographic parameters.

Results
Among 1,064 patients (82% female, mean age: 14.4±2.1 yrs, mean follow-up: 43 months), 85 (8%) developed DJK with higher BMI (23.0 vs 21.6, $p<0.01$) than those without. Mean age at follow-up was 18.0 yrs. The cut-off value of preop DJA was determined as 1°(kyphosis) using the ROC curve (AUC=0.77). Independent risk factors of DJK were DJA≥1°, LIV at SSV-2 or above, UIV of T2 or above, lumbar modifier B or C, and higher preoperative T5-12 kyphosis (Table 1). DJK incidence was 43% when LIV was SSV-2 or above and DJA≥1°, but only 3% when LIV was SSV-1 or below and DJA≤0° (Table 2). Patients with DJK had deterioration of T10-L2 kyphosis and lumbar lordosis over time without increasing SVA (Fig 1). DJK did not significantly affect SRS-22. Five patients with DJK required extension of fusion to a distal level.

Conclusion
PTF should end at a vertebra below significant kyphosis and at least at or one level above SSV when treating patients with thoracic AIS to prevent DJK. DJK after PTF deteriorated regional TL alignment but did not affect global sagittal alignment and PROs at minimum 2-year follow-up, with few reoperations in this adolescent and young adult cohort.

Table 1

	OR	95% CI	P value
BMI	1.02	0.97 - 1.08	0.402
Lumbar modifier B	**2.20**	**1.15 - 4.21**	**0.018**
Lumbar modifier C	**2.58**	**1.25 - 5.32**	**0.010**
DJA ≥ 1°	**3.07**	**1.60 - 5.90**	**<0.001**
LIV: **SSV-2 or above**	**5.80**	**2.46 - 13.70**	**<0.001**
SSV-1	2.16	0.89 - 5.21	0.087
at SSV	1.31	0.51 - 3.34	0.576
UIV: **T2 or above**	**2.97**	**1.48 - 5.96**	**0.002**
T3	1.39	0.69 - 2.80	0.362
Preop T5-12	**1.05**	**1.01 - 1.09**	**0.018**
T5-12 change	0.97	0.93 - 1.01	0.137
Preop T10-L2	1.04	0.996 - 1.08	0.077

Table 2

LIV	DJ angle ≥ 1°	DJ angle ≤ 0°
SSV-2 or above	35/82 (**43%**)	9/50 (**18%**)
SSV-1	11/53 (**21%**)	5/110 (5%)
At SSV	5/53 (9%)	5/145 (3%)
Below SSV	6/92 (7%)	9/453 (2%)

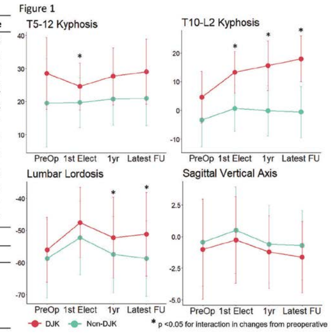

Table 1. Risk factors for developing DJK. Table 2. Occurrence of DJK based on LIV. Fig 1. Changes in radiographic parameters

201. Dystrophinopathy in Paravertebral Muscle of Adolescent Idiopathic Scoliosis: A Prospective Cohort Study

Junyu Li, MD; Danfeng Zheng, MD; Zekun Li, MD; Jiaxi Li, MD; Zexi Yang, MD; Xiang Zhang, MD; Yingshuang Zhang, MD; Miao Yu, MD

Hypothesis
AIS is commonly associated with paraspinal muscle pathology based on previous studies, but the patients did not show typical symptoms of decreased limb muscle strength and respiratory muscle function limitation. So AIS may be a particular kind of core myopathy, and we infer that the pathological changes of paravertebral muscles are involved in the development and evolution of AIS, especially the proteins therein.

Design
prospective cohort study

Introduction
AIS's mechanism remains unknown.Based on the hypothesis that the onset and clinical progression of AIS may be associated with certain neuromuscular diseases, we used pathological methods to further analyze paraspinal muscle changes in AIS patients and introduced immunohistochemical antibody markers used in neuromuscular disease diagnosis through routine morphology. And we are particularly interested in the Dystrophin protein.

Methods
A total of 40 patients with AIS, 20 patients with Congenital Scoliosis (CS) and 20 patients with Spinal Degenerative Disease (SDD) have been enrolled so far. All patients underwent open posterior surgery in our hospital, and paravertebral muscle (multifidus muscle) biopsy was performed during the operation. Many indexes describing muscle were included in this study, especially dystrophin staining. The above pathological results were compared among AIS, CS and SDD groups. The correlation between Cobb Angle and Nash-Moe classification and the above pathological findings was analyzed in AIS patients.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Results
There were significant deletions of dystrophin-1 (P<0.001), dystrophin-2 (P<0.001) and dystrophin-3 (P<0.001) in AIS group compared with both CS group and SDD group. The higher the Nash-Moe classification in the AIS group, the more significant the loss of dystrophin-2 (P=0.042) in the convex paraspinal muscles. In addition, there was a positive correlation between the degree of dystrophin-1 and 2 deletion on the concave side of AIS group and Cobb Angle, and there was a significant correlation between dystrophin-2 and Cobb Angle (P=0.011).

Conclusion
Dystrophin protein deletion of paraspinal muscles plays an important role in the formation and development of AIS. The severity of scoliosis is correlated with the degree of dystrophin deletion in paravertebral muscle of AIS patients. Therefore, dystrophin dysfunction may contribute to the occurrence and development of AIS.

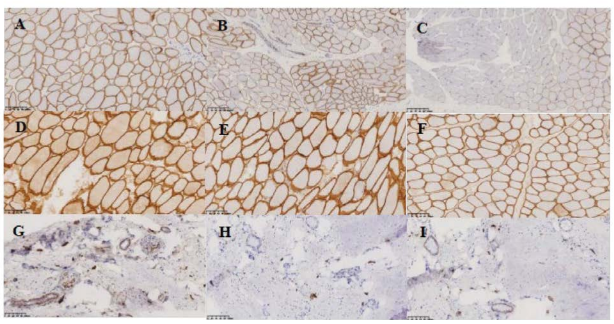

Figure of AIS(A-C), CS(D-F) and SDD (G-I) groups.

202. Effectiveness of Patient Specific Scoliosis Exercises for Adolescent Idiopathic Scoliosis: A Systematic Review and Meta-Analysis

Anthony Baumann, DPT; Kevin Orellana, BS; Caleb Oleson, MS; Deven Curtis, BA; Patrick J. Cahill, MD; John (Jack) M. Flynn, MD; Keith Baldwin, MD, MPH, MSPT

Hypothesis
The hypothesis of the current study is that patient specific scoliosis exercises (PSSE) will show small but clinically meaningful improvements in outcomes in patients with adolescent idiopathic scoliosis (AIS)

Design
Systematic review with meta-analysis

Introduction
AIS is a common pediatric spinal deformity that is often treated conservatively with PSSE. Uncertainty exists on the effectiveness and utility of PSSE in patients with AIS. The purpose of this systematic review and meta-analysis is to determine the impact of PSSE on spinal deformity outcomes in patients with AIS.

Methods
A systematic review and meta-analysis on the effectiveness of PSSE for patients with AIS was performed using PubMed, CINAHL, MEDLINE, Cochrane, and ScienceDirect. Search terms used include "adolescent idiopathic scoliosis" AND "Schroth" OR "scoliosis specific exercise." Primary outcome measures were Cobb angle (degrees), angle of trunk rotation (ATR, degrees), and overall function as measured by the Scoliosis Research Society – 22 (SRS-22) outcome measure.

Results
In total, 628 articles were initially retrieved with 26 articles meeting final inclusion criteria (10 Level I studies, 16 Level IV studies). Overall, 3.20 degrees of improvement was seen with PSSE at 18 months follow-up compared to 1.4 degrees of worsening in controls at a mean of 15.7 months follow-up (p<.001). Meta analysis revealed a statistically significant difference of Cobb angle delta between treatment and control groups with an overall mean improvement of 2.6 degrees (0.91, 4.30; p=0.018). There was a significant improvement in small curves (less than 30 degrees)(p<0.001) with no significant improvement in larger curves (greater than 30 degrees) (p=0.565) in patients treated with PSSE. No significant improvement was seen in ATR (p=0.07) or SRS-22 scores (p=0.16) after PSSE.

Conclusion
PSSE demonstrates a small but statistically significant improvement in Cobb angle in patients with AIS. When stratified based on curve size, improvement was seen for smaller curves, but not in larger curves. No significant improvement was seen in ATR and SRS-22 scores after PSSE in patients with AIS. The current study represents with largest systematic review and meta-analysis to date on the effectiveness of PSSE in patients with AIS.

203. Distal Fusion Level in Duchenne Scoliosis: The Relevance of Preoperative Pelvic Obliquity

Ruben A. Morales Ciancio, MD, FRCS; Claudia Craven, MD, FRCS; Thomas Ember, MD, FRCS; Mark Harris, MD, FRCS; Martin J. Gagliardi, MD, FRCS; Edel Broomfield, ANP; Stewart Tucker, MD, FRCS

Hypothesis
To determine clinical and radiographic outcomes for Duchenne Muscular Dystrophy (DMD) patients who underwent posterior spinal fusion from T2/3 to L5.

Design
Single centre, retrospective case series

Introduction
Duchenne scoliosis (DS) frequently progresses after loss of ambulation and conservative treatment is not effective. Worsening scoliosis can create sitting imbalance, pain, compromising quality of life. Surgery is associated with a high incidence of cardiorespiratory complications, massive bleeding, infection and peri operative mortality but deformity correction improves the quality of life. Recent findings suggest that surgery can have benefits in terms of respiratory decline, mortality, and survival. All these findings justify surgical treatment. As scoliosis surgery for patients with Duchenne muscular dystrophy (DMD) can be life-threatening, these patients require an

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effective and efficient surgery. Posterior spinal fusion (PSF) using pedicle screws and rods is considered the standard practice and usually includes pelvic fixation (PF). This technique can increase surgical time, bleeding, and complications but may be necessary for deformity correction under specific conditions.

Methods

From January 2012 to January 2020, 29 consecutive DMD scoliosis patients underwent posterior spinal fusion using pedicle screws from T2/3 to L5 in a single center with a minimum of 3 years follow-up (FU). Radiologic measurements and chart review were performed.

Results

29 patients aged 14 ± 1.5 years were included. No patient was lost to FU. All patients had significant correction in Cobb angle, pelvic obliquity (PO) and lumbar lordosis (LL), without loss of correction at last FU. The mean values for preoperative, immediate postoperative and last FU were CA 62o, 15o and 17o, PO: 21o, 8o and 9o; and LL 10o, -41o and -41o respectively. Correction in CA was independent of any variable analysed including implant density, rod diameter, traction, or bone density. Regarding PO, it was inversely related to age and independent of all other variables. Factors associated with postoperative complications were age and respiratory function.

Conclusion

Pelvic fixation might not always be required in DMD scoliosis surgery, independently of preoperative PO when using pedicle screws constructs with lowest instrumented vertebra at L5. It seems that probably related to the underlying condition, early surgery may decrease incidence of complications.

204. A Unique Multimodal Pain Management Regimen Reduces Opioid Use in Adolescent Spinal Deformity Surgery

Reid Collis, MD; Tonia Dry, PA-C; Herman Ray, PhD; Nina Grundlingh, MS; Gilbert Chan, MD; Timothy Oswald, MD

Hypothesis

Patients receiving a unique multimodal pain management regimen including IV Acetaminophen, Ketorolac, and Liposomal Bupivacaine during posterior spinal fusion will have decreased opioid utilization and better outcomes.

Design

This is a retrospective chart review of pediatric patients having received PSF at a dedicated children's hospital (CH) and a regional tertiary referral center (TRC) with a dedicated pediatric spine program.

Introduction

Adolescent idiopathic scoliosis (AIS) is a structural deformity of the spine found in otherwise healthy adolescents. 60% of children undergoing surgery report at least 1 day of moderate-to-severe pain, especially in patients receiving posterior spinal fusion (PSF) where significant tissue trauma is associated with debilitating pain. Common perioperative medications for pain control include opioids, despite known risk factors including addiction and increased postoperative complications. The goal of this study is to evaluate outcomes in patients having received a unique multimodal pain management regimen versus those having not received such a combination.

Methods

This is a retrospective analysis of patients aged 10-17 receiving PSF with >5 levels fused for AIS at a TRC (n=88) and CH (n=49) between 1/18 and 9/22.

Results

There were no significant differences in background characteristics of the two patient populations. Patients receiving PSF at the TRC received equivalent or greater amounts of all non-opioid pain medications and demonstrated decreased time until ambulation (19.3 vs 22.3h), postoperative opioid use (56.1 vs 70.1 MME), and postoperative hospital length of stay (36.0 vs 58.3h). Hospital location was not individually associated with a difference in postoperative opioid use. There was not a significant difference in postoperative pain ratings. When accounting for all other variables, liposomal bupivacaine had the greatest contribution to decrease in postoperative opioid use.

Conclusion

Patients receiving greater amounts of non-opioid intraoperative medications utilized 20% fewer postoperative morphine milligram equivalents, discharged 22.3 hours earlier, and had a reduction in time until first recorded ambulation by 3 hours. Postoperatively, non-opioid analgesics were as effective as opioids in reduction of subjective pain ratings. This study further demonstrates the efficacy of a multimodal pain management regimen in pediatric patients receiving PSF for AIS.

Baseline Characteristics	Tertiary Referral Center (N=88)				Children's Hospital (N=49)				p
	Mean ± SD or n (%)		95% CI		Mean ± SD or n (%)		95% CI		
Age	14.42	± 1.81	14.04 to 14.80		14.16	± 1.67	13.69 to 14.63		0.41
Female Sex	72	(81.82%)			35	(71.43%)			0.20
Race									0.99
White	38	(46.91%)			23	(46.94%)			
Black	33	(40.74%)			20	(40.82%)			
Asian	2	(2.47%)			1	(2.04%)			
Hispanic/Latino	1	(1.12%)			5	(10.20%)			
Other	7	(8.64%)			0	(0.00%)			
Body Mass Index (BMI)	22.14	± 5.35	21.02 to 23.26		22.23	± 4.44	20.99 to 23.48		0.92
Number of Levels Fused	9.86	± 1.96	9.45 to 10.27		9.65	± 1.45	9.25 to 10.06		0.51
Intraoperative Medications (mg)				N*				N*	
Acetaminophen	786.59	± 224.32	739.72 to 833.46	84	0.00	± 0.00	0.00 to 0.00	0	**<0.0001**
Bupivacaine (Non-liposomal)	150.63	± 36.67	142.96 to 158.29	88	3.06	± 12.11	-0.33 to 6.45	3	**<0.0001**
Bupivacaine (Liposomal)	274.76	± 83.09	257.41 to 292.13	88	0.00	± 0.00	0.00 to 0.00	0	**<0.0001**
Dexamethasone	7.53	± 1.51	7.22 to 7.85	87	4.57	± 3.46	3.60 to 5.54	35	**<0.0001**
Dexmedetomidine (mcg)	0.00	± 0.00	0.00 to 0.00	0	5.52	± 9.90	2.75 to 8.29	14	**<0.0001**
Diazepam	0.00	± 0.00	0.00 to 0.00	0	0.29	± 1.08	-0.02 to 0.59	4	**0.01**
Hydromorphone	0.52	± 0.59	0.49 to 0.65	56	0.35	± 0.31	0.26 to 0.44	37	0.06
Ketamine	43.24	± 18.40	39.39 to 47.08	81	0.00	± 0.00	0.00 to 0.00	0	**<0.0001**
Ketorolac	15.57	± 12.63	12.93 to 18.21	56	18.78	± 12.57	15.25 to 22.30	35	0.16
Lidocaine	57.44	± 25.94	52.02 to 62.86	84	5.31	± 19.05	-0.03 to 10.64	4	**<0.0001**
Methocarbamol	440.86	± 417.57	353.62 to 528.11	49	0.00	± 0.00	0.00 to 0.00	0	**<0.0001**
Midazolam	0.61	± 1.01	0.40 to 0.83	26	0.00	± 0.00	0.00 to 0.00	0	**<0.0001**
Morphine	0.00	± 0.00	0.00 to 0.00	0	0.24	± 0.35	-0.11 to 0.60	2	0.07
Postoperative Characteristics†									
Average Pain Visual Analogue Scale (VAS)									
First 24h	4.32	± 1.49	4.01 to 4.63	88	4.17	± 1.51	3.75 to 4.59	49	0.58
24-48h	4.43	± 1.89	3.98 to 4.88	67	4.66	± 1.43	4.26 to 5.06	49	0.47
At 1st PT eval	4.94	± 1.94	4.51 to 5.36	80	4.98	± 2.11	4.39 to 5.57	49	0.91
At 2nd PT eval	4.82	± 2.37	4.22 to 5.45	59	4.67	± 2.29	4.02 to 5.31	48	0.73
Total Milligram Morphine Equivalents (mg)	56.09	± 30.70	49.67 to 62.5	88	70.14	± 28.81	62.08 to 78.21	49	**0.009**
Hospital Length of Stay Following Surgery (h)	35.95	± 10.30	33.80 to 38.10	88	58.29	± 16.40	53.70 to 62.88	49	**<0.0001**
Time Until First Recorded Ambulation (h)	19.30	± 5.05	18.24 to 20.35	88	22.33	± 4.131	21.17 to 23.48	49	**<0.001**

*Number of patients receiving each medication or with available data for inclusion
†These characteristics include the time period from the cessation of anesthesia to time of discharge unless otherwise noted

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

205. Withdrawn

206. The Outcome of New Growth Guidance Surgery (Upper Thoracic Fusion with Distal Growth Guidance: UTF-DGG) for Early-onset Scoliosis: In Comparison with Conventional Shilla Surgery

Masaaki Ito, MD, PhD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD

Hypothesis
New growth guidance surgery with upper thoracic fusion with distal growth guidance (UTF-DGG) might reduce unplanned surgery and have better outcome in controlling kyphosis than Shilla surgery.

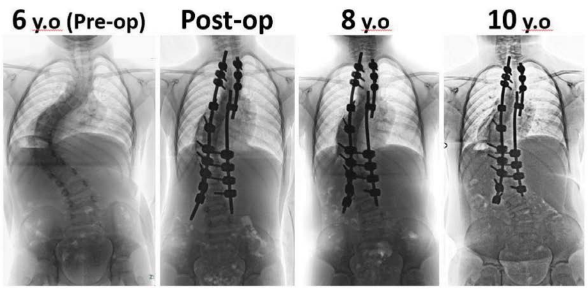
Design
Retrospective case series study

Introduction
Conventional Shilla often results in insufficient strength of the upper and lower anchors, which can be a problem for implant dislodgement and secondary to PJK or DJK. To avoid these problems, we fused upper thoracic foundation and performed segmental growth guidance screwing at apex to distal foundation. It is a method in which the proximal thoracic spine is fused and growth in the caudal direction is allowed. The purpose of this study is to compare the new growth guidance method (UTF-DGG) with Shilla surgery during the growth guidance period.

Methods
We examined consecutive 52 cases who underwent growth guidance surgery for EOS more than 2 years after surgery. There were 38 cases of conventional Shilla (group S) and 14 cases of UTF-DGG (group U). The radiological outcomes and the number of complications until 3 years after the initial surgery were examined.

Results
The average age at the initial surgery and the follow-up period were 7.9 y.o and 7.0 years in group S, 8.2 y.o and 3.2 years in group U, respectively. The main thoracic curve was 84, 44, 71 degrees (pre, post, final) in group S, and 85, 48, 59 in group U (P=0.02). The thoracic kyphosis was 56, 43, 74 degrees (pre, post, final) in group S and 49, 33, 38 degrees in group U (P<0.01). The T1-S1 length were 247, 297, 290 mm in group S and 268, 314, 340 mm in group U (P<0.01). The unplanned surgeries until 3 years after the initial surgery were required for 14 cases in group S, whereas there is no unplanned surgery in group U (P=0.01). The distal implant problem was seen 23 case (61%) in group S and 2 cases (14%) in group U (P<0.01).

Conclusion
The new growth guidance surgery (UTF-DGG) showed less correction loss of the main thoracic curve and maintained thoracic kyphosis, further had larger T1-S1 length with less complications comparing to Shilla surgery. The UTF-DGG using segmental growth guidance screws on the distal side of the spine may reduce unplanned surgery due to the distal implant problems.



The example of UTF-DGG: good sliding between rod and screw-head was observed at distal end.

207. Withdrawn

208. Changes in Sagittal Balance and Pre-existing Junctional Angle Influence Development of Proximal Junctional Kyphosis in Growth Guidance Systems for Early Onset Scoliosis

Emmanuel Arhewoh, MD; Ian Marigi, BA; Richard E. McCarthy, MD; David L. Skaggs, MD, MMM; Paul D. Sponseller, MD, MBA; Scott J. Luhmann, MD; Pediatric Spine Study Group

Hypothesis
Growth Guidance Systems have a lower rate of PJK compared to other systems.

Design
Retrospective analysis of Prospectively maintained database

Introduction
Proximal Junctional Kyphosis (PJK) has been reported in up to 30% of Traditional and Magnetically Controlled Growing Rods. Rigid foundations coupled with distraction in these systems can potentiate kyphosis, and possible PJK. In contrast, Growth Guidance Systems (GGS) have non-rigid, gliding fixation which may mitigate PJK. No studies have been done in GGS around PJK, hence we aimed to assess the occurrence, risk factors and timeline.

Methods
A prospective, multicenter database was queried for EOS patients who underwent surgery utilizing GGS. Inclusion criteria: < 10 years at index surgery and >2 year follow up. X-rays were re-measured by one trained observer at three time points; pre-op, post-op and final. Proximal Junctional Angle (PJA) was measured between the inferior plate of the upper instrumented vertebra and the superior plate of the vertebra two segments cranial. PJK was defined using the Glattes definition.

Results
65 patients (36 female) met inclusion criteria. Mean age at index surgery was 6.2 y (2 – 9); mean follow-up was 66 m. Most common etiologies were syndromic (n=23) and neuromuscular (n = 18). Mean thoracic kyphosis at pre-op was 41.8°, post-op 35.5°, and final 42.2°. Mean PJA at pre-op 6.15°, post op 14.2° and final 15.6°. Incidence of PJK at post-op was 35% and final 43%.

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Etiology, pre-op hyperkyphosis (>50°), and choice of UIV were not associated with PJK at any timepoint (NS). Pre-op sagittal balance and change in sagittal balance from pre-op to post op were associated with post-op PJK (p = 0.05, 0.02). Change in spinal height from pre-op to post-op was associated with PJK at final (p = 0.04). Logistic regression identified the same factors as predictive. Increased PJA at pre-op was associated with decreased PJK at post-op and final (p = 0.01, 0.03). 15% of patients had proximal implant complications. Increased anchor prominence was associated with PJK at post-op (p = 0.035), due to screw pullback.

Conclusion

PJK was identified in 43% of patients after GGS for EOS. Preop PJA was negatively correlated with an increased incidence of PJK. Changes in sagittal balance, in either direction, was the strongest predictor for development of PJK post-operatively.

209. Utility of a Risk Severity Scoring System in Patients Undergoing Growth Guidance Surgery for Early Onset Scoliosis

Ian Marigi, BA; Emmanuel Arhewoh, MD; Richard E. McCarthy, MD; David L. Skaggs, MD, MMM; Paul D. Sponseller, MD, MBA; Scott J. Luhmann, MD; Pediatric Spine Study Group

Hypothesis

Risk Severity Score (RSS) and Surgical Site infection (SSI) will be associated.

Design

Retrospective analysis of prospectively maintained database.

Introduction

Post-operative surgical site infection (SSI) is a feared and common complication in children undergoing surgical treatment of Early Onset Scoliosis (EOS), with rates up to 40%. The EOS SSI Risk Severity Score (RSS) is a tool that uses etiology and co-morbidity data as predictive variables to determine an estimated risk of SSI. There have been few validation studies done with the RSS.

Methods

A prospective, multicenter EOS database was queried to identify GGS patients. Inclusion criteria: age < 10 at time of index surgery, 2 years follow-up, and deep SSI. Infections were classified as early (< 6 months postop) or late (>/= 6 months postop). Demographic information, prior treatment data, spinal deformity magnitude, procedure data, post-op data, and RSS from the EOS SSI RSS risk calculator were recorded. RSS scores were calculated with and without diaper dependence due to a lack of data from the database and are reported as a range.

Results

66 patients met (38 females) inclusion criteria. Mean age at surgery 5.8 years (1-9 years). Highest incidence was in syndromic patients (31.5%). Neuromuscular patient infection rate was 21.1%. EOS SSI RSS calculator predicted an SSI rate of 5.8 - 7.3% for our cohort. There was a 17.1 – 15.4% difference between expected and observed SSI rates. RSS predicted the highest SSI rates in neuromuscular (9.9-12.7%), followed by congenital (4.4-5.7%). There was no significant correlation between RSS and SSI (p=0.97). There was a higher RSS in neuromuscular patients with SSI, when compared to non-neuromuscular SSI patients (p=0.052, p=0.04). These results were not affected by the selection of diaper dependence.

Conclusion

The incidence of SSI (22.7%) was higher than the RSS estimations. RSS was not significantly associated with the development of SSI in our total patient cohort, but was significantly associated with SSI among neuromuscular patients. Syndromic patients had the highest infection rate. The RSS should be used with caution in estimating the SSI risk in GGS.

Table 1: Actual SSI Rates vs. RSS Prediction

	N	Deep SSI	RSS (No Diaper Dependence)	RSS (Diaper Dependence)	P-value (No Diaper Dependence)	P-value (Diaper Dependence)
Neuromuscular	19	4 (21.1%)	9.87%	12.74%	0.052	0.04
Syndromic	19	6 (31.5%)	3.98%	5.26%	0.153	0.161
Idiopathic	17	4 (23.5%)	3.42%	4.50%	0.208	0.205
Congenital	11	1 (9.1%)	4.37%	5.73%	0.087	0.092
Overall	66	15 (22.7%)	5.60%	7.30%	0.955	0.991

Actual SSI Rates vs. RSS Prediction

210. Spontaneous Correction of the Thoracic Curve in Lenke 5 Patients: Lumbar Vertebral Body Tether (VBT) versus Posterior Fusion

Jennifer M. Bauer, MD; Suken A. Shah, MD; Jaysson T. Brooks, MD; Baron S. Lonner, MD; Amer F. Samdani, MD; Firoz Miyanji, MD; Burt Yaszay, MD; Peter O. Newton, MD; Harms Study Group

Hypothesis

A smaller spontaneous correction of the unoperated thoracic curve is expected from lumbar VBT compared to lumbar fusion because of decreased 3D correction with VBT.

Design

Retrospectively compared prospectively collected multicenter cohort study

Introduction

VBT is a non-fusion option for skeletally immature patients with idiopathic scoliosis. As with posterior spinal fusion (PSF), compensatory curves are not commonly included in the construct. Prior studies demonstrated spontaneous correction of the compensatory thoracic curve after selective lumbar fusion, which can guide decision making of instrumented levels. However, no prior studies have examined thoracic curve correction after lumbar VBT.

Methods

Lenke 5 lumbar VBT patients with at least 2 years' follow-up were compared to lumbar fusion patients. Groups were compared for thoracic and lumbar curve correction, coronal/sagittal balance, and complications. Mann Whitney-U test was used to compare continuous variables.

Results

24 VBT and 24 fusion patients were matched 1:1 for UIV (T8-11),

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

LIV (L2-3), and thoracic Cobb with no differences between pre-operative thoracic or lumbar curves. Fusion patients were 1.4yr older (p=0.008). There were no significant differences between VBT and PSF for average pre-op or 2yr post-op major T or L curves, T1 tilt, or coronal balance. VBT had 4° less PJK and 10° less L lordosis at 2yr; PSF had 12mm better coronal balance (Table 1). Thoracic curves worsened an insignificant amount from first erect to 2yr (2° in VBT, <1° in PSF). Compared to pre-operative flexibility radiographs, 2yr post-op thoracic curves were 6.2° (VBT) and 7.0° (PSF) larger (p=0.83). There were 7 (24%) reoperations in the VBT group: 2 overcorrections relaxed, 2 T adding-on (extended to T by PSF-1, VBT-1), 1 broken tether converted to PSF. 1 (4%) reoperation in the fusion group (pseudarthrosis/broken screw). No other major complications.

Conclusion

Spontaneous thoracic correction is achieved to a similar degree for lumbar VBT and PSF patients operatively treated for their lumbar curves. There is little change in thoracic curve magnitude over time, and, on average, the correction does not reach the pre-operative flexibility curve measurement. There is a higher rate of revision in VBT patients to achieve these outcomes.

	Pre-Op			2yr Post-Op		
	Lumbar VBT	Lumbar PSF	p-value	Lumbar VBT	Lumbar PSF	p-value
T Cobb (°)	29 (12-45)	30 (13-45)	0.68	24 (11-48)	23 (5-44)	0.94
L Cobb (°)	44 (22-56)	45 (36-59)	0.90	22 (6-36)	22 (11-42)	0.83
T1 Tilt (mm)	4.9 (0-13)	4.3 (0-14)	0.33	4.9 (0-15)	4.0 (0-10)	0.33
L Lordosis (°)	56 (37-76)	57 (29-78)	0.49	55 (35-74)	67 (44-90)	**0.001***
Coronal CSVL-C7 (mm)	27 (12-30)	25 (3-42)	0.65	26 (0-52)	14 (4-25)	**0.003***
Pre-op flexibility T Cobb (°)	17 (0-45)	19 (4-24)	0.74			
Post-op proximal junctional kyphosis (°)				3.7 (-5-15)	7.3 (-1-16)	**0.02***

Comparison of averages (range) of measurements between groups:

211. Intraoperative and Short-term Postoperative Complication Rates for Robotic-Assisted Placement of Over 1,500 Pedicle Screws in Pediatric Posterior Spinal Fusion

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Hypothesis

Robotically navigated pedicle screw placement has a low rate of clinical complications and inadvertent breach rates decrease over time.

Design

Retrospective cohort

Introduction

This study assesses complication rates associated with over 1,500 consecutive robotically placed pedicle screws in pediatric patients undergoing posterior spinal fusion (PSF) for idiopathic scoliosis (IS) or Scheuermann's kyphosis (SK).

Methods

We conducted a retrospective review of 93 patients (ages 10-22) with IS or SK who underwent PSF with robotic navigation from 2020-2022. Operative data included the number of screws placed with and without robotic assistance, intraoperative neuromonitoring changes and robotic complications. Robotic screw position was verified intraoperatively with a ball tip probe, fluoroscopy, and full-length AP/lateral spine x-rays.

Results

Of the 93 patients, 71.0% were female and the average age was 14.8 years, with a median of 13 fused levels (range 5-15). 1,653 (74.4%) of 2,221 pedicle screws were navigated robotically. Forty-three (2.6%) robotically placed screws had unintentional breach (34 medial, 7 lateral, 1 inferior, and 1 combination), all of which were identified intraoperatively and redirected or removed. In the first quartile, there were 13 (4.2%) robotic pedicle breaches; by the fourth quartile, only 7 (1.3%) breaches (Figure 1). There was 1 durotomy due to screw placement with no associated neurological changes, 2 neuromonitoring alerts remote to the surgical field that resolved with patient repositioning, 10 clamp/bridge strikes precluding screw placement at that level, 3 instances of inability to register the intraoperative fluoroscopy to the preoperative CT scan, and 1 loss of registration due to patient shifting. There were 0 cases of postoperative infection or reoperation, and 2 (2.2%) cases of nonunion or delayed union (Table 1).

Conclusion

Robotic navigation is a safe and effective method for pedicle screw fixation in pediatric spinal deformity. Error rates and unintentional breach rates decrease in frequency with user experience.

E-Point Presentation Abstracts

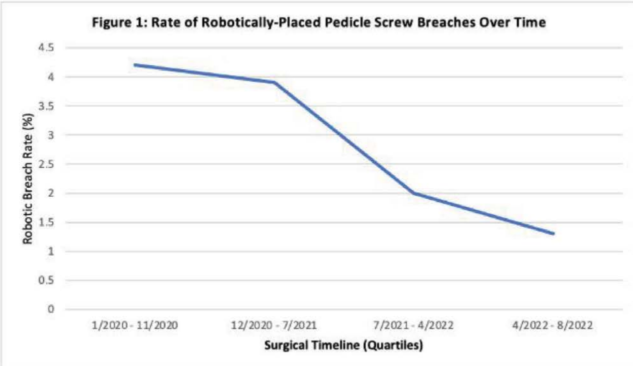

Table 1: Intraoperative and Postoperative Complications Associated with Robotically Placed Pedicle Screws

Complication	Rate of Complication
Intraoperative Complications	N=1,653 screws
Breach	43 (2.5%)
Medial	34 (2.1%)
Lateral	7 (0.4%)
Inferior	1 (0.06%)
Combination	1 (0.06%)
Durotomy	1 (0.06%)
Bridge or Clamp Strike	10 (0.6%)
Inability to Register an Isolated Level	5 (0.3%)
Loss of Registration	1 (0.06%)
Inability to Register the Proximal Spine	3 (3.2% of patients)
Neuromonitoring Changes (associated with screw placement)	0
Neuromonitoring Changes (associated with patient positioning)	2 (2.2% of patients)
Postoperative Complications	N=93 patients
Infection	0
Return to Operating Room	0
Non-union or Delayed Union	2 (2.2%)
Postoperative Weakness	0
Postoperative Transient Sensory Changes	2 (2.2%)

Figure 1: the rate of robotically placed pedicle screw breaches over time. Table 1: intra and postoperative complications associated with robotically placed pedicle screws.

212. Autofusion at Costovertebral Joints after Posterior Fusion with Thoracic Pedicle Screws for Adolescent Idiopathic Scoliosis(AIS) -CT evaluation at 10 years follow-up after surgery

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Hypothesis
A pedicle screw inserted into the vertebral body for a long term may affect the surrounding area.

Design
Retrospective review

Introduction
Posterior spinal fusion with thoracic pedicle screwing has been widely performed for AIS patients, but there have been no reports concerning postoperative changes in the costovertebral joints. In this study, we investigated the changes in the costovertebral joints in AIS patients who underwent posterior fusion with thoracic pedicle screws using CT images immediately after surgery and at 10 years after surgery.

Methods
109 AIS patients (4 males, 105 females) who underwent posterior fusion with pedicle screws were included in this study. The mean age at the time of surgery and 10-year follow-up were 18.1 and 29.3, respectively. The mean Cobb angle of the main curve pre. op, post. op, and 10-year follow-up were 56.1°,18°, 18.4°respectively. A total of 1629 thoracic pedicle screws were inserted in 1039 thoracic vertebrae, the changes in the costovertebral joint(CV joint) ,which consists of costocorporeal joint(CC joint) and the costotransverse joint(CT joint), were evaluated with CT images taken immediately after surgery and at 10-year follow-up.

Results
CT images at 10-year follow-up showed autofusion at the CV joints of 88 thoracic vertebrae (8.5%) in 35 patients (32.1%). Autofusion at the CC joints ,at the CT joints or at the both were observed in 31 ,27 and 21 cases respectively. The level of autofusion was at T5 in 8 , T6 in 10 , T7 in 17 , T8 in 14 , and T9 in 17 cases. There were 70 autofusions on the concave side alone, 18 on both sides and none on the convex side alone. The mean magnitude of the preoperative main thoracic curve was 64.9 ° in the autofusion group and 51.9° in the non autofusion group($p<0.05$), and the mean magnitude of the postoperative main thoracic curve was 24°(63.5%correction) in the autofusion group and 14.8 °(71.3%correction) in the non autofusion group ($p<0.05$).

Conclusion
Autofusion at the CV joints developed in 32.1% of AIS patients 10 years after surgery. The CV joints on concave side from upper to mid thoracic spine or the CV joints in patients who had bigger preoperative and postoperative curve tend to be autofused. Further study is necessary concerning lung function, for which movement of the CV joints play an important role.

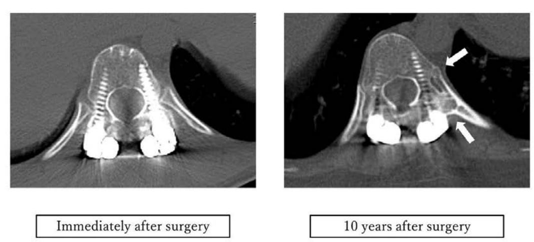

Figure. A CT image at 10 years after surgery demonstrated autofusion at the costocorporeal and the costotransverse joints.

213. Cervical Spine Deformity Patients Have High Rates of Poor Sleep Quality Which Do Not Improve Following Deformity Correction †

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Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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Hypothesis

We hypothesize that cervical spine deformity (CSD) patients frequently have poor sleep quality (PSQ) which is associated with radiographic parameters and improves postoperatively.

Design

Retrospective Analysis

Introduction

Poor sleep quality is associated with higher levels of pain, poor mental health and disability in patients with degenerative spinal conditions. We examined the relationship between pre-operative sleep quality and radiographic parameters of adult cervical spine deformity and impact of deformity surgery on sleep.

Methods

A retrospective analysis of a prospective multicenter CSD database stratified patients as poor sleep quality (PSQ) and normal sleep quality (NSQ) using the Neck Disability Index (NDI) sleep domain (PSQ=NDI Sleep ≥2 and NSQ=NDI Sleep≤1). Preoperative demographics, radiographic measurements, and HRQL were compared between both groups. Primary outcomes included neck pain and sleep quality at 1-year follow-up. Multivariable analysis was performed to assess neck pain and sleep quality at 1-year post-op.

Results

Of 168 patients included, 117 (69%) had PSQ pre-op. PSQ patients were younger (59.9 vs 65.0, p<0.01), had higher BMI (30.5 vs 26.8, p<0.01), worse anxiety (EQ5D 1.9 vs 1.5, p<0.01) and worse neck pain (7.4 vs 5.2, p<0.01). Radiographic measurements showed difference in C7-S1 SVA (1.3 vs -1.5, p=0.01), C7 Vertical Tilt (-0.1 vs -3.5, p=0.01), and T1 Spinopelvic Inclination (-5.0 vs -7.8, p<0.01). Univariable analysis showed that PSQ patients have worse Neck pain scores (5.0 vs 2.3, p<0.01). At one-year post-op, poor sleep persisted in 66% of patients who underwent corrective surgery. 34% of patients with normal sleep preoperatively reported poor sleep at 1 year follow up. Patients who underwent posterior approach were more likely to develop new PSQ at 1 year compared to anterior or combined (27% vs 4% vs 0,p<0.01). After controlling for possible confounders, preoperative PSQ was associated with worse Neck Pain (Difference= 0.30, [0.08 – 0.52]; p=0.007) and poor sleep (OR=6.2, [1.9 – 20]; p<0.01) at 1-year follow-up (67% Follow up).

Conclusion

Preoperative poor sleep quality in adult cervical spinal deformity patients is common and is significantly associated with preoperative malalignment. Sleep quality did not improve substantially with deformity correction, while 34% of CSD patients with normal sleep developed de novo sleep disturbance post op.

	Poor Sleep	Normal Sleep	p-value
Age (SD)	59.9 (10.7)	65.0 (9.1)	**0.003**
Gender			0.153
Male	41 (35.3%)	24 (47.1%)	
Female	75 (64.7%)	27 (52.9%)	
Smoking	10 (8.6%)	3 (6.0%)	0.564
BMI	30.5 (8.0)	26.8 (5.4)	**0.005**
Previous Cervical Surgery	58 (50.0%)	16 (32.0%)	**0.032**
Baseline HRQL			
Depression	40 (34.4%)	13 (25.5%)	0.250
EQ5D Anxiety	1.9 (0.6)	1.5 (0.6)	**0.001**
NSR Neck Pain	7.4 (2.1)	5.2 (2.8)	**<0.001**
mJOA	13.3 (2.7)	14.1 (2.9)	0.086
SWAL-Mental	82.7 (27.2)	90.7 (20.5)	0.066
Radiographic Measurement			
C2-C7	-6.01 (20.7)	-9.3 (25.7)	0.422
SVA C2-C7	4.6 (2.5)	4.9 (2.5)	0.518
SVA C7-S1	1.3 (7.5)	-1.5 (5.4)	**0.019**
C7 Plumb Line	2.2 (2.9)	2.3 (2.0)	0.810
C7 Vertical Tilt	-0.1 (8.2)	-3.5 (6.2)	**0.01**
T1 Spinopelvic Inclination	-5.0 (6.3)	-7.8 (5.5)	**<0.01**
Outcomes at 1 year			
NSR Neck Pain	5.0 (2.8)	2.3 (2.4)	**<0.01**
Poor Sleep Quality	54 (66%)	28 (34%)	**<0.01**
mJOA Score	13.9 (3)	14.4(3)	0.37

214. Etiology Remains King: Health-Related Quality of Life Outcome at 5 Years Following Growth Friendly Instrumentation for EOS

Kenneth A. Shaw, DO; David C. Thornberg, BS; Anna McClung, BSN; Chan-Hee Jo, PhD; Mark A. Erickson, MD; Michael G. Vitale, MPH; Scott J. Luhmann, MD; Lindsay M. Andras, MD; Pediatric Spine Study Group; Brandon A. Ramo, MD

Hypothesis

Curve etiology would remain a significant predictor of health-related quality of life (HRQoL) outcomes 2-5 years following growth friendly instrumentation (GFI)

Design

Multi-center, retrospective review of prospective database

Introduction

The etiology of early-onset scoliosis (EOS) has been shown to significantly influence baseline parent-reported HRQoL measures as assessed by the Early Onset Scoliosis Questionnaire (EOSQ). However, it remains unclear how etiology influences mid-term outcomes following GFI for EOS.

Methods

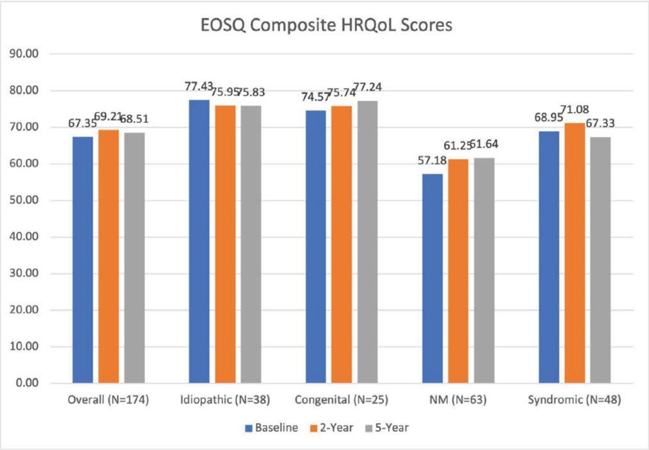
A retrospective review of a multi-center prospective EOS database was performed. Children undergoing primary distraction-based, GFI for EOS with complete baseline, 2-year, and 5-year post-surgical EOSQ were included. Identified children were subdivided by etiology as classified by the C-EOS system. EOSQ scores were compared over time according to etiology cohorts and between instrumentation types. Minimal clinically important difference (MCID) was defined as ≥20% change in domain score and compared across etiologies.

Results

A total of 178 children (mean 7.3 +/-2.1 years, 51.1% female) were included. The most common etiology was neuromuscular (NM: 36.5%), with the majority of children treated with MCGR (N=125). Significant differences between etiology groups were present with congenital and idiopathic cohorts demonstrating similar EOSQ domain scores that were significantly higher than neuromuscular and syndromic cohorts, Figure 1. In assessing clinically important change in EOSQ scores over the 5-year follow-up period, neuromuscular and syndromic patients demonstrated the greatest capacity for improved outcomes. Instrumentation type had no influence on HRQoL scores at 5-year follow-up, but MCGR use was associated with greater perceived parental satisfaction and impact.

Conclusion

EOS etiology remains a significant driver of key domains for HRQoL following growth-friendly instrumentation. Despite, or perhaps because of, having significantly lower domain scores, neuromuscular and syndromic patients demonstrate the greatest capacity for clinically important improvement in HRQoL measures 5 years following intervention.



Mean EOSQ composite HRQoL score, subdivided by etiology over study time-points.

215. T1 Tilt and Clavicle Angle are the Best Predictors of Postoperative Shoulder and Neck Balance in AIS Patients

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Hypothesis

T1 tilt and CA play a role in predicting shoulder balance status.

Design

Retrospective review

Introduction

Shoulder imbalance after PSF is a major concern. Most studies have analyzed multiple radiographic parameters associated with postop uneven shoulders. However, there is paucity in the literature analyzing predictors for balanced shoulders. This study evaluated XRs of AIS patients who underwent PSF, and control patients (no spinal curvature) to identify radiographic predictors of shoulder balance.

Methods

Radiographic shoulder height (RSH) was used as our proxy for shoulder height. RSH <2cm was considered normal. T1 tilt and CA in the same orientation as RSH was defined as concordant. Part I: XRs of control patients were evaluated with T1, clavicle angle (CA) and RSH recorded to determine 'normal' T1 and CA values. Kruskal-Wallis tests were performed. Part II: Preoperative, postoperative, and final follow up XRs of AIS patients who underwent PSF were measured. Spearman's correlation was used to evaluate correlation between radiographic parameters and RSH. Fisher's exact test was used to evaluate distribution of abnormal postop RSH. Part III: XRs from multiple surgeons were evaluated to predict RSH. Fisher's exact test was used to evaluate distribution of abnormal postop RSH.

Results

Part I: 211 control patients were evaluated. 191 had normal RSH and 20 were abnormal. T1 tilt (2.0 vs 4.1) and CA (1.1 vs 4.95) were significantly different between the two groups ($p<.05$). Part II: In 186 patients, preoperative and postoperative CA correlated very strongly with RSH ($r = 0.856/0.921$). T1 tilt correlated moderately with RSH ($r = 0.399$), but was better when concordant ($r = 0.51$). RSH did not change significantly from immediate postop to final follow up ($p=0.423$). Restoring CA below 3 degrees yielded normal RSH postop ($p<0.0001$). Restoring Concordant T1 tilt below 3 degrees yielded normal RSH in nearly all cases ($p<0.006$). Part III: In 59 patients across 4 surgeons, restoring CA below 3 degrees yielded normal RSH at postop in all cases. Restoring concordant T1 tilt below 3 degrees yielded normal RSH at postop in nearly all cases.

Conclusion

We found that restoring the CA < 3° yields normal RSH postoperatively. In addition, when T1 is concordant, restoring it to < 3° can yield normal RSH. Proximal thoracic fusion did not correlate with post op RSH.

216. Difficulty in Head Control and Horizontal Gaze Caused by Cervical Spinal Imbalance after Neuromuscular Scoliosis Correction Surgery: Chin-to-Sky Deformity

Seong Hwa Hong, MD; Bong-Soon Chang, MD, PhD; Sam Yeol Chang, MD; Dong-Ho Kang, MD; Hyoungmin Kim, MD, PhD

Hypothesis

Postoperative sagittal alignment and balance are associated with difficulty in head control and horizontal gaze following deformity correction of neuromuscular scoliosis.

Design

Retrospective case series

Introduction

Neck muscle weakness is often observed in neuromuscular scoliosis (NMS) patients. Following deformity correction surgery for NMS, some patients experience posterior head drop during neck extension and cannot actively return to a position for horizontal gaze due to neck flexor weakness. We authors named this phenomenon Chin-to-Sky deformity due to the characteristic position of the chin pointing toward the sky. In this study, we reviewed NMS patients who underwent deformity correction for NMS to identify factors that may contribute to the occurrence of Chin-to-Sky deformity postoperatively.

Methods

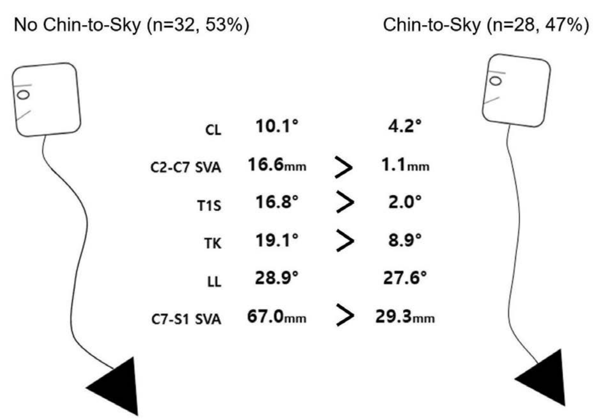
This retrospective case series study from a single tertiary hospital included patients who underwent posterior spinal deformity correction surgery for NMS from 2012 to 2019. Patient information including demographics, and clinical surgical data was collected. Following radiological parameters were measured using preoperative and postoperative whole spine simple radiographs in a sitting position: cervical lordosis, thoracic kyphosis (TK), lumbar lordosis, C2-C7 sagittal vertical axis (SVA), C7-S1 SVA, and T1 slope (T1S). Comparative and logistic regression analyses were used to determine the factors associated with postoperative Chin-to-Sky deformity.

Results

Sixty patients were enrolled and divided into two groups according to the occurrence of Chin-to-Sky deformity. Postoperative Chin-to-Sky phenomenon was observed in 28 (47%) patients. In comparative analysis, the Chin-to-sky group had smaller preoperative T1S (p=.041), smaller postoperative TK, T1S, C2-C7 SVA, and C7-S1 SVA (p=.034, .006, .001, .006, and .004, respectively) (Figure 1). In logistic regression analysis, Chin-to-sky deformity was significantly associated with preoperative T1S, postoperative T1S and C7-S1 SVA (odds ratio=.955, .887, and .975 respectively).

Conclusion

Correction of NMS requires special consideration of sagittal balance and head position. In patients with smaller preoperative T1S, attention should be paid to avoid postoperative Chin-to-sky deformity. Optimal correction of T1S and C7-S1 SVA is essential to prevent such phenomenon after deformity correction surgery.



217. Withdrawn

218. Utilization of TXA in ASD Patients with Potential Contraindications for TXA does NOT Lead to Increased Thromboembolic Complications: Critical Information for Surgical and Anesthesia Teams

Jeffrey P Mullin, MD; Jeffrey L. Gum, MD; Mohamed Soliman, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Stephen J. Lewis, MD, FRCS(C); David O. Okonkwo, MD, PhD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis, MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; D.Kojo Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Peter G. Passias, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis

The use of TXA in ASD surgery patients with prior thromboembolic events (TE) does not result in significant risk of further TE compared to ASD without TE history undergoing ASD surgery.

Design

A prospective, multicenter, case-control study

Introduction

Complex spinal deformity surgeries may involve significant blood loss. The use of antifibrinolytic agents such as tranexamic acid (TXA) has proven to reduce perioperative blood loss. However, for patients with a history of thromboembolic events there exists a concern of increased postoperative TE after the use of TXA during complex spinal deformity surgeries.

Methods

All complex spinal deformity patients that underwent surgical correction and received TXA between August 2018 and October 2022 in 21 centers were analyzed. Patients with pre-existing TE risk factors were identified (history of DVT, PE, MI, CVA, PVD, cancer). The rates of thromboembolic complications were assessed during the postoperative 90 days. Univariate analysis was done to assess the thromboembolic outcomes after using TXA in high-risk patients.

Results

There was no significant difference in thromboembolic complications between patients who received TXA (regardless of pre-existing TE risk factors) in the univariate analysis (High-risk group[HR]=5.9%, control[c]= 2.9%; p=0.12) based on 461 consecutive patients who underwent complex spinal deformity surgery and received TXA. Specifically, there were no significant differences between groups regarding the 90-day postoperative DVT (HR=1.4%, c=0.8%; p=0.59), PE (HR=2.7%, c=1.3%; p=0.26), AMI (HR=0.9%, c=0.4%; p=0.51), nor CVA (HR=1.4%, c= 0.8%;p=0.59). EBL (HR=1668 ml,

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

c=1492ml; p=0.19) and transfusion rates (HR=2.1 units, c=1.81 units; p=0.21) were similar between the two groups.

Conclusion

High-risk patients undergoing spinal deformity surgery did not have an increase in TE after TXA as compared to others receiving TXA.

219. When Should You Tether the Main Thoracic Curve in Lenke 5 and 6 Patients?

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Hypothesis

Untethered thoracic curves will not improve after lumbar VBT.

Design

Retrospective, single center study

Introduction

As lumbar vertebral body tether (VBT) surgery increases, there is a paucity of data on untreated compensatory thoracic curves. We sought to investigate untreated thoracic curves after lumbar VBT and risk factors for progression.

Methods

We reviewed demographic and radiographic variables for all patients at our institution undergoing VBT with Lenke 5 or 6 curves with at least 2 years of follow-up. Radiographs were obtained pre-op, and post-op at 6 weeks, 6 months, 1 year and annually thereafter. We compared patients who underwent single TL VBT (TL-VBT) vs. double VBT (BL, thoracic VBT with contralateral TL VBT). Success was defined as curves at last follow-up < 35° and no fusion surgery. A subgroup of patients from TL-VBT were divided into those with stable/improved thoracic curves (ST) vs. worsening (W) from first erect (FE, change > 3°).

Results

24 patients had TL-VBT and 24 had double VBT (BL). 15/24 in BL had Lenke 5 curves compared to 23/24 in TL-VBT (p<0.05). 83% of surgeries were successful with 3 failures in TL-VBT and 5 in BL (p>0.05). Age, gender, menarchal status, pre-op Sanders score, triradiate status, flexibility, mean follow-up and primary lumbar curve size were similar between both groups (p>0.05). Intuitively, BL had more levels instrumented, greater EBL and longer OR time (p<0.05). BL patients had larger proximal and main thoracic curves as well as more apical thoracic and lumbar translation, but lumbar curves were similar in magnitude. Of the 24 patients in TL-VBT, 13 were stable or had improvement in the thoracic curve (ST) and 11 worsened (W). In group W, the main thoracic curve progressed from 35° pre-op to 20° at FE to 29° at last FU, whereas the ST group went from 29° pre-op to 20° at FE and 17° last (p=0.02). W patients were younger (12.3 vs. 13.5 years, p<0.05), less skeletally mature (Sanders 3 vs. 4, p=0.03), more often had open triradiates (63% vs. 25%, p=0.03), and had less lumbar apical translation (4.8 vs. 5.6 cm, p=0.03).

Conclusion

More Lenke 6 patients underwent double VBT, with similar success rates compared to single VBT. In primary thoracolumbar curves, 46% of single lumbar VBT did not have improvement of their uninstrumented thoracic curves. Surgeons should consider bilateral VBT in less skeletally mature patients.

Demographic Information	TL-VBT (single)	BL(Bilateral)	p-value
Total number of lumbar tethers	24	24	
Number of females	22 (91.67%)	23 (95.83%)	>0.99
Premenarchal	11 (50.00%)	13 (54.17%)	0.77
Average age at surgery	12.93 ± 1.41	13.04 ± 1.22	0.78
Average years follow-up	3.7 ± 1.45	4.21 ± 1.49	0.65
Surgical information	**Single**	**Bilateral**	**p-value**
Average levels tethered	6.46 ± 1.74	11.71 ± 0.95	<0.05
Average EBL	90.00 ± 53.41	162.54 ± 115.04	0.01
Average OR time	215.58 ± 50.37	391.96 ± 56.40	<0.05
Radiographic Information	**Single**	**Bilateral**	**p-value**
Average pre-op proximal coronal curve	7.16 ± 4.96	17.26 ± 7.71	<0.05
Average pre-op thoracic coronal curve	31.76 ± 8.98	47.60 ± 9.34	<0.05
Average pre-op lumbar coronal curve	51.88 ± 7.05	55.25 ± 9.10	0.16
Average % correction thoracic	65.89% ± 19.88%	52.05% ± 20.69%	0.02
Average % correction lumbar	75.94% ± 13.07%	70.23% ± 14.06%	0.15
Average pre-op Risser	0.83 ± 1.05	0.50 ± 0.72	0.21
Median	1	0	
Average pre-op Sanders	3.39 ± 0.78	3.59 ± 0.85	0.42
Median	3	3	
% open triradiates	9 (37.50%)	5 (20.83%)	0.34
Apical translation ratio (lumbar/thoracic)	8.97 ± 12.64	1.38 ± 0.63	0.01
Average latest proximal coronal curve	11.42 ± 7.77	12.19 ± 6.51	0.71
Average latest thoracic coronal curve	22.58 ± 11.97	25.34 ± 9.84	0.39
Average latest lumbar coronal curve	17.25 ± 16.39	23.44 ± 13.35	0.16
Latest >35° or was fused	3 (12.50%)	5 (20.83%)	0.70
Reoperation Information	**Single**	**Bilateral**	**p-value**
No. of patients requiring reoperations	3 (12.50%)	3 (12.50%)	>0.99

220. Influence of Smoking on Patient-reported Outcome Measures (PROMs) in Patients Undergoing Surgery for Adult Spinal Deformity. A Propensity Score- matched Analysis Excluding Known Tobacco-related Complications †

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Hypothesis

Smoking is associated with worse PROMs in adult spinal deformity (ASD) patients.

Design

Retrospective review of a prospective, multi-center database

Introduction

The correlation between smoking and diminished clinical outcomes in ASD surgical treatment is usually attributed to pseudoarthrosis and higher surgical site infection rates. However, the systemic effects of nicotine are likely also significant. The purpose of the study was to determine, for the first time, the specific influence of smoking in PROMs for adult spinal deformity surgery excluding known tobacco-related complications.

Methods

Inclusion criteria: patients operated on ASD with 2 year postoperative follow-up (FU). Former smokers (non-active smokers) and patients developing mechanical or infectious complications were

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excluded. Changes of PROMs over FU were analyzed using mixed models for repeated measures (MMRM). Propensity score matching (PSM) (1:1 ratio, caliper 0.10) was performed without replacement using optimum algorithm, tolerance ≤0.001, and estimated with 95% confidence interval (CI). PROMS in both groups were compared by paired t test or Wilcoxon signed rank test.

Results
692 out of 1246 surgical patients met our inclusion criteria. 153 smokers were matched with 153 non-smokers according to age, BMI, number of fused levels and global tilt. After PSM both groups were homogeneous regarding baseline parameters, surgical data and complications (MC and infection excluded). Smokers had worse baseline results for SRS-total, SRS-pain COMI-back, NRS-Back pain/leg pain and ODI; smokers also showed worse 2-year outcomes for SRS-total, SRS-function, SRS-pain, SRS-image and ODI (table). However, no differences between the two groups were found in the improvement from baseline to two-year FU or in the timing of this improvement (MMRM). The proportion of patients reaching the minimal clinically important difference (MCID) after surgery was similar in the two groups, but the proportion of patients reaching patient acceptable symptom state (PASS) was significantly lower in smokers for SRS-Subtotal, SRS-function and SRS-image.

Conclusion
Smokers had a more severe clinical impairment as measured by PROMs. Even after selecting patients free of tobacco-related complications, clinical status 2 years after surgery was worse for smokers.

	ENROLLMENT (BASELINE)		P value	2 YEAR FOLLOW-UP		P value
	Smokers (N = 153)	Non-smokers (N= 153)		Smokers (N = 153)	Non-smokers (N= 153)	
SRS-Total	**2.91 (0.68)**	**3.09 (0.73)**	**0.026***	**3.73 (3.05; 4.16)**	**3.95 (3.32; 4.38)**	**0.031***
SRS-Function	3.2 (2.5; 4)	3.4 (2.6; 4.4)	0.82	**3.6 (3; 4.4)**	**4 (3.2; 4.6)**	**0.013***
SRS-Pain	**2.66 (0.89)**	**2.98 (1.08)**	**0.013 ***	**3.6 (2.75; 4.4)**	**4 (3.2; 4.6)**	**0.035 ***
SRS-Image	2.6 (2; 3)	2.6 (2; 3.2)	0.61	**3.6 (2.8; 4.2)**	**3.8 (3.2; 4.4)**	**0.042***
SRS-Mental Health	3.17 (0.87)	3.26 (0.84)	0.21	3.6 (3; 4.1)	3.8 (3.2; 4.2)	0.12
SRS Satisfacción	3 (2; 4)	3.5 (2.5; 4)	0.97	4.5 (3.78; 5)	4.5 (4; 5)	0.41
COMI back	**6.65 (4.75; 8.48)**	**6.2 (3.5; 7.5)**	**0.043***	3.2 (1.6; 5.52)	2.64 (0.95; 5.1)	0.06
SF36 Mental Component Summary Score	42.58 (13.33)	43.70 (11.91)	0.309	48.13 (39.58; 48.13)	47.31 (38.96; 54.75)	0.12
SF36 Physical Component Summary Score	37.92 (9.69)	40.75 (11.05)	0.054	44.65 (34.21; 52.95)	51.56 (40.57; 55.95)	0.14
NRS back pain	**7 (5; 8)**	**6 (4; 8)**	**0.041***	3 (1.25; 6)	3 (0; 6)	0.35
NRS leg pain	**5 (0; 8)**	**2 (0; 7)**	**0.046***	1 (0; 4)	0 (0; 4)	0.70
ODI ("Oswestry Disability Index")	**38.56 (20.61)**	**32.79 (20.80)**	**0.019***	**21 (8.5; 36)**	**16 (6; 33.75)**	**0.039***

Data presented as mean (standard deviation) for normally distributed variables . Non-normally distributed variables were expressed as median (interquartile range)
** statistically significant for P < 0.05*

221. Early Sagittal Spinal Shape as a Risk Factor for Scoliosis: a Prospective Cohort Study

Steven de Reuver, MD; Tom Schlosser, MD, PhD; Moyo C. Kruyt, MD, PhD; René M. Castelein, MD, PhD

Hypothesis
Early sagittal spinal shape predicts the risk for adolescent idiopathic scoliosis development.

Design
Prospective cohort.

Introduction
Idiopathic scoliosis is a deformation of the spine, developing in 2-4% of otherwise healthy, mostly female, early adolescents. Its etiology is largely unknown, but posteriorly inclined segments of the spine (unique to humans) have been demonstrated to be less rotationally stable and may be important in scoliosis initiation. Our study is the first to prospectively analyze the predictive value of the sagittal spinal shape, before the actual onset of scoliosis. For this, we followed a pediatric model with a high likelihood of developing scoliosis during growth, i.e. children with 22q11.2 deletion syndrome (22q11.2DS).

Methods
We prospectively followed a cohort of children with confirmed 22q11.2DS by biplanar spinal radiographs at two-year intervals. Included children initially had normal spines, were skeletally immature, and were followed until skeletal maturity. To quantify the severity of the 'at risk' segment, the previously described parameter 'posteriorly inclined triangle' (PIT) area was measured on the initial lateral radiograph.

Results
Of 50 included children (54% boys, mean age 10.7±1.7, mean follow-up 4.8±1.6 years), 24 (48%) developed scoliosis. An above average PIT-area of >60cm2 at inclusion, showed a relative risk of 2.55 (95%CI:1.22-5.34) for scoliosis to develop. PIT-length and PIT-inclination, representing the PIT's shape, both significantly correlated with scoliosis apex location: higher/thoracic or lower/lumbar.

Conclusion
The magnitude of the posteriorly inclined segment of the pre-adolescent spine in this population predicts later scoliosis development, the segment's shape determines the scoliosis apex. This underlines the biomechanical component of scoliosis etiology, and may aid early detection, treatment, and ultimate scoliosis prevention.

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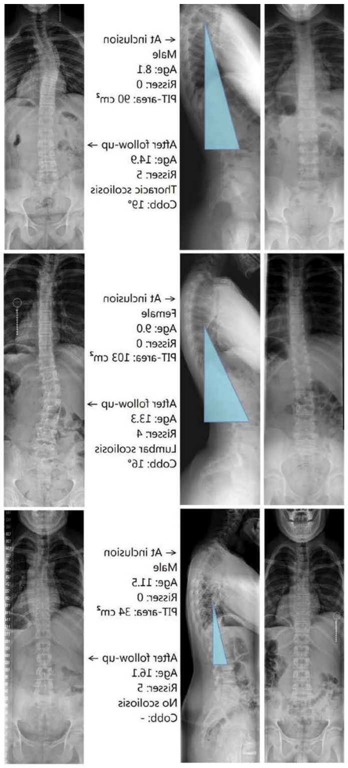

Examples of three participants, demonstrating a larger PIT-area before the development of scoliosis compared to no scoliosis. Note the slender PIT in thoracic scoliosis versus wider PIT in (thoraco) lumbar scoliosis.

222. Adult Spinal Deformity Correction in Parkinson's Disease Patients: Assessment of Surgical Complications, Reoperation and Cost

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Hypothesis

Patients undergoing deformity correction with Parkinson's disease (PD) are more likely to experience increased rates of surgical and medical complications.

Design

Retrospective cohort study between 2010-2020.

Introduction

PD is a degenerative disorder that manifests with progressive postural instability and gait imbalance. Correction of spinal deformity in Parkinson's patients presents a challenge as these patients often experience poor bone quality and profound musculoskeletal dysfunction.

Methods

The PearlDiver database was queried between 2010-2020 to identify adult patients with a known diagnosis of spinal deformity prior to undergoing deformity correction with posterior spinal fusion. The cohort was stratified according to a pre-operative diagnosis of PD. Outcome measures included reoperation rates, surgical technique, cost, surgical complications, and medical complications. Multivariable logistic regression adjusting for CCI, age, gender, region, and number of levels fused was utilized to assess the rates of reoperation and complications by comparing PD patients to controls.

Results

26,984 patients met the inclusion criteria and were retained for this study. 725 patients had a diagnosis of PD prior to undergoing deformity correction. PD patients underwent significantly higher rates of pelvic fixation (OR=1.33, p<0.001) and 3-column osteotomies (OR=1.53, p<0.001). On adjusted regression, PD patients exhibited significantly increased rates of reoperation at 1-year (OR=1.37, p<0.001), 5-years (OR=1.31, p<0.001), and overall (OR=1.30, p<0.001). PD patients also experienced an increased rate of medical complications within 30-days following deformity correction including deep venous thrombosis (OR=1.64, p=0.016), pneumonia (OR=1.50, p=0.030), and urinary tract infections (OR=1.31, p<0.001). Deformity correction in Parkinson's patients was also associated with significantly higher 90 day cost (p=0.004) on adjusted analysis.

Conclusion

PD patients undergoing long fusion for deformity correction are at significantly increased risk of 30-day medical complications and revision procedures after 1-year. When considering deformity corrections in this patient subset, surgeons need to consider the risk of complications, subsequent revision procedures, and increased cost.

	OR Parkinson vs Control (Unadjusted)	p value	OR Parkinson's vs Control (Adjusted)	p value
Total Reoperations	1.50	<0.001	1.30	**<0.001**
Total Reoperations within 30 days	1.39	0.010	1.25	0.094
Total Reoperations within 1 year	1.60	<0.001	1.37	**<0.001**
Total Reoperations within 5 years	1.51	<0.001	1.31	**<0.001**
Medical Complications				
Acute kidney injury	1.64	0.002	1.10	0.555
Cardiac complications	2.01	<0.001	1.33	0.103
Deep venous thrombosis	2.01	<0.001	1.64	**0.016**
Pulmonary embolism	1.54	0.078	1.35	0.219
Pneumonia	1.71	0.004	1.50	**0.030**
Urinary tract infection	1.85	<0.001	1.59	**<0.001**

Medical complications and re-operation rates for PD patients

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

223. The Sanders Classification and Obesity: Do Obese Kids with AIS Present with More Advanced Skeletal Maturity?

Jeffrey M. Henstenburg, MD; Jeremy Heard, BS; Hamdi Sukkarieh, MD; Suken A. Shah, MD; Jaysson T. Brooks, MD; Tyler C. McDonald, MD

Hypothesis
We hypothesize that in patients with AIS, OOW patients will have a higher SMS score on initial presentation when compared to NW patients.

Design
Retrospective Cross-Sectional Study

Introduction
Obese and overweight (OOW) patients with adolescent idiopathic scoliosis (AIS) have been shown to initially present with a more advanced Risser score compared to normal weight (NW) patients. The Sander's Maturity Scale (SMS) is now more commonly used by surgeons to assist with treatment decisions because it more reliably predicts skeletal maturity. However, the relationship between SMS and obesity has not been described.

Methods
Billing data from two different institutions were used to identify patients with AIS presenting to a pediatric orthopedic spine surgeon for an initial visit between July 2012 and March 2020. We excluded those without height/weight data, spine radiographs, or left hand radiographs for measuring SMS stage. BMI-for-age percentiles were calculated and used to group patients into NW (<85th percentile) or OOW (85th percentile and above) per CDC guidelines. After collecting preliminary data, a power analysis was performed using average SMS scores between NW and OOW patients with an alpha of 0.5, determining a needed sample size of approximately 300 male and 300 female subjects.

Results
590 patients (296 female, 294 male) were identified. The SMS stage at presentation was significantly greater in OOW compared to NW patients for both females (5.9±1.8 vs 5.2±1.7; P=.003) and males (4.9±1.9 vs 4.1±1.8; P=.002). The major curve magnitude for OOW females was significantly different from NW females (36 ± 16 degrees vs 30 ± 16 degrees; P=.004). The major curve magnitude was not different for OOW and NW males (P=.3).

Conclusion
At initial presentation, OOW patients present at a greater skeletal maturity as measured by the SMS compared with NW patients. OOW female patients present with a greater major curve magnitudes than NW female patients. These results highlight negative implications of the pediatric obesity epidemic as it relates to the AIS population. These findings reinforce the importance of early, vigilant screening for scoliosis in obese patients which may allow for earlier intervention to negate or delay the need for surgery.

224. Effectiveness of a Subcutaneous Bupivacaine Catheter for Pain Control and Opioid Reduction in Pediatric Spine Fusion Surgery: A Retrospective Cohort Study

Joshua Acebo, MD; Kenzo Cotton, MS; Emma Wiest, MS; Jordan Walters, MD; Eric Siegel, PhD; Richard E. McCarthy, MD; David B. Bumpass, MD

Hypothesis
Pediatric patients who receive continuous postoperative subcutaneous bupivacaine infusions (SQBI) after posterior spine fusion (PSF) for adolescent idiopathic scoliosis (AIS) or neuromuscular scoliosis (NMS) have better pain scores and less inpatient opioid consumption, compared to patients who do not receive SQBI.

Design
Single-center retrospective cohort study

Introduction
The invasiveness of PSF continues to provide challenges in minimizing opioid medications. In addition to multimodal oral/intravenous pain regimens, SQBI may improve patient comfort, early mobilization, and efficient discharge while minimizing opioids. The best existing study of postoperative bupivacaine infusion was not controlled for tissue depth of the catheter and only studied AIS patients. At our institution, one pediatric spine surgeon uses SQBI while a second surgeon performing identical surgeries does not. Postoperative multimodal pain regimens are otherwise identical.

Methods
We performed chart review of patients who underwent PSF by 2 pediatric spine surgeons between the dates of 2015–2021. Inclusion criteria included patients between the ages of 10-18 at the time of surgery and a diagnosis of AIS or NMS. Exclusion criteria included non-fusion procedures, congenital scoliosis, or patients who were contraindicated for patient-controlled analgesia PCA. Inpatient opioid consumption was calculated using morphine milligram equivalents (MME); inpatient pain scores were quantified using a visual analog scale 0-10. Primary outcome was inpatient MME usage, and secondary outcomes were mean pain scores and hospital length of stay (LOS).

Results
205 patients met inclusion criteria. 103 patients received a SQBI catheter while 102 did not. Overall, MME difference between the two groups was 37.4 mg, with the SQBI group receiving fewer MME (p<0.01) and achieving shorter median LOS of 1 day (p<0.01). No difference in MME use was found within the NMS group, but the benefit of SQBI was maintained in the AIS group. Pain scores were low in all comparisons without difference. A subgroup analysis for patients with LOS <10 days was done to control for outliers, without substantial differences when compared to the entire population.

Conclusion
The use of SQBI after pediatric spine fusion reduces overall opioid consumption and facilitates shorter hospital LOS.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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	Total Group		
	No SQBI (n=102)	Yes SQBI (n=103)	p
Mean Total MME (mg)	166.1	128.7	0.0002
Median LOS (days)	4	3	0.003
Mean VAS Pain Score	2.8	2.8	0.97

	Neuromuscular Scoliosis Group		
	No SQBI (n=20)	Yes SQBI (n=20)	p
Mean Total MME (mg)	108.6	95.4	0.67
Median LOS (days)	5	4.5	0.33
Mean VAS Pain Score	0.7	1.1	0.91

	Adolescent Idiopathic Scoliosis Group		
	No SQBI (n=82)	Yes SQBI (n=83)	p
Mean Total MME (mg)	180.1	136.7	0.0003
Median LOS (days)	4	3	0.0003
Mean VAS Pain Score	3.3	3.2	0.78

	Patients w/ Length of Stay <10 Days		
	No SQBI (n= 96)	Yes SQBI (n=95)	p
Mean Total MME (mg)	166.5	126.4	0.0002
Median LOS (days)	4	3	0.0001
Mean VAS Pain Score	2.9	3.0	0.83

Effects of bupivacaine vs. no bupivacaine

225. Decompression and Dynamic Sagittal Tether for Degenerative Spondylolisthesis: 48-month Comparative Results to TLIF from US IDE Trial

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Hypothesis

Decompression and dynamic sagittal tether (DST) stabilization can achieve equivalent outcomes with lower operative morbidity and cost vs decompression and instrumented TLIF for degenerative spondylolisthesis (DS) at 48mo postop.

Design

Prospective follow-up of concurrently enrolled IDE trial with propensity score matching of groups.

Introduction

Durable outcome for patients with DS usually requires decompression and fusion. A dynamic sagittal tether (DST) is proposed for segmental stabilization after decompression for DS as an alternative to fusion. An FDA IDE study (NCT03115983) compares direct surgical decompression and stabilization with the DST to decompression and instrumented TLIF for symptomatic DS.

Methods

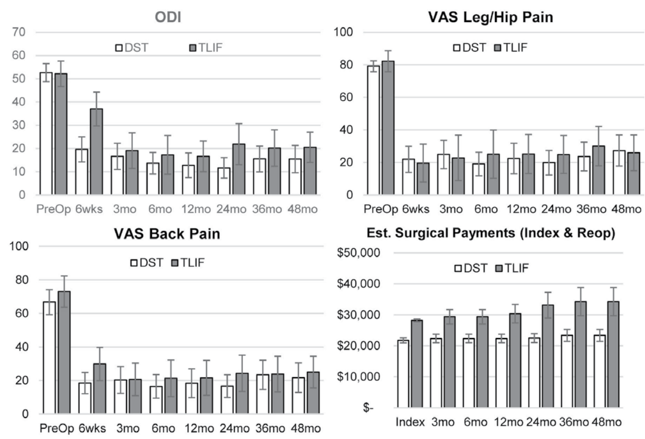
All patients had grade I DS and spinal stenosis with ODI≥35 and VAS-leg/hip≥5. Patients received a decompression and either DST or TLIF at the level of DS, +/-adjacent level decompression if indicated. Patient-reported outcomes and reoperations were tracked through 48mo follow-up. Perioperative outcomes were collected and reoperations at the index or adjacent level were tracked through 48-months. We report as-treated outcomes in the group of patients with 48mo followup. The costs of index surgery and reoperations were estimated with 2023 Medicare rates or 120% of MC for patients<65yo.

Results

72 PS-selected patients (49DST/33TLIF) reached 48mo clinical followup. Mean ODI for the DST/TLIF groups decreased from 52.6/52.1 preop to 15.5/20.5 at 24mo. VAS back pain decreased from 66.7/73.0 to 21.7/25.0 and VAS leg/hip pain from 79.1/82.2 to 27.3/25.9. There were 4/6 (8.2%/18.2%) reoperations in the DST/TLIF groups: 2/0 additional decompressions, 2/1 index level fusions, 0/1 adjacent level fusions and 0/4 fusions involving index and adjacent levels. Mean estimated payments for index surgeries and reoperations through 48mo in the DST/TLIF groups were $24,065/$34,229.

Conclusion

Both DST and TLIF groups had significant, durable improvement in pain and disability. The experimental group had lower observed reoperation rates within the first 4 years and lower total cost of surgery including reoperations. This data supports that lasting clinical improvement, similar to that of a fusion for DS, can be obtained with a decompression and DST stabilization. Further follow-up from the entire cohort of patients in the IDE will be presented once that data is available.



48mo Outcomes

226. Use and Efficacy of Antifibrinolytic Agents in Patients Undergoing Growth Friendly Surgery for Neuromuscular Scoliosis

Wei Wu, MD; Pediatric Spine Study Group; Ishaan Swarup, MD

Hypothesis

Antifibrinolytic agents are used in the majority of growth friendly procedures for neuromuscular scoliosis.

Design

Retrospective Cohort

Introduction

There is a paucity of data on the use, efficacy, and safety of antifibrinolytic agents (AF) in patients with neuromuscular scoliosis undergoing growth-friendly instrumentation. Previous studies have

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shown mixed results of AF agents in young patients with neuromuscular conditions. The purpose of this study was to investigate the rate of use of AF agents for growth-friendly surgery in patients with neuromuscular scoliosis, and assess its impact on blood loss and transfusion requirements.

Methods

This is a retrospective cohort study of patients from a multicenter spine study group with neuromuscular scoliosis that underwent an index growth-friendly procedure. Patients with a history of venous thromboembolism and those undergoing revision surgery or lengthening surgery were excluded. Perioperative data was collected including patient demographics, type of instrumentation, use and type of AF agent, estimated blood loss (EBL), use and volume of cell saver, and intraoperative blood transfusion. Univariate statistics were used to determine differences.

Results

This study included 556 patients with a mean age of 7 years (SD: 2.5). Of these patients, 294 patients were managed with VEPTR/TGR instrumentation and 261 patients were managed with MCGR instrumentation. AF agents were used in 36% of index cases. In cases with AF use, TXA was the most frequently used agent (TXA:68%, ACA:21%). There was no statistical difference in EBL between patients who received AF agents compared to patients that did not receive AF agents (AF=184.9ml, no AF=103ml, p=0.23). In addition, there was no difference in cell saver volume (AF=127ml, no AF=145ml, p=0.88). The overall rate of blood transfusion was low (8.31%). In this cohort, and there was no significant difference in transfusion rates between groups (AF=7.6%, no AF=8.8%, p=0.7).

Conclusion

AF agents are being used for patients undergoing growth friendly procedures with TXA being the most commonly used AF. However, there is no significant difference in EBL, cell saver volume, and intraoperative transfusion rates between patients that do or do not receive AF agents for these procedures. Additional studies are needed to validate these results, as well as determine their safety and value in neuromuscular patients.

227. Substantial Lumbar Curve Correction Increases Postoperative Intervertebral Disc Volume After Surgery in AIS Patients with Lenke Type 5C

Shoji Seki, MD, PhD; Hiroto Makino, MD, PhD; Yoshiharu Kawaguchi, MD, PhD

Hypothesis

The more corrected the scoliotic lumbar curvature, the greater the residual lumbar intervertebral disc volume after surgery in patients with Lenke type 5C.

Design

prospectively collected retrospective analysis

Introduction

For the selection of the lowest instrumented vertebra (LIV) in the Lenke type 5C curve, it is preferable that the lumbar curve is corrected as much as possible and the mobile intervertebral segment remains. Therefore, it is debatable whether correction or mobility is more important. We analyzed three-dimensional volumetric analysis and T2 intensity of residual intervertebral discs after surgery using MRI in Lenke type 5C patients.

Methods

A total of 31 AIS patients (15.5y) who underwent spinal correction surgery were included. Pre- and post-operative lumbar MRI at least postoperative 2 years or later were analyzed for changing volume and T2 intensity of residual intervertebral disc with three-dimensional analysis software (Dragonfly). There were 23 patients with LIV in L3 and 8 patients with L4. The average duration of MRI imaging was 4.1 years (range 2.0-8.9). Association between the changed in volume of intervertebral discs after surgery and radiographical parameters, such as Cobb angle, Risser sign, disc angulation and LIV tilt, were analyzed and compared with changing in disc volume and T2 intensity.

Results

Pre- and post-operative mean volumetric change in nucleus pulposus (NP) was 2305mm3, 2622mm3, respectively, and Annulus fibrosus (AF) was 9601mm3, 10525mm3, respectively. There were significantly increased the volume of NP and AF after surgery ($P<0.001$). On the other hand, changing in T2 intensity of NP and AF were significantly decreased after surgery ($P<0.01$). Association between increased volume of NP just below LIV and changed in thoracolumbar/lumbar curvature and LIV tilt after surgery ($P<0.01$). Selection of L3 significantly increased the volume of the residual intervertebral disc and reduced the decrease in T2 intensity ($P<0.05$).

Conclusion

The volume in residual intervertebral discs was significantly increased with NP and AF after surgery. Substantial correcting lumbar curvature and LIV tilt is likely to increasing volume of the discs after surgery.

228. Prediction of Longitudinal Growth and Growth Modulation after VBT Surgery: A Comparative Analysis of Different Skeletal Maturity Staging Systems

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Hypothesis

Axial skeletal maturity staging system of Cervical Vertebral Maturity (CVM) better predicts growth modulation compared to staging systems that use appendicular markers

Design

Retrospective analysis of prospectively collected data

Introduction

Risser has been a standard assessment method for AIS patients. Sanders Skeletal Maturity Staging (SSMS) became popular, especially in decision-making for VBT. Thumb-Ossification Com-

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posite Index (TOCI), using ossification of thumb epiphyses, has been claimed to more accurately stage patients at their peak height velocity (PHV). However, during puberty, growth peaks occur separately at lower limbs and trunk. Hence, CVM, using cervical spine morphology, possesses a potential to estimate spinal growth better. Aim was to compare the predictive ability of each method for longitudinal growth and growth modulation after VBT.

Methods

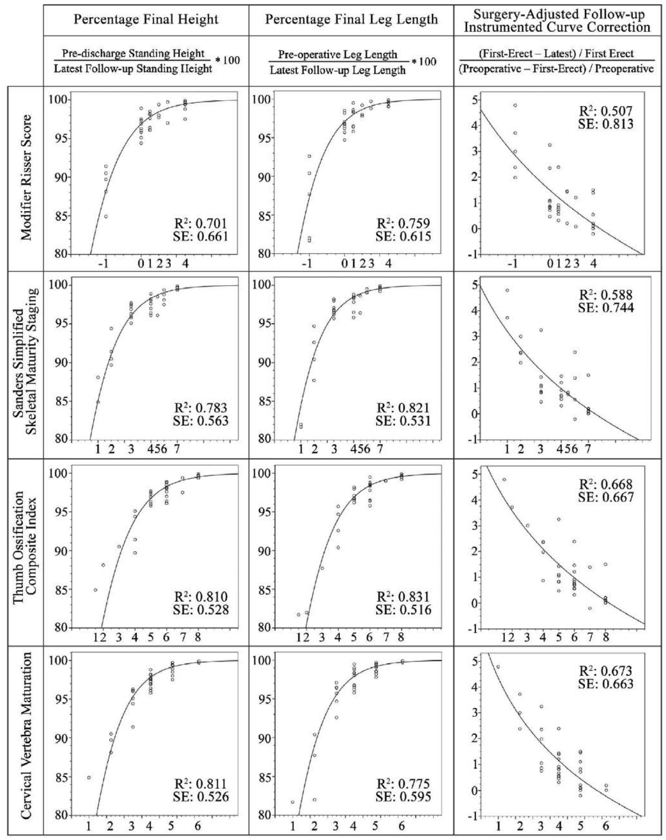
Demographic and radiographic data were analyzed. Skeletal maturity was determined using all 4 systems (Risser, SSMS, TOCI and CVM) for each patient. Crosstabulations of axial vs appendicular markers were formed. Predictive abilities were compared for total height gain, leg length growth and follow-up curve behavior in tethered segments (Fig 1). Logistic and logarithmic regression models were run to assess longitudinal growth and growth modulation, respectively.

Results

34 patients (32F, 2M, mean age: 12.8±1.5 years, mean f-up: 45.3 (24-80) months) were included. The median preop stages were: Risser: 1 (2-4), SSMS: 4 (1-7), TOCI: 6 (1-8) and CVM: 4 (1-6). Preop mean height of 155.7cm (130-171) was increased to 162.9 cm (151-177) at latest follow-up. All patients reached skeletal maturity. The mean preop instrumented MT curve magnitude of 45.0°±7.3° was corrected to 20.7°±6.1° at first-erect, which was modulated to 8.4°±13.3°. R-squared values are given in Fig 1. Concordance and discordance were observed between axial vs appendicular systems that demonstrated a range of possible scenarios and distribution of CVM: 1) Trunk PHV before Height PHV, 2) simultaneous PHVs, 3) Trunk PHV after Height PHV.

Conclusion

TOCI and SSMS had similar leg-length predictions that outperformed CVM. However, in terms of prediction of total height gain and follow-up curve correction after VBT, CVM and TOCI were found to be better predictors compared to SSMS. Mutual use of TOCI and CVM may provide an improved decision-aid for VBT.



229. Responses to Individual SRS-22r Questions Can be Modeled After AIS Surgery

Lauren Stone, MD; Christopher P. Ames, MD; Ferran Pellisé, MD, PhD; Joshua M. Pahys, MD; Nicholas D. Fletcher, MD; Lawrence G. Lenke, MD; Vidyadhar V. Upasani, MD; Peter O. Newton, MD; Firoz Miyanji, MD; Michelle Claire Marks, PT; Michael P. Kelly, MD

Hypothesis

A precision-medicine approach to AIS surgery will inform patients of the likelihood of achieving particular results from surgery. The SRS-22r is the "legacy" patient-reported outcome measure (PROM) ranking pain, function, self-image, and mental health on scales of 1-5. Our abilities to predict individual responses and domains are unknown.

Design

Post-hoc analysis

Introduction

A precision-medicine approach to AIS surgery will inform patients of the likelihood of achieving particular results from surgery. The SRS-22r is the "legacy" patient-reported outcome measure (PROM) ranking pain, function, self-image, and mental health on scales of 1-5. Our abilities to predict individual responses and domains are unknown.

Methods

An AIS registry was queried for surgical AIS patients treated be-

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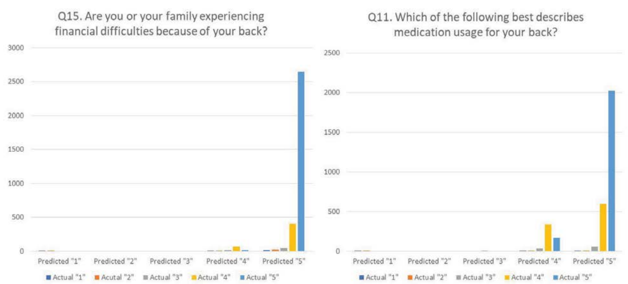
tween 2002-2020. Preoperative data collected included standard demographic data, deformity descriptive data, and SRS-22r scores. Postoperative 2yr SRS-22r scores were modeled as recovery is expected at this point. Missing values were imputed. Ordinal logistic regression calculated probabilities of each ranked response, 1-5, using baseline data. The highest probability was the most likely response. Model performance was examined by c-statistics, where c>.8 was considered excellent. Ceiling effects were measured by the proportion of patients reporting "5" to each question.

Results
3251 patients contributed data to the study; mean age 14.4 (±2.2) yrs, female 2631 (81%), major thoracic coronal curve 53°, mean lumbar 41°. C-statistic values ranged from .6 (poor) to .8 (excellent) evidence of varied predictive capabilities. Q17 ("days off work/school", c = .84, ceiling achieved 75%) and Q15 ("financial difficulties", c = .86, ceiling 82%) had the greatest predictive capabilities while Q11 ("pain medication", c=.73, ceiling 67%), Q10 ("appearance", c=.72, ceiling 35%), and Q19 ("attractive", c=.69, ceiling 37%) performed poorly.

Conclusion
Prediction of SRS-22r responses perhaps most germane to AIS treatment was poor. Prediction of less relevant outcomes, where ceiling effects are present, was good as "5" was chosen for all responses. A precision-medicine approach to AIS surgery requires more refined outcome instruments with continuous measures of health-state, rather than ordinal responses. This may reduce the effect of response ceilings and allow for better discrimination of baseline self-perceived health-state particularly for Self-Image.



Response Distributions

230. Rare Variant Association Analyses Reveal the Significance of Carbohydrate Metabolism in Severe Idiopathic Scoliosis *

Wen Wen, MD; Zhengye Zhao, MD; Hengqiang Zhao, PhD; Shengru Wang, MD; Xi Cheng, BS; Sen Zhao, BS; Zhihong Wu, MD; Terry Jianguo Zhang, MD; Nan Wu, MD

Hypothesis
Genetic variants affecting carbohydrate metabolism may contribute to the idiopathic scoliosis (IS) onset, particularly adolescent idiopathic scoliosis (AIS).

Design
Case-control genetic study using next-generation sequencing, gene- and pathway-based burden tests, followed by RNA-seq validation

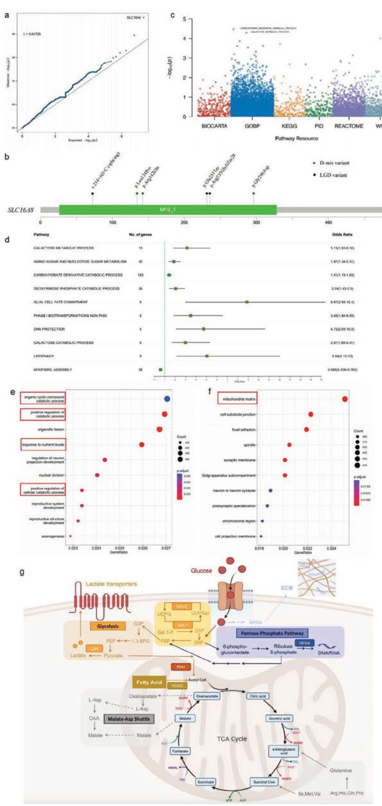
Introduction
Abnormal energy metabolism, such as a lower body mass index, has been commonly observed in AIS patients, suggesting a potential role for energy metabolism in the development of the disorder. However, the relationship between metabolism and the pathogenesis of AIS is little known.

Methods
Whole-genome/exome sequencing on 400 Chinese Han severe IS patients and 4200 unrelated controls was performed. Gene-based rare variant burden test was conducted using SAIGE-GENE+. Variants were weighted based on type and bioinformatic predictions. Pathway-based burden analysis was performed to determine the aggregate impact. Pathway enrichment was executed using expression data from paraspinal muscle tissue of 7 AIS patients and 20 controls.

Results
Gene-based burden analysis identified SLC16A8, a lactate transporter, as a novel candidate gene for severe IS (P=3.80E-04), influencing glucose metabolism and extracellular matrix synthesis through lactate accumulation. Pathway-based analysis showed rare variants in galactose, deoxyribose phosphate, and amino/nucleotide sugar metabolism to be significantly enriched. GALE, DERA, and LDHD, critical for pathway function, were also among the top results in gene-based analysis. Restricting to AIS subgroup, the significance became more pronounced, suggesting abnormal carbohydrate metabolism as a predominant mechanism in AIS. Gene expression data in muscle tissue demonstrated consistent significance in carbohydrate pathways but not individual genes, implying mild but widespread pathway perturbation.

Conclusion
Our study suggests a link between genetic varaints affecting carbohydrate metabolism and the etiology of IS, especially AIS, providing a new perspective.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster



Genetic analysis of IS patients. a) Q-Q plot of gene-based burden analysis. b) Distribution of deleterious variants in SLC16A8. c,d) Manhattan & forest plot of pathway-based burden analysis. e,f) Enrichment result of muscle expression with carbohydrate pathways in red frame. g) Carbohydrate metabolism model, highlighting candidate genes & pathways.

231. The Three Dimensional Coupling Mechanism in Scoliosis and Its Consequences for Correction

Lorenzo Costa, MD; Tom Schlosser, MD, PhD; Peter R. Seevinck, PhD; Dong-Gune Chang, MD, PhD; Moyo C. Kruyt, MD, PhD; René M. Castelein, MD, PhD

Hypothesis

Extension of the scoliotic spine in the sagittal plane should provide room for that longer anterior column to swing back to the midline, reducing the coronal Cobb angle and the axial vertebral rotation

Design

Prospective cohort study

Introduction

Adolescent Idiopathic Scoliosis is a complex 3-D spinal deformity in which the anterior spinal column has rotated away from the midline and has become longer through unloading and expansion of the intervertebral discs (IVD), making full reduction difficult. Extending the spine should make room for the anterior column to reduce back to the midline, leading to a reduction of both coronal Cob angle and transverse plane rotation. Aim of this study was to analyse, using novel bone MRI sequences, the effect of simple extension of the spine in the sagittal plane on the magnitude of the coronal plane curvature as well as the horizontal plane vertebral rotation. Furthermore, the changes in the shape of the IVD as well as the shape and position of the nucleus pulposus (NP) were studied

Methods

MRIs with C-VISTA and Bone-MRI sequences with focus on the scoliotic primary thoracic curve were performed in a study of 10 AIS patients in standard supine and extended supine position, provided by a broad MRI compatible bolster positioned under the thorax at the level of the thoracic apex. Rotation (apical vertebra, two vertebrae above and two below), coronal curve angle (Cobb angle), anterior thoracic (T) height (T4-T12) and IVD shape as well as NP shape and position were analysed and compared between the two positions

Results

Extension of the spine reduced thoracic kyphosis by 9,90° (P <0,001), the coronal Cobb angle by 9,40°(P <0,001), and transverse plane rotation by 4,16°(P 0,009). Rotation reduced mostly around the apex by 6,59° (P 0,003), anterior T height increased by 0,69 cm (P <0,001). The peri-apical discs became less wedge shaped and the NPs changed to a more symmetrical conformation, translating to the midline.

Conclusion

This study shows that extension in the sagittal plane leads to a reduction of both the Cobb angle in the coronal plane and rotation in the horizontal plane. The shape of the disc and the shape and position of the nucleus pulposus normalized. This may have important consequences for conservative treatment, analogous to clubfoot treatment where manipulative techniques make correction of the deformity in one plane possible by creating room in another plane

232. Blood Titanium Levels in Children with Magnetically Controlled Growing Rods

Martina Tognini; Harry S Hothi, PhD; Anna Di Laura, PhD; Edel Broomfield, ANP; Stewart Tucker, MD, FRCS; Masood Shafafy, FRCS; Johann Henckel, PhD, MBBS; Alister Hart, MD, MBBS, FRCS

Hypothesis

Children implanted with Magnetically Controlled Growing Rods may have blood titanium levels that are greater than baseline levels for titanium implants.

Design

Multicentre, retrospective, case-control study.

Introduction

Magnetically Controlled Growing Rods (MCGRs) are used in the treatment of Early-Onset Scoliosis (EOS); the primary constituent metal in these is titanium. Rod failures due to wear and/or corrosion have been widely documented; blood titanium testing may help monitoring of these patients however there is currently little data about the spread of blood titanium levels in these patients.

Methods

We measured titanium levels in whole blood samples from 20 patients implanted with MCGRs. Samples were collected at routine lengthening clinics (n=4) or prior to rod removal (n=16). These were compared with baseline titanium levels established from patients with well-functioning titanium hips (n=95). Clinical data and the functional state of the implant at the time of blood sample collection was recorded for all patients.

Results

Median (range) blood titanium levels in MCGR patients were 8.9ppb (1.1-25.4). The median age at implantation and follow-up time were 6.5 years (2-14) and 30 months (3-57), respectively. Blood titanium levels in MCGRs patients were significantly greater than baseline levels of 1.2 ppb (p<0.001). There was no association between titanium levels and age at implantation (p=0.169), follow-up time (p=0.380), and the amount of rod extension (p=0.196). There was no difference in pre-removal titanium levels between rods determined as being functional or non-functional following retrieval analysis (p>0.05).

Conclusion

Patients implanted with MCGRs in this study had blood titanium levels that were elevated compared with baseline titanium levels. There is now a need for prospective, longitudinal blood sampling of these patients to establish the role of blood titanium measures as a biomarker for implant function.

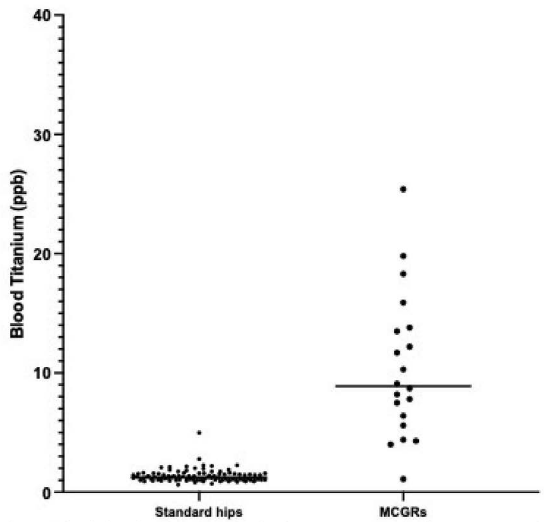


Fig. 1: Blood Titanium levels (ppb) for the two groups. The line represents the median.

233. Severe Dysphonia is Reported in 25% of Adult Cervical Deformity Patients Prior to Surgery

Alex Soroceanu, MD, FRCS(C), MPH; Christopher P. Ames, MD; Themistocles S. Protopsaltis, MD; D.Kojo Hamilton, MD, FAANS; Peter G. Passias, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Eric O. Klineberg, MD; Munish C. Gupta, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis

We hypothesize that a sizeable proportion of cervical deformity patients report pre-operative dysphonia.

Design

Prospective multicenter adult cervical deformity study.

Introduction

The purpose of this study was to quantify the presence of impairment due to dysphonia in a cohort of adult cervical deformity (ACD) patients prior to undergoing deformity correction, to investigate the relationship between dysphonia and dysphagia, and to assess how patients with pre-operative dysphonia differ from their counterparts in terms of demographics, frailty, baseline HRQOL, and baseline alignment.

Methods

Retrospective analysis of a prospective multicenter cervical deformity database. The voice handicap index-10 (VHI-10) was used to assess patient's perception of impairment due to problems with their voice. A score >=11 was considered indicative of dysphonia. Patients were divided into two groups : normalVHI group (VHI-10 score <11) and highVHI group (VHI score >=11). The groups were compared in terms of baseline demographics, HRQOL, and cervical alignment. T-tests and chi2 tests were performed, as appropriate.

Results

95 ACD patients were included: normalVHI (n=72, average VHI score 2.88) and highVHI (n=23, average VHI score 17.04). The groups were similar in terms of gender , BMI, smoking status, history of past cervical spine surgery, and co-morbidities (p>0.05). There was no statistically significant difference between normalVHI and highVHI patients in baseline sagittal alignment (C2-C7 lordosis, T1S, TS-CL, CBVA, and C2-C7 SVA p>0.05). HighVHI patients had a higher Edmonton Frail Score (6.43 vs 4.75, p=0.0149) and higher ACFI (0.39 vs 0.268, p=0.006). The highVHI group also had worse baseline HRQOL scores : NDI 62.29 vs 45.52 (p=0.0001), VR-PCS 20.75 vs 27.3 (p=0.018), and VR-MCS 37.92 vs 48.21 (p=0.002). HighVHI patients had higher scores on the EAT-10 questionnaire : 13.45 vs 2.98, p=0.0001 (a score >3 on the EAT-10 questionnaire is indicative of oropharyngeal dysphagia). The VHI-10 and EAT-10 questionnaires were strongly correlated (correlation coefficient 0.62, p=0.0001).

Conclusion

Twenty-five percent of adult cervical deformity patients undergoing deformity correction have impairment due to a voice problem prior to surgery. Surgeons should consider formal preoperative ENT dysphonia and dysphagia evaluation for ACD patients.

234. Differential Spine and Total Height Growth Between Sanders Maturation Stage 7A and 7B in Patients with Idiopathic Scoliosis Have Implications for Clinical Care

Yusuke Hori, MD, PhD; Burak Kaymaz, MD; Luiz Silva, MD; Kenneth J. Rogers, PhD; Petya Yorgova, MS; Irene Li, MS; Peter G. Gabos, MD; Suken A. Shah, MD

Hypothesis
Growth assessment in the subclassification of Sanders Maturation Stage (SMS) 7 reveals important differences in the spine and total height growth.

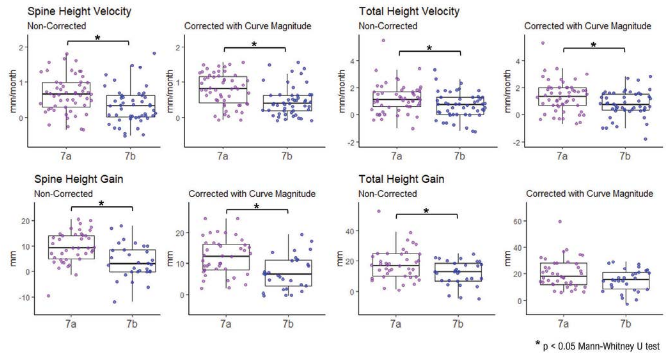
Design
A single-center retrospective case-control study

Introduction
Curve progression after skeletal maturity is rare but has been reported even in SMS 7. SMS 7 has recently been subtyped into 7A and 7B; however, no literature clearly describes their differential growth. Therefore, we aimed to compare the growth velocity and potential in the spine and total height between SMS 7A and 7B.

Methods
We included patients with AIS staged SMS 7 who had regular f/u over 6 months and measured T1-S1 spine height, total body height, and curvature at each visit. Considering the effect of curve magnitude on the height measurement, the corrected height was adjusted using a validated formula. We compared spine and total height velocity per month between patients staged SMS 7A and 7B. Additionally, spine and total height gain and degree of curve progression were investigated for patients who followed until skeletal maturity, defined by Risser stage 5 or fully capped 4.

Results
A total of 104 patients (81% girls, mean age: 13.8±1.2 yrs, mean Cobb: 31±8°) were included. Patients staged 7A had higher spine (0.8 vs 0.5 mm/month) and total height velocity (1.3 vs 0.8 mm/month) than 7B, and these differences were significant after correcting for curve magnitude (Fig). Among 72 patients who reached skeletal maturity with a mean 32±17 months f/u, spine height gain was greater in patients staged 7A than 7B (9.6 vs 3.9 mm), as well as total height gain (18 vs 12 mm) (Fig). Curve progression was comparable between 7A and 7B (3.8 vs 4.9°, p=0.372). Among the patients with an initial curve < 40°, three in each group progressed >50°.

Conclusion
Patients in SMS 7A had greater spine and total height velocities and growth potentials than 7B, although the differences were small. In contrast to differential growth, curve progression occurred similarly in 7A and 7B, requiring further investigation to find related factors for curve progression and growth cessation. This has important implications for brace treatment cessation and counseling for curve progression after maturity.



Boxplots of spine and total height velocity (above) and height gain to skeletal maturity (below) between SMS 7A and 7B indicate significant differences

235. Withdrawn

236. Withdrawn

237. Timing of Intrathecal Morphine Administration and its Impact on Pain Control in Adolescent Idiopathic Scoliosis

Jacob Maier, MD; Andrew Meyer, MD; Catherine Hord, BS; Richard Steiner, PhD; Tarun Bhalla, MD; Todd F. Ritzman, MD; <u>Lorena Floccari, MD</u>

Hypothesis
Patients given intrathecal morphine preoperatively have improved perioperative pain control compared to administration at time of incision closure.

Design
Level 3: Retrospective Cohort Comparison study

Introduction
Multimodal pain control is a key factor driving functional recovery and hospital length of stay following posterior spinal fusion (PSF). Intrathecal morphine (ITM) can improve pain control, but the optimal timing of administration is unclear. Our study examines the effect of ITM administered preoperatively versus post-deformity correction in adolescent idiopathic scoliosis (AIS) patients.

Methods
146 consecutive AIS patients who underwent PSF at a single institution were retrospectively reviewed. Patients were either given ITM preoperatively before/at time of exposure (PRE, n=101), or post-correction at wound closure (PO, n=45), decided at the discretion of the surgical and anesthetic teams.

Results
There were no differences between the PRE and PO groups in baseline demographic variables, including age, gender, BMI, or main curve magnitude (58.9° vs 62.3°), or in number of instrumentation levels, estimated blood loss, or operative time (all p≥0.1). The IT morphine dose was similar in PRE and PO groups (5.0 vs 4.7 ug/kg, p=0.76) with no difference in intraoperative vasopressor

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

administration for hypotension or intraoperative morphine milligram equivalents (MME, all p≥0.1). No patient in either group required allogeneic transfusion. Postoperatively, the PRE group had a trend for lower MME on the day of surgery (3.3 vs 4.9, 0.078), but there was no difference in MME given on subsequent hospital days or during total hospitalization (68.0 vs 75.3, p=0.211). There also was no difference in hospital length of stay (2.87 vs 2.91 days), respiratory depression, pruritus, nausea/vomiting, or other complication, including 30-day ED visit or readmission (all p≥0.1).

Conclusion

Intrathecal morphine can be given either pre- or postoperatively, with no significant impact on perioperative pain control or functional recovery. There is no difference in MME administration, hospital length of stay, potential side effects (hypotension, pruritus, nausea/vomiting), or 30-day ED visits/readmissions. Given these findings, standardized intraoperative placement by the surgeon in the operative field may provide improved utilization of operating room time, anesthesiology resources, and cost.

238. Magnetically Controlled Growing Rod Coupled Distraction Mechanics: A Strategy to Enhance Distraction Force *

Benjamin Sinder, PhD; Vincent Ruggieri, BS; John (Jack) M. Flynn, MD; Patrick J. Cahill, MD; Jason B. Anari, MD

Hypothesis

Magnetically controlled growing rod distraction force will decrease with increased lateral distance from the external remote controller and between two rods in coupled distraction

Design

Basic Science

Introduction

While magnetically controlled growing rods (MCGR) represent an advance in growth friendly EOS instrumentation, MCGR failure to lengthen is a clinical problem and there may be scenarios where additional distraction force is beneficial. In some patients, two "standard" rods are implanted with the goal of simultaneously lengthening each rod and collectively generating more distraction force than either rod can alone. However, the ideal distances between MCGR rods that result in additive gains in force is not known. Therefore, the purpose of this study was to 1) determine MCGR distraction force as a function of lateral distance from the external remote controller (ERC), 2) determine if coupled MCGR distraction in a "standard/standard" configuration results in additive gains in force and 3) identify lengthening strategies to potentially enhance coupled distraction force.

Methods

MCGRs (n=3) were tested on a servohydraulic mechanical testing machine (Fig. 1A). Custom 3D printed nylon spacers were used to define a range of ERC to rod lateral offset distances (single rod testing), and rod to rod distances (two rod coupled distraction testing).

Results

We first found that relative to a single rod centered under the ERC, MCGR distraction force was largely maintained through 30mm of lateral offset, and then began to rapidly decline (p<0.05) through a distance of 80mm (Fig. 1B). Next, we tested two rods in coupled distraction and confirmed that distraction force was additive in nature as predicted by the individual single rod data. Thus, when rods were close (~20mm apart), up to 400N of total force could be applied, but this significantly decreased (p<0.05) with increasing rod-to-rod distances and there was no added benefit compared to single rod forces by 80mm of rod-to-rod separation (Fig. 1C). Finally, in coupled distraction (standard/standard) configurations where the rod is more than 20mm apart, up to an additional 100N of force (p<0.05) can be gained by placing the ERC between the two MCGRs instead of centered over either rod (Fig. 1C).

Conclusion

Coupled magnetically controlled rod distraction force is additive and this "benefit" is greatest when the rods are close together.

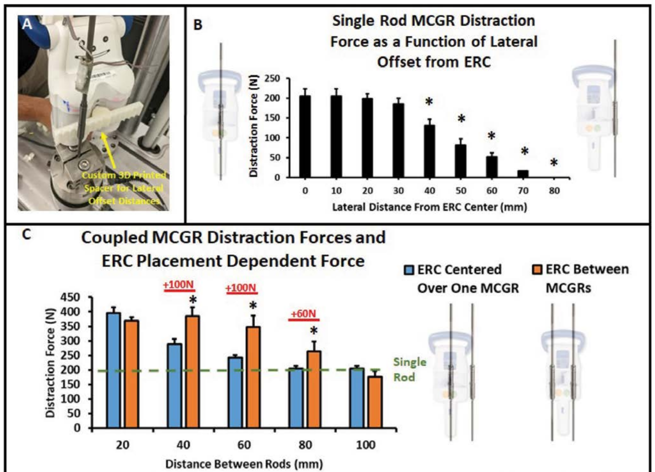


Figure 1: A) Magnetically controlled growing rod (MCGR) distraction force was quantified as a function of lateral offset distance from the center of the external remote controller (ERC). B) We first tested single rods and found that MCGR distraction force was significantly reduced at lateral offset distances greater than 30mm and was near zero force by 70mm of lateral offset. *p<0.05 relative to centered (0mm offset) position. C) Next we tested two rods in coupled simultaneous distraction at various rod-to-rod distances and found the distraction force was largely additive, as would be predicted by the individual single rod data. Finally, when attempting to lengthen two rods at the same rod-to-rod distance, we found greater force can be generated by placing the ERC between the MCGRs instead of centered over one MCGR. *p<0.05 ERC between vs centered over one rod. All data n=3.

Figure 1

239. Axial Plane Pelvic Asymmetry (APPS) in Cerebral Palsy Results from Iliac-Wing External Rotation Deformity

Akbar Syed, MD; Jenny L. Zheng, BS; David A. Spiegel, MD; Christine Goodbody, MD; Keith Baldwin, MD, MPH, MSPT

Hypothesis

A standardized method for measuring Axial Plane Pelvic Asymmetry (APPS) in cerebral palsy (CP) can be established to characterize the deformity.

Design

Retrospective case control

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Introduction
Asymmetric pelvic orientation can lead to postural imbalance and can cause infra-pelvic effects such as hip instability and/or lower limb contractures. Pelvic obliquity is well-recognized coronal plane radiographic feature of neuromuscular spinal deformity in CP, and APPS is poorly in CP scoliosis (CPS). We aimed to describe axial plane asymmetry of the iliac wing (IW) and sacral ala (SA) in CPS versus normal control pelvis (NCP).

Methods
Using CPT codes 74176-8, we identified CT scans of the abdomen/pelvis for patients with CPS (GMFCS IV/V) and controls with no boney deformities or pathologies, matched by age and sex. Pelvic asymmetry was evaluated based on the supra-acetabular region of bone. For each hemipelvis, we measured the angle between a line bisecting the sacrum and a line drawn from the midportion of the PSIS to the midportion of the AIIS, and between a line across the highest points of the sacral ala. CPS measurements were compared to matched NCP values. External/internal rotation (ER/IR) of IW and SA were termed IWE/IWI and SAE/SAI respectively. Absolute difference in ER/IR of IW and SA were termed as Iliac Wing Angle Variance (IWAV) and Sacral Ala Angle Variance (SAAV) respectively.

Results
40 patients were included in each cohort with similar mean age (12.7 years) and sex. In the CP cohort (GMFCS V n=38/40), the mean Cobb angle was 48.8 degrees (n=36/40). IWE was 47.3±18.1 degrees in CPS vs 26.4±3.7 degrees in NCP (p<0.001) while IWI was 25.5±11.4 degrees in CPS vs 23.6±4 degrees in NCP (p=0.170). SAE was 119.5±9.5 degrees in CPS vs 111.2±7.7 degrees in NCP (p<0.001) while SAI was 114.1±8.5 degrees in CPS vs 107.9±7.5 degrees in NCP (p=0.001). Difference between control and CP hemipelvis in terms of difference between ER/IR for IW and SA was only significant for IW with IWAV being 21.8 degrees (p<0.001).

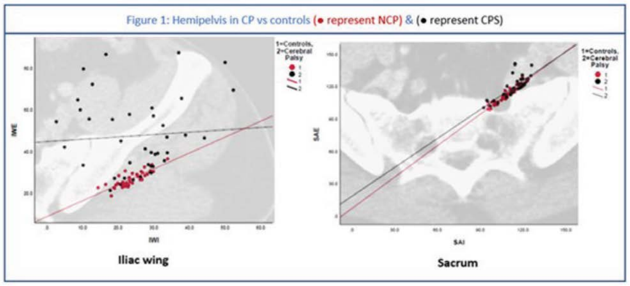
Conclusion
Hemipelvises are asymmetrically oriented with the asymmetry being more ER than IR in CP patients indicated by the difference in IWE, SAE, SAI, and no difference in IWE compared to control. Furthermore, APPS is CP driven by the IW as indicated by a greater difference of IWAV compared to SAAV which may indicate a greater resistant to spatial change of the well-supported sacrum.

Table – 1: Patient Characteristics and Measurements

		Normal Control Pelvis (NCP)		Cerebral Palsy Pelvis (CPS)		p-value
		n	Mean (Std Dev)	n	Mean (Std Dev)	
Age (years)		40	12.73 (4.5)	40	12.73 (4.5)	1.000*
Sex	Male	40	23	40	22	0.822+
	Female		17		18	
Cobb Angle (deg.)			-	36	48.76 (30.4)	-
GMFCS	IV		-	40	2	
	V				38	
Iliac Wing	IWE	40	26.4 (3.7)	40	47.3 (18.1)	<0.001*
	IWI	40	23.6 (4.0)	40	25.5 (11.4)	0.170*
Sacral Ala	SAE	40	111.2 (7.7)	40	119.5 (9.5)	<0.001*
	SAI	40	107.9 (7.5)	40	114.1 (8.5)	<0.001*
Iliac Wing Angle Variance (IWAV)		40	2.9 (2.2)	40	21.8 (20.7)	<0.001*
Sacral Ala Angle Variance (SAAV)		40	3.2 (2.4)	40	5.4 (6.3)	0.022*

+ Chi-Square test, * two-tailed student's t-test. p <0.05 was considered significant

Figure 1: Hemipelvis in CP vs controls (● represent NCP) & (● represent CPS)



240. Withdrawn

241. Withdrawn

242. Selecting the C7-LIV Line Vertebra as the Upper Instrumented Vertebra for Adolescent Idiopathic Scoliosis-Lenke Type 1A Curves: Multicenter and a Minimum 2-year Follow-up Study

Ryo Munakata, MD, PhD; Hiroki Oba, MD, PhD; Shota Ikegami, MD, PhD; Masashi Uehara, MD, PhD; Jun Takahashi, MD, PhD

Hypothesis
Better coronal trunk balance was obtained without reducing corre. ction rate by setting the novel modified Shinshu line vertebra (MSLV) as the upper instrumented vertebra (UIV)

Design
Multicenter, retrospective cohort study

Introduction
Oba et al. have recently devised the Shinshu line (S-line) as a preoperative UIV and lower instrumented vertebra (LIV) selection method for AIS Lenke type 5C deformities that does not exacerbate the MT vertebral curve after surgery. In the present study, we devised a novel UIV determination method for Lenke 1A adolescent idiopathic scoliosis (AIS) curves using the C7-LIV line (modified S-line; MSL) and established the selected UIV as the MSL vertebra (MSLV). The purpose of this study was to investigate if coronal and sagittal balance and correction were optimal when the UIV was at, proximal to, or distal to the MSLV.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Methods
45 consecutive patients (44 female, 14.4 ±2.4 years) receiving posterior spinal fusion (PSF) for a Lenke 1A AIS curve were analyzed. We defined the novel MSL as the line between the center of the spinous process of C7 and that of the spinous process of the LIV. The vertebral body with which the MSL first contacted proximally was defined as the MSLV. The groups in which the UIV was at, proximal to, or distal to the MSLV were defined as the matched group (M-group; 15 cases, 14.7±2.1 years), proximal group (P-group; 20 cases, 15.0 ± 2.2 years), and distal group (D-group; 10 case [10 female], 14.8 ± 2.5 years), respectively. We measured Cobb angle, main thoracic (MT) curve correction rate and absolute value of distance between C7 plumb line and the CSVL (C7PL) at pre- and 2 years postoperatively for comparisons using Dunnett's test, with the M-group as the control.

Results
In the M-group, P-group, and D-group, the Cobb angle correction rate between pre- and postoperative time points were 65.3±1.3%, 62.4±1.6%, and 52.8±6.8%, respectively, and comparable apart from a smaller correction tendency in the D-group versus the M-group (P=0.08). At 2 years postoperatively, C7PL was 0.5±0.4 cm, 1.0±0.6 cm, and 1.3±0.9 cm, respectively, and significantly smaller for the M-group (both P<0.05).

Conclusion
Better coronal trunk balance were obtained without reducing correction rate by setting the novel MSLV as the UIV in PSF for Lenke type 1A curves.

243. Two AIS Cases, Two Surgeons, One Operating Room, One Day. Faster and Safer Than One Case in a Day.

Jonathan R. Warren, MD; Robert C. Link, MD; Sean Bonanni, MD; John T. Anderson, MD; <u>Richard Schwend, MD</u>

Hypothesis
Two spine cases will have shorter OR times compared to single spine cases.

Design
Prospective

Introduction
To lessen surgical times for AIS patients undergoing posterior spinal instrumentation and fusion (PSIF), our department developed a quality improvement initiative where two AIS cases were completed in one day by a specialized team with two surgeons operating together in the same operating room (OR). We describe the results of this initiative and compare operative times and outcomes to single cases completed by a single surgeon during the same period.

Methods
From 2017-2022, patients aged 10-18 years with AIS were scheduled to undergo primary PSIF on the dedicated "Two Spine Tuesday" at our institution (Group 1). Data from Group 1 was collected prospectively. During the same time, patients scheduled to undergo PSIF as a single case by one surgeon on other days were reviewed and matched for sex and age (Group 2). Primary outcomes of interest included time from entrance to the OR to first incision, total surgery time, total time from surgery stop to exiting the OR, total time spent in the OR, estimated blood loss, and complications.

Results
56 patients composed the two-spine group, Group 1. These patients were compared to 56 sex- and age-matched controls, Group 2. For Group 1, average Cobb angle and average number of levels fused were similar to the Group 2. The time from patient entrance to the OR to first incision was significantly lower for Group 1 compared to controls (p<0.001) as were overall surgery time (208 vs 298 min, p<0.001), surgery stop to out of OR time (p=0.047), total OR time (p<0.001), and estimated blood loss (400 vs 524 cc, p=0.02). There were no 90-day readmissions for either group and rate of revision surgery was similar (1/56 Group 1 vs. 3/56 Group 2, p=0.16). Results are shown in Table 1.

Conclusion
Performing two AIS cases in one OR by two surgeons during the same day resulted in significantly faster patient preparation times, surgery times, less total time spent in the operating room, and less blood loss compared to sex- and age-matched control patients with similar Cobb angles and number of levels fused whose surgery was done by a single surgeon. Using this model, surgery time for AIS cases can be faster compared to single-surgeon cases, which may reduce overall complications and has potential for meaningful cost savings.

Two AIS Cases, Two Surgeons, One Operating Room, One Day. Faster and Safer Than One Case in a Day. Warren et al.

Table 1: Group Comparison of Two AIS Spine Cases, in One OR in One Day Compared to Usual One Spine Case in One Room in One Day with One Surgeon.

Variable	Two-Spine/day Group 1	One Spine/day Group 2	p-value
	n = 56	n = 56	
Sex, n (% Female)	41 (73%)	41 (73%)	1.0
Age in years, mean ± SD	15.2 ± 1.8	15.1 ± 1.7	0.8
Preoperative Cobb angle degrees, mean ± SD	60 ± 13	57 ± 10	0.17
Number of levels fused, mean ± SD	10.5 ± 2.2	10.3 ± 2.8	0.7
In room to incision time, mean ± SD	65 ± 10	76 ± 13	**<0.001**
Surgery stop to out of OR, mean ± SD	16.9 ± 6.1	22.1 ± 12.8	**0.047**
Surgery time, mean ± SD	208 ± 41	298 ± 64	**<0.001**
Total OR time, mean ± SD	292 ± 53	396 ± 64	**<0.001**
Room turnover time, mean ± SD	53 ± 10		
Estimated mL blood loss, median (range)	400 (100-1600)	524 (60-2340)	**0.02**
Percent blood loss, median (range)	10.5 (2.8-52)	13.5 (1.4-50)	0.08
Cell saver, median (range)	77.5 (0-470)	96 (0-615)	0.9
Transfusion, median (range)	0 (0-320)	0 (0-786)	0.7
90-day readmission, n(%)	0 (0%)	0 (0%)	1.0
Revision surgery, n(%)	1 (1.8%)	3 (5.4%)	0.16
MCID follow up, n with preop and postoperative scores (%)	31 (86%)	41 (87%)	
Achieved MCID, n(%)	16 (52%)	25 (61%)	0.43

Group Comparison of Two AIS Spine Cases and One Spine Case

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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244. Comparison of Radiologic Outcomes and Assessment of the Degeneration of Unfused Segments with MRI and Core Muscle Strengths and Quality of Life in Lenke Type 5 AIS Patients Treated with either Anterior or Posterior Spinal Fusion; Mean 13 Years Follow up

Hamisi M. Mraja, MD; Ayhan Mutlu, MD; Onur Levent Ulusoy, MD; Halil Gok, MD; Cem Sever, MD; Tunay Sanli, MA; Ali T. Evren, MD; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

Hypothesis

Anterior Spinal Fusion (ASF) and Posterior Spinal Fusion (PSF) may demonstrate different functional, clinical and radiological outcomes in the long term f/up.

Design

Retrospective

Introduction

Selective lumbar fusion (Cobb to Cobb) was accepted as standard treatment for AIS with Lenke Type 5 curves, but the choice of surgical approach is still controversial. Study aim is to compare the long-term functional, clinical, radiological outcomes and assess disc degeneration(DD) and facet joint degeneration(FJD) at unfused lumbosacral spine with MRI in pts

Methods

43 (15ASF, 28PSF)Lenke 5 AIS pts treated with ASF or PSF between Cobb levels with >10 yrs f/up were included. Preop, postop,f/up coronal&sagittal parameters were analyzed. Lumbar core muscle strengths were evaluated with computer-assisted 3D spatial rotation device(SRD).DD and FJD at unfused lumbar segments were assessed with MRIs and clinical outcomes were evaluated with SRS22r at f/up.

Results

ASF group included 15 pts with 18,7(12-23) yrs f/up. PSF group included 28pts with 13(10-17) yrs f/up. Mean age at the time of surgery was 15 for both. LIV levels were similar for both (L3;80% ASF vs 78% PSF). Mean TL/L curve correction was 76% in ASF and 85% in PSF without any correction loss at f/up. Residual lumbar curve magnitudes were similar and stable over time(ASF;6.4° vs PSF;5.8°). DD and FJD grades of distal unfused segments were similar for both despite the longer f/up period and higher mean age at f/up(ASF;18yrs f/up, age:34yrs vs PSF;13yrs f/up, age:28yrs). Posterior lumbar core muscle strengths measured with SRD were significantly higher in ASF (p<0,05;U=21). SRS22r domains including pain, self-image, function & satisfaction scores were higher in ASF. Revision surgery was performed only in 1pt (1.9%) for pseudoarthrosis in PSF.

Conclusion

ASF and PSF provided satisfactory functional, clinical and radiologic outcomes in long term f/up. ASF group demonstrated better functional outcomes in terms of lumbar core muscle strengths. Although mean f/up length and mean age was at least 5 yrs greater in ASF compared to PSF, in the unfused lumbosacral spine below the fusion level, both groups had similar grades of DD and FJD. SRS22r pain, self-image, function&satisfaction scores are higher in ASF than PSF at f/up.

245. Does the Presence of Cervical Deformity in Patients with Baseline Mild Myelopathy Increase Operative Urgency in Adult Cervical Spinal Surgery?: A Retrospective Analysis

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Tobi Onafowokan, MBBS; Emmanuel Budis, BS; M. Burhan Janjua, MD; Peter G. Passias, MD

Hypothesis

Delaying surgical management of CD with concomitant mild myelopathy increases risk of suboptimal outcomes.

Design

Retrospective

Introduction

Cervical deformity can result in cord compression, leading to pain, loss of function, and myelopathy. However, whether the presence of CD with concomitant mild myelopathy necessitates surgical management remains unanswered.

Methods

Cervical deformity patients ≥18yrs that have a baseline diagnosis of mild myelopathy with pre-(BL) and up to two-years (2Y) of data were assessed. Patients were categorized as having cervical deformity (CD+) or not (CD-) at baseline. Patients with symptoms of myelopathy for greater than 1Y after initial visit prior to surgery were considered delayed. Clinical and radiographic data were assessed using means comparison analyses. Multivariate regression analysis assessed correlations between increasing time to surgery and peri- and post-operative outcomes adjusting for BL age and frailty score. Backstep logistic regression analysis assessed the risk of complication or reoperation, while controlling for BL TS-CL

Results

106 patients were included (58.11 ± 11.97 years, 48% female, 29.13 ± 6.89 kg/m2). Of the patients with baseline mild myelopathy, 22 (20.8%) were CD-, while 84 (79.2%) were CD+. Overall, 9.5% of patients were considered to have delayed surgery. Linear regression revealed that both CD- and CD+ patients were more likely to require reoperation when there was more time between the initial visit and surgical admission (p<.001). Additionally, an adjusted logistic regression indicated that CD+ patients who had a greater length of time to surgery had a higher likelihood for major complications (p<0.001). Conversely, CD+ patients who were operated on within 30 days of initial visit had significantly lower risk for major complication [OR: .901 [.889 – 1.105), p=.022), and a lower risk for reoperation [OR: .954 [.877 – 1. 090, p=.043], while controlling for the severity of deformity based upon baseline TS-CL.

Conclusion

The findings of the present study demonstrate that delay in surgery

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

after initial visit increases the risk for major complication and reoperation significantly in patients with CD with associated mild baseline myelopathy. As such, early operative treatment in this patient population may lower the risk of postoperative complications.

246. Withdrawn

247. Withdrawn

248. Withdrawn

249. Withdrawn

250. Impact of Sacral Oblique Angle on the Lumbosacral Fractional Curve Magnitude and Degenerative Changes Below Lowest Instrumented Vertebra in AIS Patients with Double Major Curves Treated with Posterior Fusion Stopped at L3

Hamisi M. Mraja, MD; Inas M. Daadour, MD; Ali T. Evren, MD; Cem Sever, MD; Baris Peker, MD; Celaleddin Bildik, MD; Halil Gok, MD; Tunay Sanli, MA; Meric Enercan, MD; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

Hypothesis
Sacral oblique angle affects the lumbosacral fractional curve (LFC) and degenerative changes below lower instrumented vertebra and should be taken in consideration in preoperative planning

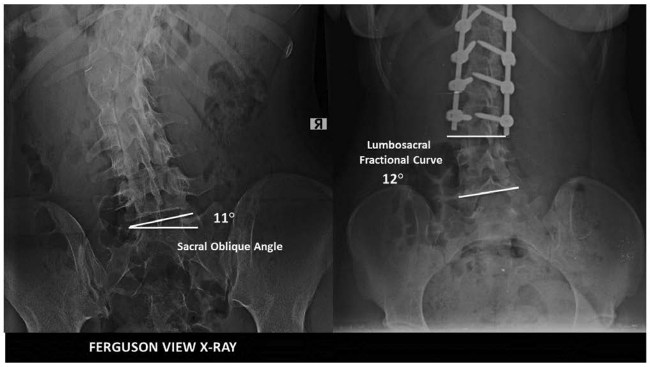
Design
Retrospective

Introduction
Sacral oblique angle (SOA) is defined as the angle between the sacrum superior end plate and horizontal line and measured preoperatively on Ferguson view x-ray. When SOA > 5°, this parameter can effect the postoperative lumbosacral fractional curve magnitude below LIV. The aim of this study is to evaluate the relationship between SOA between lumbosacral fractional curve magnitude and degenerative changes below the LIV in AIS patients with double major curves treated with posterior fusion stopped at L3 level

Methods
AIS pts with double major curves treated with posterior surgery stopped at L3 were included. Preop, f/up coronal & sagittal parameters were analyzed. Ferguson view x-rays were used to measure SOA. Degenerative changes were evaluated with lumbar MRIs. Two radiologists independently reviewed and classified for each patient in terms of disc degeneration (DD) according to Phirmann classification and facet joint degeneration (FJD) according Fujiwara classification. Clinical outcomes were evaluated with SRS22r scores

Results
195 surgically treated AIS pts with LIV at L3 were reviewed. LIV end plate was horizontal in all pts (LIV tilt 1.1°). 74 pts who had SOA > 5° were included. 45 pts had SOA between 5°- 10° and 29 pts had SOA > 10°. Mean LFC was 6.1° in pts who had SOA > 5°. Mean LFC was 10.6° in pts who had SOA > 10°. There was significant correlation between SOA and LFC magnitude (p<0,01). Mean DD and FJD grades were higher in pts with SOA > 10° than pts who had SOA <10°. There was a correlation between DD and FJD grades and magnitude of SOA. Despite the degenerative changes, total SRS-22r scores improved in all pts

Conclusion
The results of this study showed that sacral oblique angle effects the lumbosacral fractional curve magnitude and degenerative changes below lower instrumented vertebra. In patients with a sacral oblique angle (SOA) above 5 degrees, lumbosacral fractional curve magnitude and degenerative changes below the LIV increase in parallel with the increased SOA. Degenerative changes increase significantly when the SOA is greater than 10 degrees



SOA

251. Changes in 3D Vertebra Alignment and Morphology Following Vertebral Body Tethering

Craig R. Louer, MD; Vidyadhar V. Upasani, MD; Jennifer K. Hurry, MASc; Hui Nian, PhD; Christine L. Farnsworth, MS; Peter O. Newton, MD; Stefan Parent, MD, PhD; Pediatric Spine Study Group; Ron El-Hawary, MD

Hypothesis
Thoracic VBT will create 3D changes in vertebral body and disc morphology at two years post-op.

Design
Retrospective

Introduction
There is variability in clinical outcomes with vertebral body tethering (VBT) for treatment of adolescent idiopathic scoliosis (AIS), partly due to a limited understanding of the growth modulation (GM) response. The purpose of this study is to characterize the vertebral body and disc changes that occur with thoracic VBT over the first two years of treatment using 3D reconstructions.

Methods
A multicenter registry was used to identify AIS patients who underwent VBT with 2 years of follow-up. Calibrated biplanar X-rays obtained at longitudinal timepoints (pre-op, post-op, and 2-year)

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underwent 3D reconstruction and subsequent analysis with custom MATLAB software to obtain precision measurements of vertebra and discs. Growth modulation (GM) was defined as change in Cobb from post-op to 2-years. GM magnitude was analyzed for correlations with coronal morphologic changes over the same period.

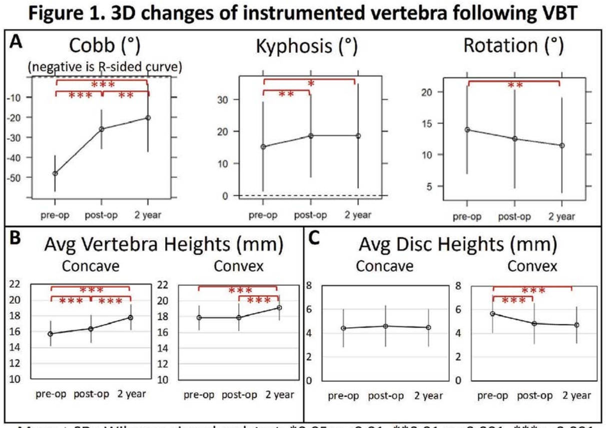
Results

Fifty-three patients (mean age: 12.5±1.3yrs) met inclusion criteria. Instrumented Cobb significantly improved at post-op and 2-year timepoints. Kyphosis and apical rotation experienced minimal change (Fig. 1A). Vertebra heights showed minimal change from pre-op to post-op (80.2 mean elapsed days), then grew asymmetrically from post-op to 2-years (mean growth concave: 1.5mm, convex: 1.2mm; Fig 1B). Convex disc heights decreased from pre-op to post-op period, then remained constant to 2-years, while concave disc heights were unchanged throughout (Fig. 1C). Instrumented 3D spine length increased significantly by 2-years (11.3mm; p<0.001). GM was positively correlated with change in concave vertebral height (r=0.55; p<0.001) and instrumented 3D spine length (r=0.36; p=0.008), while inversely correlated with change in convex disc height (r=-0.42; p=0.002).

Conclusion

This is the first study to use 3D imaging to quantify spine alignment following VBT, showing only modest improvement in apical rotation and hypokyphosis. When a convex tether is placed, there is drastic reduction in the convex disc height, while concave disc heights remain constant. Vertebra body heights increase asymmetrically during the growth modulation phase. A strong GM response is correlated with concave vertebral body height growth and overall instrumented spine growth.

Figure 1. 3D changes of instrumented vertebra following VBT



Mean ± SD ; Wilcoxen signed rank test: *0.05<p<0.01, **0.01<p<0.001, ***p<0.001

252. Majority of Magnetically Controlled Growing Rods Are Implanted Longer Than FDA Recommended 2 Years

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Hypothesis

We hypothesize that duration of MCGR implantation is exceeding FDA-recommended two years.

Design

Retrospective analysis of pediatric spine registry data

Introduction

Magnetically controlled growing rods (MCGR) are commonly used in surgical treatment of early-onset scoliosis in the United States (US). The US Food and Drug Administration (FDA) has approved MCGR devices for implantation no longer than two years. The purpose of the study was to investigate the duration in which MCGR devices have been implanted in children in the US.

Methods

An international pediatric spine registry was retrospectively revieweed. Patients were included if they underwent primary or conversion to MCGR procedures, had a minimum follow-up of 2 years following index surgery, and completed MCGR treatment with documented device removal. Individuals who had procedures performed at centers located in the US were included in the final analysis. Implant duration was dichotomized as ≤2 years and >2 years. Univariate and multivariate logistic regression analyses were used to identify predictive factors of having an implant duration of over 2 years.

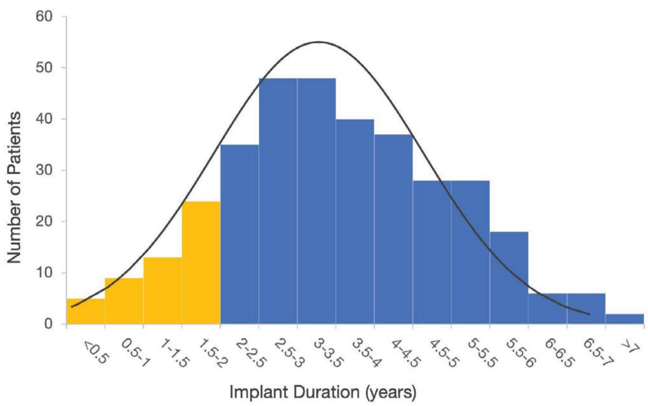
Results

347 patients who underwent MCGR implantation in the US between December 2009 and July 2019 were included. Mean age at index surgery was 8.6 ± 2.4 years, the majority were female (58%) and primary procedures (67%). MCGR implant duration exceeded >2 years in 85% of cases. Mean implant duration was 3.5 ± 1.5 years and demonstrated a normal distribution pattern. MCGR implants were removed either as part of a final fusion procedure in 75% of cases, followed by removal-only procedures (16%) or conversion to another growth-friendly instrumentation (9%). Multivariate logistic regression analysis revealed that patients who experienced a complication were more likely to have implants removed at less than 2 years (OR = 3.18; 95% CI = 1.5-6.7; p = 0.007). No significant differences were found for gender, race, scoliosis etiology, or MCGR being placed primarily versus part of a conversion from another type of implant.

Conclusion

Despite FDA recommendation for implantation of less than 2 years, 85% of MCGR implants remain implanted for greater than 2 years. A significant proportion of implants were removed prior to the 2-year mark due to complications. Further investigation is warranted to determine if longer implantation time is detrimental to patients.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster



MCGR Implant Duration in the US

253. The Long-Term Impact of Short Segment Fusion in Congenital Scoliosis

Tyler D. Metcalf, BS; Amer F. Samdani, MD; Mark A. Erickson, MD; Joshua M. Pahys, MD; Pediatric Spine Study Group; Craig R. Louer, MD

Hypothesis
Early short segment fusion in congenital scoliosis will result in fewer levels fused at skeletal maturity than those managed non-operatively in similar patients.

Design
Retrospective

Introduction
Short-segment fusion (SSF–with or without hemivertebra excision) is reported to have favorable short-term results, though follow-up to skeletal maturity is underreported. The goal of this study is to compare patients treated with early SSF to those managed non-operatively to better characterize how SSF alters natural history in congenital scoliosis.

Methods
A multicenter pediatric scoliosis registry was queried for patients with congenital scoliosis and an initial visit before 10 years of age with follow-up to maturity. Study was limited to patients with congenital anomaly affecting ≤4 segments, focal deformity (FD) >20°, treated prior to age 10 with either non-operative management (N-OP) or SSF (≤6 levels). Patients with growing-rod constructs or fusions ≥7 levels before age 10 were excluded. Independent sample t-tests were used to compare continuous variables and Chi-square tests were used to compare categorical variables.

Results
Thirty-five patients were included: 12 were initially treated with SSF and 23 were managed N-OP. SSF patients had more severe deformities than N-OP at a similar initial age (Table 1). Five SSF patients (42% SSF) underwent additional fusion for progressive deformity, while 14 N-OP (61%) patients were eventually fused, resulting in similar average number of levels fused per group (5.4±3.8 vs. 6.0±5.8; p=0.75). SSF patients requiring extended fusion had larger pre-op FD (p=.042), main curve (p=.011), secondary curve (p=.005), and number of involved levels (p=.040) compared to those without additional procedures. The N-OP receiving fusion had main curves that were larger (p=.022), more likely located in lumbar spine (p=.044) and include hemivertebra (p=.010) compared to N-OP not requiring fusion.

Conclusion
SSF prior to age 10 can provide durable long-term results for congenital scoliosis with FD>20°, with 58% of patients not requiring additional procedures through maturity. Similar-aged patients with less severe deformities treated N-OP resulted in fusions 61% of the time, though 39% avoided surgery all-together. Further efforts should be made to determine which patient characteristics predict successful treatment with N-OP and SSF strategies.

Variables	Treatment Group			
	SSF (n=12)		N-OP (n=23)	
Baseline				
Age (yrs)	5.8 ± 2.6		6.2 ± 2.6	
Focal Deformity	38 ± 10°		31 ± 7°	
Main Cobb	42 ± 12°		35 ± 11°	
Secondary Curve	32 ± 13°		21 ± 11°	
Post-SSF				
Average # Levels fused	2.5 ± 0.4		N/A	
# HV excisions (%)	10 (83%)		N/A	
Focal Deformity (% correction)	13 ± 9° (74)		N/A	
Main Cobb (% correction)	23 ± 11° (51)		N/A	
Secondary Curve (% correction)	19 ± 9° (30)		N/A	
Spine Fusion (near maturity)	**YES**	**NO**	**YES**	**NO**
	5/12 (42%)*	7/12 (58%)	14/23 (61%)	9/23 (39%)
Pre-op				
Age (yrs)	13.4 ± 2.9	N/A	13.2 ± 3.2	N/A
Focal Deformity	38 ± 12°	N/A	46 ± 15°	N/A
Main Cobb	47 ± 10°	N/A	54 ± 17°	N/A
Secondary Curve	34 ± 15°	N/A	28 ± 12°	N/A
Post-op				
Average # Levels fused	9.4 ± 0.9	N/A	9.8 ± 3.8	N/A
Focal Deformity (% correction)	19 ± 9° (59)	N/A	17 ± 12° (59)	N/A
Main Cobb (% correction)	28 ± 12° (58)	N/A	23 ± 15° (51)	N/A
Secondary Curve (% correction)	21 ± 5° (37)	N/A	13 ± 11° (48)	N/A
Maturity				
Age	15.9 ± 1.4	15.0 ± 1.2	14.5 ± 0.7	15.1 ± 0.8
Focal Deformity	20 ± 10°	14 ± 9°	20 ± 13°	35 ± 9°
Main Cobb	30 ± 9°	28 ± 12°	23 ± 13°	39 ± 11°
Secondary Curve	23 ± 3°	20 ± 8°	15 ± 11°	26 ± 13°
Average # Levels fused	5.4 ± 3.8		6.0 ± 5.8	
*Mean±SD unless otherwise specified; *Radiographs available for only 3/5 SSF-SF cohort*				

Table 1. Comparison of Treatment Options for Congenital Scoliosis with FD>20°

254. Long-term Results of Pedicle Screw Fixation for Patients with Adolescent Idiopathic Scoliosis (AIS): CT Evaultaion at 10 Years after Surgery

Masao Ryu, MD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Masaaki Ito, MD, PhD; Kenichiro Kakutani, MD, PhD; Takashi Yurube, MD, PhD; Yoshiki Takeoka, MD, PhD

Hypothesis
A pedicle screw inserted into the vertebral body for a long term may affect the surrounding area.

Design
Retrospective review

Introduction
Pedicle screws are widely used for AIS surgery, but there are no reports on the evaluation of long-term results with CT scan. We

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evaluated the relationship between pedicle screws and the vertebral body, right after and 10 years after AIS surgery.

Methods

109 AIS patients (4 males, 105 females, mean age: 18.1) who had posterior fusion were included. The mean Cobb angle of the main curve preoperatively, immediately, and 10 years post-operatively was 56.1°, 18°, 18.4°, respectively. A total of 2195 screws were evaluated with CT scans immediately after and 10 years after surgery.

Results

In the immediate postoperative CT, 55 screws were perforated <2 mm (7 were medially, 31 were laterally) , 78 screws were perforated >2 mm (26 were medially, 52 were laterally), and 17 screws were perforated anterioronly. The rate of perforations over 2mm was 3.6%, which was comparable to previous reports. Two cases showed a screw breakage at L3, both are asymptomatic. Screw loosening was observed in 5 patients, 5 screws. One patient underwent additional surgery a year later to extend the fixation since the right L3 screw perforated medially and caused back pain. In one patient, right T2 pedicle screw perforated antero-laterally just after surgery was accommodated in the cancellous channel of the pedicle at 10 years follow up. Although the remaining three patients were asymptomatic, the screws initially inserted correctly shifted medially and perforated the inner wall of the pedicle (right T2, right T3 and right L3). There were 15 laterally perforated screws in close proximity to the aorta, but none of them showed any change at the site of perforation including aneurysm. In one case, anterior perforation progressed due to atrophy of the vertebral body.

Conclusion

CT evaluation at 10-year follow-up after AIS surgery showed screw loosening and associated perforation, screw breakage, and increased anterior protrusion due to vertebral atrophy. There was no major problem with the screw in close proximity to the aorta such as aneurysm formation. Although all of them were asymptomatic, further follow-up is required.

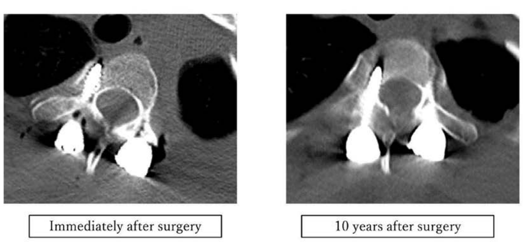


Figure. CT showed the right T2 pedicle screw perforated antero-laterally just after surgery was accommodated in the cancellous channel of the pedicle at 10 years follow up.

255. No Adjacent Segment Hypermobility Following Lumbar Vertebral Body Tethering

Smitha E. Mathew, MBBS; Christina M. Regan, BS; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD

Hypothesis

In adolescent idiopathic scoliosis (AIS) patients undergoing lumbar vertebral body tethering (VBT), coronal arc of motion of the distal uninstrumented lumbar segments will be preserved with no evidence of hypermobility at 1-year follow-up.

Design

Retrospective review

Introduction

Vertebral body tethering (VBT) is a non-fusion approach for skeletally immature scoliosis patients and is thought to preserve spinal motion over the instrumented segments. A recent spinal fusion study showed significant disc hypermobility at L4-5 and L5-S1 in scoliosis patients who were fused into the lumbar spine. However, to date, there are no reports regarding motion of the uninstrumented lumbar segments in AIS patients following lumbar VBT.

Methods

Patients treated with lumbar VBT underwent low dose coronal bending radiographs at 1-year follow-up to assess motion. L3-L4, L4-L5 and L4-S1 intervertebral angles were measured on left and right-bending radiographs to evaluate coronal intervertebral arc of motion and were compared with preoperative values over the same levels. Measurements at L5-S1 were difficult to visualize.

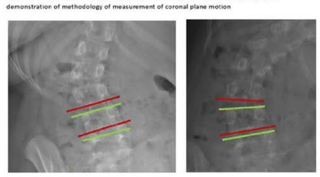
Results

Of the 71 scoliosis patients who underwent VBT at our center, 20 had lumbar instrumentation all of whom had lumbar bending films available at 1 year follow-up (7 thoracic and lumbar VBT, 13 isolated lumbar or thoracolumbar). Mean age was 13.5+1.9years. Mean preoperative major Cobb angle was 52⁰+8⁰ (range, 42-70), mean 27⁰ (range, 13-40) at latest f/up. Mean levels instrumented was 8 (range, 5-12), with the lowest instrumented level typically L3 (N=14). Side-bending radiographs revealed that mean intervertebral arc of motion at L3-L4 was unchanged from 10°±5°preoperatively to 12°±5° at 1-year postop (p=0.2) (Figure 1). Mean coronal intervertebral arc of motion at L4-L5 was 7°±4° preoperatively and 8°±4° at 1-year postoperatively (p=0.4) (Figure 2). Mean coronal arc of motion of the distal unfused segment L4-S1 also remained unchanged from 8°±4°preoperatively to 9°±6° at 1-year postop (p=0.3).

Conclusion

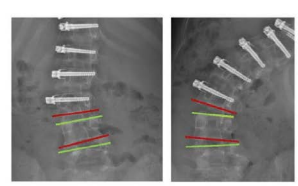
In contrast to spinal fusion patients, motion in the distal lumbar uninstrumented segments showed no evidence of hypermobility in skeletally immature patients with lumbar VBT. This suggests that lumbar VBT may reduce the incidence of adjacent segment disease, although further long-term studies are warranted.

Figure 1: Preoperative bending radiographs, made in a biplanar slot scanning imager, with demonstration of methodology of measurement of coronal plane motion



	Pre-op Left bend (°)	Pre-op Right bend (°)	Pre-op arc of motion (°)
L3-L4	1 (R)	9 (L)	10
L4-5	9 (R)	3 (L)	12

Figure 2: 1-year post-operative bending radiographs, made in a biplanar slot scanning imager, with demonstration of methodology of measurement of coronal plane motion



	Post-op Left bend (°)	Post-op Right bend (°)	Post-op arc of motion (°)
L3-L4	2 (L)	12 (L)	10
L4-5	3 (R)	8 (L)	11

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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256. Factors Affecting Scoliosis Progression during Nusinersen Treatment in Spinal Muscular Atrophy

Hayley Ip, MBBS; Sophelia Chan, MD; <u>Kenny Y. Kwan, MD</u>

Hypothesis
Independent risk factors may affect scoliosis progression during Nusinersen treatment in spinal muscular atrophy (SMA).

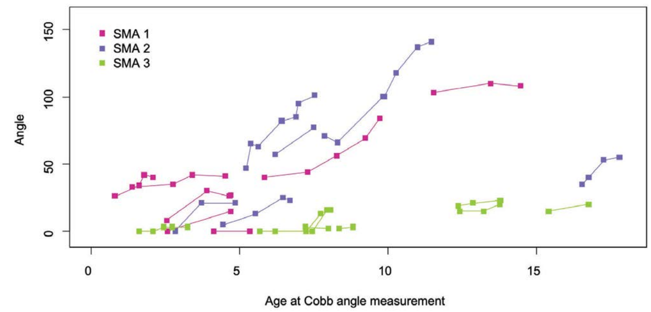
Design
Prospective longitudinal study.

Introduction
The lifetime probability of spinal deformity progression reaching surgical threshold in SMA is high. Nusinersen can improve motor function but its impact on and the risk factors for scoliosis progression in different SMA subtypes are unknown.

Methods
Prospective study of all SMA patients treated with Nusinersen between 2018 and 2022 were studied. Radiographic parameters, functional motor scores (CHOP-INTEND and HINE for type 1, and HMFSE for types 2 and 3) and ambulatory status were analysed pre- and post- nusinersen treatment longitudinally.

Results
21 patients (Type 1=7, Type 2=7, Type 3=7) were included in the analysis. The median age at the time of nusinersen initiation was 6.83 years, and mean follow-up period was 24 months (range, 15-47). Motor function scores improved in all subtypes (86% in type 1, 83% in type 2, and 86% in type 3). Scoliosis progressed in all subtypes. The average rate of scoliosis progression for type 1 patients was 6.0o/year, 16.3o/year for type 2 patients, and 3.6o/year for type 3 patients. The highest rate of scoliosis progression was found in symptomatic type 1 and type 2 children with nusinersen started between the age of 5-10 years. Baseline Cobb angle was an independent factor correlated with the rate of scoliosis progression ($t = 2.402$, $p = 0.027$) having adjusted to age of starting nusinersen. There was no statistically significant correlation between the average rate of Cobb angle progression with the age of starting nusinersen ($p = 0.708$). For type 2 and 3 patients, there was a significant negative correlation between Cobb angle and motor scores with ($r = -0.651$, $p < 0.001$).

Conclusion
Nusinersen treatment did not stop scoliosis progression in our SMA cohort, and the rate of progression was fastest in type 2 patients. Baseline Cobb angle was predictor for progression but not the age of nusinersen initiation. However, there was a negative correlation between Cobb angle progression and HMFSE motor scores in types 2 and 3.



Scoliosis progression in all subtypes

257. MRI Vertebral Bone Quality Score Does Not Correlate with Traditional Measures of Bone Density and is Not Associated with Mechanical Complications in Adult Spinal Deformity Patients †

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Hypothesis
The vertebral bone quality (VBQ) score will correlate with dual-energy X-ray absorptiometry (DEXA) T-scores and be associated with mechanical complications in adult spinal deformity (ASD) patients.

Design
Retrospective cohort

Introduction
Poor bone quality has been linked to complications following ASD surgery. While DEXA is commonly used to assess bone quality, it has been shown to be unreliable, especially in the lumbar spine. Previous studies have used magnetic resonance imaging (MRI) to calculate the VBQ score as an alternate way to measure bone quality. In a cohort of ASD patients undergoing surgery, we sought to: 1) evaluate the degree to which VBQ correlates with DEXA T-scores and 2) evaluate the VBQ score as a predictor of mechanical complications.

Methods
A single-institution, retrospective database was queried for patients undergoing ASD surgery from 2009-21. Inclusion criteria consisted of patients with ≥5-level fusion; sagittal/coronal deformity; 2-year follow-up; and availability of preoperative non-contrast, T1-weighted MRI scan. The independent variables were lowest T-score and VBQ score—calculated by dividing the median signal intensity of L1-L4 vertebrae by the signal intensity of cerebral spinal fluid at L3. Outcome variables were osteoporosis/osteopenia (T-score <-1) and mechanical complications. Pearson's correlation was used to assess correlation between T-score and VBQ, and univariate/multivariate logistic regression was used to identify predictors of mechanical complications.

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Results
A total of 130 patients met inclusion criteria with a mean age of 63.4±17.4 years and mean total instrumented levels of 10.5±3.2. No correlation was found between T-score and VBQ score (r=0.116, p=0.309). No difference in VBQ score was found between the healthy and osteopenic/osteoporotic groups (2.92±0.57 vs 2.73±0.52, p=0.116). VBQ score was not found to discriminate the two groups (AUC=0.596, p=0.184). Mechanical complications occurred in 81/130 patients (62.3%). No association was found between VBQ and mechanical complications.

Conclusion
Contrary to previous studies, VBQ score did not correlate with T-scores in this cohort or be associated with mechanical complications in patients with adult spinal deformity. Adult spinal deformity surgeons should utilize other methods to quantify bone mineral density.

258. The Longitudinal Decline in Postoperative SRS Scores After Definitive Fusion for Adolescent Idiopathic Scoliosis Over 10 Years

Adam Jamnik, BA; Anne-Marie Datcu, BS; Emily Lachmann, BS; David C. Thornberg, BS; Chan-Hee Jo, PhD; Brandon A. Ramo, MD

Hypothesis
The Health Related Quality of Life (HRQoL) of patients with Adolescent Idiopathic Scoliosis (AIS), as measured by the Scoliosis Research Society (SRS) questionnaire, continually declines as time passes since their definitive fusion (DF).

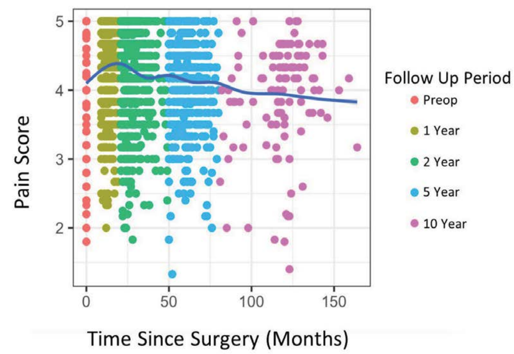
Design
Retrospective Review

Introduction
Healthcare providers often attempt to forecast the course of a disease or treatment to make informed medical decisions and to counsel patients appropriately. The purpose of this study was to determine the trend in HRQoL that patients experience as additional time passes since their DF.

Methods
A retrospective review of patients with AIS that underwent primary DF between 2002 and 2022 at a single institution. Demographic and clinical data, as well as SRS scores, were collected for each patient. Postoperative SRS scores were binned into the following time-periods: 1 Year: 9-20 months, 2 Year: 21-49 Months, 5 Year: 50-80 Months, 10 Year: >80 Months. Patients were only included if they had SRS scores from 2 or more of the different time-periods. A mixed-effects model was performed to assess the relationships between time since surgery (TSS) and a patient's SRS scores in each domain: Pain, Appearance, Mental Health, Activity, Satisfaction, and Total Score.

Results
A total of 1086 patients (84% female, mean age at surgery 14.1 ±2.0 years old) were included in this study. In the mixed effects model, 3441 SRS scores were included across the time points for the Pain domain, 3440 for Appearance, 3436 for Activity, 3433 for Mental Health, 3267 for Satisfaction, and 3264 for Total Score. SRS questionnaire completion date ranged from 9-164 months after DF. Analyses demonstrated that there was a significant negative association between TSS and HRQoL for Pain (Fixed Effects Estimate: -0.003, p=0.0097) and Activity (Estimate: -0.001, p=0.013), but not for Appearance (p=0.49), Mental Health (p=0.85), Satisfaction (p=0.66), or Total Score (p= 0.95) As an example, the trend for SRS Pain domain scores is in Figure 1, demonstrating improvement after 1-2 years, followed by decline over time.

Conclusion
In the years following DF for AIS, patients experience a decline in HRQoL with regard to Pain and Activity scores. Physicians should counsel their patients accordingly to optimize long-term pain management and they should attempt to identify potential barriers to full activity levels.



Trend in SRS Pain Scores Postoperatively

259. Multiple Protracted Learning Curves Determine the Occurrence and Timing of Specific Complications after AVT for AIS: A 13 Year Experience

John T. Braun, MD; Sofia Federico; David F. Lawlor, MD; Dan P. Croitoru, MD; Brian E. Grottkau, MD

Hypothesis
The occurrence and timing of specific complications after AVT will be determined by discrete learning curves.

Design
Retrospective 2010-2023.

Introduction
Though multiple studies have reported a relatively high complication rate after AVT, none have analyzed the potential impact of one or more learning curve(s) on the occurrence and timing of these complications. This study analyzed complications in all 213 patients treated with AVT over the past 13 years with a focus on learning curves associated with the 3 most common complications: overcorrection (OC), inadequate correction/adding-on (IC/AO), and tether rupture (TR).

Methods
Two-hundred thirteen consecutive AIS patients were treated with AVT for T and TL/L curves 33-70°. Charts and radiographs allowed

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

analysis of the occurrence and timing of complications and the identification of potential learning curve effects (defined as a decrease in a specific complication over time after an evolution in care).

Results

Overall complications in 213 patients after AVT were: 0% (0/213) intra-op; 4% (8/213) early post-op <2 years (3IC/AO, 5TR); and 32% late post-op >2 years (3OC, 5IC/AO, 15TR). All 3 OC were revised (2/3 fused); 3 early IC/AO were revised but all late IC/AO required fusion; only 5/20 tethers were revised. Learning curve effects were evident for OC and IC/AO but not for TR: OC occurred at 2 years in 3/10 patients with 33° curves at age 10.7 years (R=-0.3) over our first 2 years of AVT but was eliminated over next 11 years by avoiding curves <40° and R=-1 (p<0.001). IC/AO requiring fusion occurred at 5.2 years in 4 of 65 patients with 60° curves (36% flexibility) at age 14.0 years (R=1.2) over the next 7 years but was reduced to 1 IC/AO over the last 4 years by avoiding curves >60° with <50% flexibility. IC/AO remedied by early revision occurred in 3 patients with 57° curves (61% flexibility) at age 14.1 years (R=1.7) over the past 4 years. TR was consistent at 24% over all 13 years without a learning curve effect.

Conclusion

This study demonstrated learning curve effects for 2 of the 3 most common complications after AVT for AIS. OC was eliminated after our first 2 years by avoiding curves <40° and R=-1 (p<0.001). IC/AO requiring fusion was reduced after an additional 7 years by avoiding curves >60° with <50% flexibility. TR remained steady at 24% over 13 years despite efforts to reduce this complication.

260. Evaluation of the Odontoid-Coronal Vertical Axis Line in Coronal Alignment in a Symptomatic Cohort †

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Hypothesis

The distance between the standard central sacral vertical line (CSVL) and the plumb line drawn vertically down from the superior tip of the odontoid is associated with radiographic parameters, PROs, and postoperative complications.

Design

A retrospective cohort of patients from multiple surgeons at a single institution.

Introduction

The coronal alignment from the skull is understudied in adult spinal deformity (ASD) surgery. As previous literature on the odontoid-coronal vertical axis (OD-CVA) in an asymptomatic volunteer cohort showed its correlation with other radiographic parameters, this project assesses how OD-CVA correlates with radiographic parameters and outcomes in a symptomatic cohort.

Methods

ASD patients with ≥6 fused levels were included in the symptomatic cohort for analysis. OD-CVA was analyzed alongside parameters, including C7-CVA, maximum coronal cobb angle (Max Cobb), lumbosacral fractional curve (LSFC), SVA, pelvic obliquity (PO), and leg length discrepancy (LLD). OD-CVA was also correlated with PROs (ODI, SRS-22r) and complications.

Results

243 patients underwent ASD surgery and 173 had a 2-year follow-up. The mean age was 49.3±18.3, BMI 25.5±5.7, and 67.1% (163/243) were female. The mean preop OD-CVA was 2.8±2.8 cm, immediate postop 1.9±1.6 cm, and 2-year postop 1.7±1.5 cm (p < 0.001 for preop vs. postop, preop vs. 2-year postop). Preop OD-CVA correlated with preop C7-CVA (0.869, p<0.001), Max Cobb (0.168, p=0.009), PO (0.259, p<0.001), LLD (0.168, p=0.009). Postop OD-CVA was correlated with postop C7-CVA (0.787, p<0.001), PO (0.154, p=0.017). Preop OD-CVA correlated with preop ODI (0.167, p=0.011) and was better than C7-CVA in some SRS-22r categories: total, image, and mental health. After univariate logistic regression, preop OD-CVA was associated with increased odds of major complication (OR=1.15, p=0.010). After multivariate regression, preop OD-CVA was still associated with increased odds of major complication (OR=2.01, p=0.008).

Conclusion

Preop OD-CVA correlated with radiographic parameters, PROs, and complications. It could be used to aid in surgical planning and risk assessment.

261. A Comprehensive Analysis of Outcomes and Treatment Success of Thoracic, Thoracolumbar and Bilateral Vertebral Body Tethering Surgery

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Hypothesis

Curve type, surgical technique and remaining growth affect VBT treatment success

Design

Retrospective analysis of prospectively collected data

Introduction

As VBT treatment evolves, it is important to objectively classify results to be able to analyze clinical and radiographic predictors of successful outcomes. Aim was to determine treatment success rates, and possible factors affecting outcomes.

Methods

A 3-category radiographic outcome scheme was formulated using reoperations, final follow-up curve magnitudes, coronal alignment and sagittal plane changes (Fig 1). "Excellent" and "acceptable" outcomes were classified as "treatment success", while "poor" outcomes denoted "treatment failure". Lenke patterns, surgical techniques, and anticipated remaining growth (TRC closure & Sanders) were compared using Exact test, Chi-Squared and ANCOVA.

Results

46 patients (43F, 3M, mean age: 12.7±1.7 years) who underwent

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster   * = John H. Moe Award Nominee – Best Basic Science Research Poster

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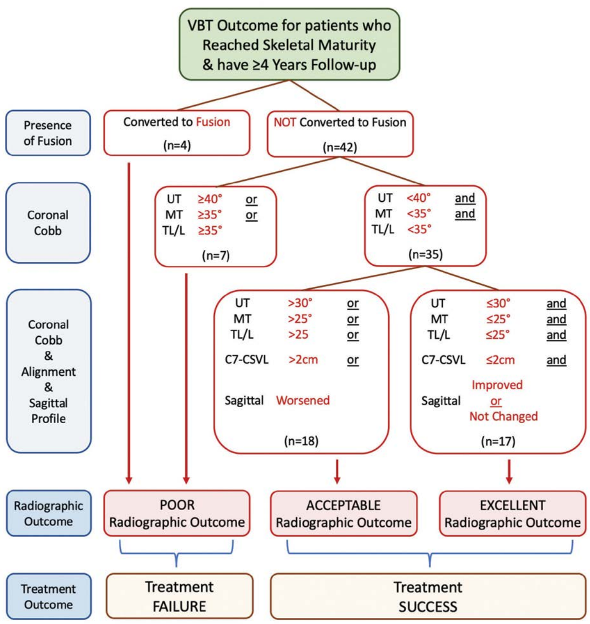
thoracic (n=34), thoracolumbar (n=5) and bilateral (n=7) VBT were included. At a mean of 56 (48-93) months follow-up, 17 (37%) patients had excellent, while 18 (39%) had acceptable, and 11 (24%) had poor radiographic outcomes. 4 patients (9%) were converted to fusion. Thoracic VBT (with or without lumbar extension) resulted in higher treatment success (85%) compared with Thoracolumbar (40%) and Bilateral (57%) surgeries (p=0.030). Lenke 1 Curves demonstrated higher success (86%; in detail 90%, 90%, 83% and 78% for 1A, 1B, 1C and 1Ar curves, respectively) compared to Lenke 2-3 (33%) and Lenke 5-6 (50%) curves (p=0.022). TRC closed patients had higher success (82%) rates compared to TRC open (43%) patients (p=0.028). Success rates for Sanders 1-2 (66%), Sanders 3-4 (88%) and Sanders 5-6-7 (71%) patients were similar (p=0.384). Patients with treatment success demonstrated better mean SRS-22 satisfaction (4.71 vs 3.85, p=0.010) and function (4.6 vs 4.4, p=0.044) scores compared with patients with treatment failure at latest follow-up, while other subdomains and the subtotal score were similar (p>0.05).

Conclusion

Although it is more desirable to preserve motion at the lumbar spine, at its current state, treatment success rate of thoracic VBT surgery is more favorable than that of thoracolumbar and bilateral VBT surgeries. Success rates were higher in TRC closed patients, compared to TRC open ones. Poor radiographic outcomes resulted with poorer function and satisfaction scores.



262. Identification of Differential Expressed Genes by Single Cell RNA Sequencing and Prediction of Target Genes in Bone Marrow Mesenchymal Stem Cells of Adolescent Idiopathic Scoliosis Patients

Qianyu Zhuang, MD; Yuechuan Zhang, PhD; Jianguo Zhang, MD

Hypothesis

Single-cell level differential genes expression profiles of BM-MSCs might play a significant role, in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.

Design

Single Cell RNA sequencing approach and integrated network analysis.

Introduction

The pathogenesis of AIS and the accompanying generalized osteopenia remain unclear. Our previous study (2016 IMAST, Whitecloud Prize Nomination) suggested differential expressed genes (DEGs) effects increased proliferation ability and decreased osteogenic differentiation ability of BM-MSCs of AIS. Therefore, we hypothesized that gene expression level of MSCs may play a significant role in the etiology and pathogenesis of AIS.

Methods

In this study, single cell RNA sequencing was used to identify DEGs of BM-MSCs from AIS patients compared with those from healthy individuals. Comprehensive bioinformatics analyses were then used to enrich datasets for Gene Ontology and pathway. Based on the mRNA-target gene network, mRNA-target GO network and mRNA-target pathway network, the top 10 potential crucial genes were selected for validation by RT-PCR.

Results

There are 2513 DEGs in BM-MSCs from AIS patients. Pathway analysis revealed dysregulated TGF-βsignaling pathway; PI3K-Akt signaling pathway, HIF-1 signaling pathway, Hippo signaling pathway, Wnt signaling pathway, and Splisosome signaling pathway, all of which have been reported to play important role in regulating the osteogenic or adipogenic differentiation of MSCs. Furthermore, gene signal transduction networks analysis indicated that NF90, CREBBP, GTF2I, PDGFRA, COL1A2, BMP4, PIK3R1, SMAD4, YAP1 may play essential roles in AIS pathogenesis and accompanied osteopenia.

Conclusion

To the best of our knowledge, this is the first Single Cell RNA Sequencing study in MSCs from AIS patients, which reports novel single-cell level differential gene expression profiles of BM-MSCs from AIS patients and related potential pathways. These previously unrecognized DEGs and related target genes, as well as molecular pathways might play a significant role, in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.

263. Is Rod Density (a Comparison Between 3 Rods and >3 Rod Constructs) a Significant Risk Factor for Implant Related Complication in Spine Deformity Patients With Severe Curves

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Samdani, MD; Peter O. Newton, MD; Oheneba Boachie-Adjei, MD; FOCOS Spine Research Group

Hypothesis
The use of "3 rods" and ">3" rod constructs has no effect on implant related complications in complex pediatric spine reconstruction

Design
Prospective observational multi center cohort

Introduction
Rod density (No. of rods) plays an important role in complex spine deformity correction. The use of high rod density constructs especially in long fusions, impacts on outcomes such as implant related complications. Higher rod constructs have been used to avert such complications. We seek to find whether there is any difference in outcomes comparing "3 rod" and "> 3" rod constructs.

Methods
109/311 pts with 2-year f/u enrolled in the FOX pediatric database from 17 international sites were queried for the impact of rod density and surgical outcomes. Patients were grouped into two rod density categories for comparative analysis Group 1 (no. of rods =3) vrs. Group 2(no. of rods=>3). Rod density below 3 was excluded from the study.

Results
109 pts: 75 (Grp1) / 34 (Grp2); Pre-op age and BMI were similar in both groups. Both pre-op cor. and sag. cobb was significantly higher in Grp 2 compared to Grp1; mean pre-op cor. cobb (83.8±47.2 vs 104±44.7, p=0.03) and mean pre-op sag. cobb. (104±38.8 vs125±25.4, p=0.004). Pre-op HGT was used in 56.0% / 79.41%, p=0.019; Grp1 and Grp2, respectively. Average ORT (min) was sig. higher in Grp 1 relative to Grp2: 451±201 vs 369 ±180.8, p= 0.04. EBL was similar in both Grps. Rate of VCR was higher in Grp 1 (60.00% vs 23.53%, p<0.001), PSO and SPO were similar in both Grps. Cor. cobb correction at 2y FU were similar in both Grps (39.48% vs 35.70%, p=0.520). Similarly, there was no difference in sag. cobb correction in both groups (42.8% vs 42.6%, p=0.95). Implant related complication rates were comparable in both Grps (9.33 % vs 2.94%, p=0.236). Firth logistic regression analysis did not show otherwise. 2 (2.67 %) pseudoarthrosis cases were recorded in Grp1. There was significant improvement in SRS scores at 2yr FU for both Grp1 and Grp 2.

Conclusion
An assessment of implant related complication outcomes did not reveal any difference between 3 rod and > 3 rod constructs in complex spine deformity correction surgery. It is safe to use 3 rod constructs in severe spine deformity correction surgery in well selected patients

Comparison of Implant Complication rates and HRQoL Stratified by 3 Rods and >3 Rods Constructs			
	3 Rods	>3 Rods	p-value
Implant complications	9.33	2.94	0.236
SRS SCORES (2yr FU)	4.2±0.49	4.2±0.53	0.740

Comparison of Implant Complication rates and HRQoL Stratified by 3 Rods and >3 Rods Constructs

264. What is the Prevalence and Impact of Vitamin D Deficiency in Adolescent Idiopathic Scoliosis?

Matthew Darlow, MD; R. Carter Clement, MBA; Claudia Leonardi, PhD; Tara Korbal, BS

Hypothesis
No association between vitamin D deficiency and AIS

Design
Retrospective review

Introduction
Vitamin D plays an important role in bone health, including development of specific deformities. Some authors have also suggested that vitamin D deficiency may precipitate certain osteochondroses and other types of bone-related pain. However, the impact of low vitamin D on the adolescent spine has not been clearly elucidated. The present study investigates the associations of Vitamin D level with spine deformity and pain in patients diagnosed with adolescent idiopathic scoliosis (AIS).

Methods
A retrospective chart review of consecutive patients, ages 10-17, diagnosed with AIS between 01/01/2018 and 12/31/2021 at an academic tertiary free-standing children's hospital with recorded vitamin D levels was conducted. Patients with surgery prior to diagnosis were excluded. Variables collected include demographic and clinical patient characteristics and Vitamin D level. Summary statistics and univariate associations (Chi-square test or analysis of variance) were produced using SAS/STAT software.

Results
A total of 175 AIS patients with vitamin D levels were included for analysis. Patient were predominantly female (75.4%), averaged 12.8 years old, had an average Cobb angle of 22.7 degrees, and mostly carried Medicaid insurance (61.1%). The majority of patients had Lenke type 1 (48.6%) and Lenke type 5 (42.9%) curves. The following Vitamin D levels were observed: 36.5% were deficient (<20 ng/ml), 33.7% were insufficient (20 – 30 ng/ml), and 29.7% had optimal level (>30 ng/ml). More than half of the patients reported back pain (57.1%). No association was observed between Vitamin D deficiency and pain presence (p=0.75), Cobb angle (p=0.44), Lenke type (p=0.72), insurance type (p=0.12), age (p=0.92), or sex (p=0.85). Race was associated with vitamin D deficiency (p=0.002).

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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Conclusion
70% of AIS patients in our study population were in the deficient/insufficient vitamin D range. However, no correlation was identified between vitamin D level and clinical characteristics including curve magnitude, curve type, or reported back pain. African American patients were more likely to have low vitamin D levels. While further research is needed to determine how to best manage bone health in AIS patients, this study provides the most robust data to-date on the prevalence and potential impact of vitamin D deficiency in this population.

265. 6.0 over 5.5 CoCr Rod Yields Modest Improvement in the Sagittal Plane Following Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis

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Hypothesis
Use of 6.0 diameter CoCr rods would improve the sagittal plane alignment without an increased complication rate.

Design
Retrospective review of a prospective AIS registry.

Introduction
Large diameter rods are increasingly being used in posterior spinal fusion for adolescent idiopathic scoliosis (AIS). Our study aims to evaluate the impact of rod size on sagittal plane correction and complications, including junctional problems.

Methods
Data and 2D radiographs were reviewed from a multicenter registry of AIS patients who were prospectively enrolled between 2016-2019 with minimum 2-year follow-up. Patients who underwent PSF with 5.5 CoCr or 6.0 CoCr were included. Other rod types/diameters were excluded from this study

Results
248 patients treated by 29 surgeons at 13 centers met inclusion criteria. 215 patients had PSF performed with 5.5 CoCr rods, and 33 had 6.0 CoCr rods. Preoperatively there was no difference in BMI, curve magnitude, flexibility, or sagittal plane parameters (Table). At 2 year follow-up, there was improved T5-T12 kyphosis in the 6.0 rod group (26 vs. 22 degrees, p=0.01). At 2 year follow-up, there was improved T5-T12 kyphosis in the 6.0 rod group (26 vs. 22 degrees, p=0.01). Additionally, there was decreased T2-T5 kyphosis (upper curve) in the 6.0 rod group (-1 vs. 8 degrees, p=0.0002). At 2 year follow-up, there was less change in radiographic proximal junctional kyphosis angle in the 6.0 CoCr group (mean 0 degrees) vs. 5.5 CoCr (3 degrees, p=0.01). In hypokyphotic patients, mean preop T5-T12 improved by 15 degrees in the 5.5 group vs. 13 degrees in the 6.0 group (p=0.5). There were no differences found in DJK, trunk rotation or coronal plane parameters. There were 5 implant-related complications in 5.5 CoCr group (2%) of which 3 required revision surgery (1.4%). No complications were noted in the 6.0 CoCr group.

Conclusion
This study analyzes the results of PSF for AIS patients using 5.5 vs 6.0 CoCr rods. Better T5-T12 kyphosis restoration was found in the 6.0 CoCr group without increased proximal junctional kyphosis.

	5.5 CoCr (N=215)	6.0 CoCr (N=33)	p-value
Age	14.3 (2)	14.3 (1.9)	0.92
Height (cm)	161 (8)	162 (9)	0.54
Weight (kg)	57 (14)	59 (13)	0.40
BMI	21 (5)	21 (4)	0.4
Preop Major Cobb (˚)	59 (12)	58 (11)	0.44
Preop Flexibility	35%	33%	0.4
Ponte Osteotomy (%)	64%	67%	0.6
2 Yr Major Cobb (˚)	21 (8)	23 (9)	>0.05
2 Yr % Correction	64% (13)	60% (14)	>0.05
2 Yr C7-CSVL	-0.3	-0.5	0.71
2 Yr T1 Tilt	6 (5)	5 (4)	0.53
Preop T5-T12(˚)	24 (16)	24 (16)	0.97
2 Year T5-T12(˚)	**22 (8)**	**26 (12)**	**0.01**
Change T5-T12 (˚)	-1.5 (14)	3 (14)	0.11
Preop % Pts Hypokyphosis	14%	5%	
2 Year % Pts Hypokyphosis	18%	7%	
Change T5-T12 in (Hypokyphotic Patients Only, N=46)	15 degrees	13 degrees	0.5
Preop T2-T12 Kyphosis (˚)	33 (16)	31 (16)	0.56
Postop T2-T12 Kyphosis (˚)	35 (11)	33 (11)	0.45
Change T2-12 Kyphosis (˚)	2 (12)	3 (15)	0.8
Preop T2-T5 Kyphosis (˚)	11 (9)	9 (8)	0.3
Postop T2-T5 Kyphosis (˚)	**15 (9)**	**8 (7)**	**0.0002**
Change T2-T5 Kyphosis (˚)	**4 (10)**	**-1.5 (8)**	**0.0024**
Preop Proximal Junctional Kyphosis	4 (7)	5 (6)	0.75
2 Year Proximal Junctional Kyphosis	**8 (6)**	**4 (3)**	**<0.0001**
Change in Proximal Junctional Kyphosis	**3 (7)**	**0 (7)**	**0.025**
2 Year Distal Junctional Kyphosis	-6 (11)	-3 (15)	0.26

266. Clinical and Radiological Outcomes of Cobb to Cobb Vertebral Body Tethering Technique using Double Screw-Double Cord Fixation in the Surgical Treatment of Lenke Type 5 Curves

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Hypothesis
Satisfactory corrections can be achieved with Cobb to Cobb VBT technique for the surgical treatment of AIS Lenke Type 5 curves. Double Screw-Double Cord (DS-DC) fixation will minimize the cord rupture problem.

Design
Retrospective study.

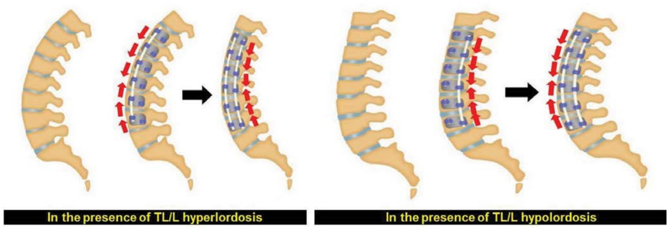
Introduction
Cobb to cobb posterior fusion is accepted as the standard treatment for Lenke type 5 curves. Recently VBT has gained popularity as a non-fusion alternative which is postulated to preserve motion and flexibility compared with posterior fusion. Cord rupture is a potential complication of VBT, and can be minimized with DS-DC fixation. The aim of this study is to evaluate the efficacy of Cobb to Cobb VBT technique using DS-DC fixation in the surgical treatment of Lenke type 5 curves.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster   * = John H. Moe Award Nominee – Best Basic Science Research Poster

Methods
20(16F,4M) pts, mean age 14 (11-17) years were included. DS-DC fixation was performed via a mini / open TL approach between Cobb levels. According to the TL/L (T10-L2) sagittal alignment anterior cord was tightened first in pts with hyperlordotic alignment and the posterior cord was tightened first in pts with hypolordotic alignment during correction maneuver. Preop, first erect and f/up coronal and sagittal parameters were compared. Preop, f/up lumbar ROM was compared. SRS-22r was used for clinical assessment.

Results
Mean f/up was 32 (24-42) months. Sander's score > 4 in all pts. LIV was L3 in 12 pts & L4 in 8 pts. Mean TL curve 45° was corrected to 9.3° (82%CR). Mean MT curve of 17° was corrected spontaneously to 8°. Preop TK of 30° improved to 37°, preop LL of 65° was restored to 57° at f/up. 12 pts with TL hyperlordosis of 11.6° improved to 1.8°. 8 pts with TL kyphosis of 13,2° improved to 2,1°. Cord rupture was observed in 2 pts (%10) at postop 30 months. Lumbar ROM & flexibility was preserved at final f/up. Total SRS-22r score improved from 3,8 to 4,4.

Conclusion
Cobb to Cobb VBT with DS-DC fixation provided satisfactory curve corrections on both planes for Lenke type 5 curves. DS-DC fixation enables ideal TL/L sagittal alignment restoration with preserved lumber flexibility. Restoration of ideal TL/L sagittal alignment improved thoracic and cervical alignment. Double cord fixation prevented cord rupture in the first 2,5 years, however, cord ruptures occurred 30 months after surgery. This emphasizes that a longer follow-up is necessary to determine the durability of DS-DC fixation.



267. Is Pedicle Morphology Influenced by Curve Magnitude or Curve Rotation in Adolescent Idiopathic Scoliosis?

Bhavuk Garg, MS; Nishank Mehta, MS; Tungish Bansal, MS

Hypothesis
Pedicle dysmorphism in adoloscent idiopathic scoliosis is a function of both curve magnitude and curve rotataion.

Design
Observational study

Introduction
Asymmetry in pedicle anatomy is most distinctly noted around the apex of the curve. The correlation of pedicle dysmorphism with apical vertebral rotation (AVR) and Coronal Cobb angle (CCA) has not been studied. To establish whether pedicle dysmorphism is linked to curve magnitude CCA and the AVR in adolescent idiopathic scoliosis (AIS)

Methods
Preoperative plain whole spine standing radiographs and non-contrast computed tomography (CT) scans of 25 AIS patients who were operated at a single centre from 2013-2019 were retrospectively reviewed by 3 independent co-investigators. CCA was noted on the standing radiograph whereas the AVR was measured on the axial cuts of CT scan. Pedicle morphometric measurements were done for apical and periapical pedicles – these included the apex vertebra (when present), 2 vertebrae above (U1 and U2) and below (B1 and B2) the apex vertebra/disc. The following pedicle morphometric measurements were performed on CT scans – transverse pedicle diameter, sagittal pedicle diameter, pedicle length and pedicle axis length. Correlation between various pedicle morphometric measurements for apical/peri-apical pedicles and curve magnitude (Cobb angle) or AVR was sought by performing the Pearson correlation test.

Results
Among the 25 patients comprising the study population, 17/25 had main thoracic (MT) curves, 4 had thoracolumbar/lumbar (TL/L) curves and 4 patients had both MT and TL/L curves. The mean Cobb angle was 59.4° whereas the mean AVR was 28.2°. The apical vertebral rotation (AVR) significantly correlated with concave pedicle length(r= 0.5, p=0.02) and convex sagittal pedicle diameter of U1 vertebrae(r= 0.56, p=0.01). AVR also correlated with convex pedicle length of U2(r=0.7, p=0.0006). The convex transverse pedicle diameter at the apex also correlated well with the AVR(r=0.78, p=0.02). The Cobb angle did not show a significant correlation with any of the pedicle measurements of any of the apical and periapical vertebrae.

Conclusion
Pedicle asymmetry and dysmorphism is better linked to the apical vertebral rotation than to the curve magnitude.

268. Outcome of Distraction-based Growing Rods at Graduation: Comparison of Traditional Growth Rods (TGR) and Magnetically Controlled Growth Rods (MCGR)

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Hypothesis
MCGR performs better than TGR based on radiographic outcomes and fewer unplanned returns to operating room.

Design
Retrospective assessment of multicenter database

Introduction
Distraction-based growing rods are considered to be the 'gold

standard' for treating EOS. MCGR has the advantage of a non-surgical lengthening with fewer planned returns to OR compared to TGR. This study explores the radiographic outcomes, unplanned returns to OR (UPROR) and complication profile of patients undergoing these procedures at the end of treatment.

Methods

All EOS patients who underwent either TGR or MCGR with spine-based anchors were followed to graduation with the radiological, complications and UPROR data. Crossover procedures were excluded. A total 549 patients (409 TGR and 140 MCGR) were eligible. The groups were well matched for gender and BMI. They were slightly younger in the TGR group (7.0 v 8.5 yrs, $p < 0.001$). Final follow up was 13.8 years after TGR and 5.65 years after MCGR.

Results

Radiographic outcomes were compared at pre and post index and definitive fusion surgery (graduation) using chi squared and unpaired t tests comparing Cobb angle of the major curve, T1-T12 and T1 -S1 heights and kyphosis. There was a significant change between the pre and post groups in all the categories. The time between the index and the final procedure was shorter in the MCGR group (42 mo v 61 mo, $p < 0.001$). 94% of the MCGR patients underwent a final fusion as compared with 67% TGR, since 29% TGR had implants retained. Complications and UPROR were evaluated with regression modelling (figure). All complications were lower in the MCGR group especially the implant related, though pain-related complications were higher. The overall risk of UPROR was lower in the MCGR group and rod breakage was 5 times less in the MCGR group. Anchor prominence was similar in both groups. At least 1 complication was noted in 77 % TGR and 61% MCGR groups and in 39% TGR and 28% MCGR groups.

Conclusion

At the time of the completion of GR treatment both TGR and MCGR were found to be effective with regards to radiological outcomes. The overall complications and UPROR were significantly lower in the MCGR groups compared to TGR.

Complications	TGR	MCGR	Hazard Ratio	
All	983 (77%)	155 (61%)	0,67	<0.001
Implant related	303	20	0,55	<0.001
Implant break	303	20	0.37	<0.001
Anchor prominence	50	6	0.66	0.38
UPROR	**TGR**	**MCGR**	**Hazard Ratio**	
All	372 (39%)	59 (28%)	0.67	0.02
Implant related	247	31	0.52	0.005
Implant break	149	7	0.22	0.001
Anchor prominence	19	4	1.2	0.77
Pain	60	8	0.48	0.11

Complications and UPROR outcomes

269. Selecting the Upper Instrumented Vertebrae in ASD Surgery: What Happens when You Stop in the Mid-Thoracic Spine? †

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Hypothesis

Choosing an upper instrumented vertebra (UIV) in the mid-thoracic spine will lead to a higher risk of mechanical complications and reoperation.

Design

Retrospective cohort study.

Introduction

While the classic adult spinal deformity surgery (ASD) teaching is to avoid a UIV in the mid-thoracic spine, this notion has not been tested. In patients undergoing ASD surgery, we sought to compare patients with a UIV in the upper thoracic, mid-thoracic, and thoracolumbar spine regarding: 1) preoperative factors, 2) perioperative variables, and 3) and postoperative outcomes.

Methods

A single-institution retrospective cohort study was undertaken for patients undergoing ASD surgery from 2009-21 with 2-year follow-up. The primary independent variable was the location of the UIV: upper thoracic: C7-T4, mid-thoracic: T5-T8, and thoracolumbar: T9-L2. Postoperative outcomes included mechanical complications, reoperations, and patient-reported outcomes measures (PROMs). Bivariate comparisons were performed.

Results

Of 231 patients undergoing ASD surgery, 51 (22.1%) had an upper thoracic UIV, 53 (23.0%) mid-thoracic UIV, and 127 (54.9%) thoracolumbar UIV. Preoperatively, patients with a mid-thoracic were older than upper thoracic UIV (63.7±21.0 vs. 49.9±19.5, $p<0.001$). Perioperatively, patients with a mid-thoracic UIV had lower estimated blood loss (EBL) ($p=0.014$) compared to upper thoracic UIV, yet higher EBL ($p=0.005$) compared to thoracolumbar UIV. Radiographically, max coronal Cobb angle correction was significantly higher in mid-thoracic UIV compared to thoracolumbar UIV (31.6±22.2 vs. 22.8±19.7, $p=0.001$), with no difference in other coronal/sagittal correction. Postoperatively, patients with mid-thoracic UIV had a higher rate of pseudarthrosis (39.6% vs. 15.7%, $p=0.007$) and reoperation due to mechanical complications (41.5% vs. 17.6%, $p=0.008$) compared to upper thoracic UIV, and more rod fractures compared to thoracolumbar UIV (30.2% vs. 16.5%, $p=0.039$). No difference was found in PJK/F or PROMs.

Conclusion

Patients with a mid-thoracic UIV had more pseudarthrosis and reoperation than patients with an upper thoracic UIV and more rod fractures compared to patients with a thoracolumbar UIV. The only superior outcome of a mid-thoracic UIV was more coronal Cobb correction compared to thoracolumbar UIV.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Variables	Total cohort N = 231	Upper thoracic N = 51	Mid-thoracic N = 53	thoracolumbar N = 127	p-value
Preoperative					
Age	63.3±17.6	49.9±19.5	63.7±21.0	68.5±11.6	<0.001
Female	178 (77.1%)	38 (74.5%)	45 (84.9%)	95 (74.8%)	0.301
BMI	28.9±7.0	28.4±8.1	27.9±6.2	29.6±6.8	0.188
Prior fusion	79 (34.2%)	11 (21.6%)	19 (35.8%)	49 (38.6%)	0.092
Comorbidities	2+	92 (39.8%)	12 (23.5%)	20 (37.7%)	0.056
Postoperative					
Total instrumented levels	10.5 ± 3.2	11.4 ± 3.3	10.4 ± 3.1		0.065
Operative time, min	419.9 ± 147.2	553.9 ± 177.4	397.4 ± 129.0		<0.001
Postoperative					
Mechanical complication	141 (61.0%)	28 (54.9%)	36 (67.9%)	77 (60.6%)	0.392
Radiographic PJK	110 (48.0%)	20 (40.0%)	27 (51.9%)	63 (49.6%)	0.42
pseudarthrosis	64 (27.7%)	8 (15.7%)	21 (39.6%)	35 (27.6%)	0.024
RF	46 (19.9%)	9 (17.6%)	16 (30.2%)	21 (16.5%)	0.101

Description of three cohorts

270. Withdrawn

271. Bone Modulus Has Value Beyond that of Bone Mineral Density and Houndsfield Units For Prediction of Postoperative Complications in Spinal Fusion Patients *

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Hypothesis

Bone modulus is able to predict the development of bone-quality related complications (BQRC) after spine surgery.

Design

Retrospective study with 2-year follow-up

Introduction

The standard-of-care to assess bone quality, dual-energy X-ray absorptiometry (DXA) generated estimation of BMD, has limitations. Similarly, HU has also recently been shown to be correlated to mechanical failures. Bone modularity is a novel parameter, computed from finite element analysis (FEA) applied to patients' computed tomography (CT) scans, that has not been explored. The goal of this study was to assess the value of bone modulus on its prediction of post-operative complications

Methods

There were a total of 85 subject split into two cohorts : those who did not (n=53) and did (n=31) suffer a BQRC within 2-years after surgery, which was defined as: proximal junctional kyphosis (PJK) or failure (PJF), pedicle screw loosening, adjacent segment disease, or pseudoarthrosis. There was no difference between groups in terms of age or body mass index. Using patients' preoperative CT scans, we applied in-house developed software to compute HU, BMD, and bone modulus, the latter via FEA. We used student's t-test to assess differences between groups in terms of theses outcome measures. Univariate and multivariate ROC analyses assed the ability of these preoperative measures to predict BQRCs.

Results

Compared to controls who did not suffer a BQRC, patients with complications demonstrated lower bone modulus (-15.7% to -23.2%) at every vertebral level from L1 to L5 ($p \leq 0.02$ for all). Patients with BQRC demonstrated lower HU and BMD from L1 to L5, though not statistically significant (p= 0.18 to 0.92). Modulus measured at any level from L1 to L5 level predicted postoperative bone quality related complication better than pure chance (AUC: 0.67-0.70, $p < 0.03$). HU and BMD, regardless of the lumbar level at which they were measured, could not predict bone quality related complication (AUC: 0.57-0.61, $p > 0.1$). Bone modulus, BMD, age, gender, and BMI resulted in higher AUC values compared to bone modulus alone (AUC: 0.74-0.81, $p < 0.001$)

Conclusion

Preoperative bone modulus has utility for prediction of complications in fusion patients. Inclusion of patient-specific clinical/demographic factors also appears to further improve the ability to predict postoperative complications.

Table 1. Differences in bone modulus (GPa), HU, and BMD (mg/cc) between groups at every lumbar level.

	Bone Quality Related Complication	Mean	Std. Deviation	% Difference	p value
Modulus L1	Complication	.557	.183	-15.7%	0.015
	None	.661	.191		
Modulus L2	Complication	.578	.173	-20.1%	0.020
	None	.723	.323		
Modulus L3	Complication	.554	.148	-18.5%	0.013
	None	.680	.251		
Modulus L4	Complication	.611	.216	-19.6%	0.006
	None	.760	.239		
Modulus L5	Complication	.617	.181	-23.2%	0.010
	None	.803	.349		
HU L1	Complication	235.0	66.9	-7.8%	0.180
	None	254.8	64.3		
HU L2	Complication	284.4	187.9	-1.1%	0.924
	None	287.6	126.9		
HU L3	Complication	266.1	136.9	-2.1%	0.830
	None	271.7	105.5		
HU L4	Complication	312.6	160.5	-2.5%	0.810
	None	320.6	131.7		
HU L5	Complication	305.6	152.2	-8.4%	0.433
	None	333.8	154.4		
BMD L1	Complication	73.9	21.0	-7.7%	0.180
	None	80.1	20.2		
BMD L2	Complication	89.4	59.1	-1.2%	0.924
	None	90.5	39.9		
BMD L3	Complication	83.7	43.1	-2.0%	0.830
	None	85.4	33.2		
BMD L4	Complication	98.3	50.5	-2.5%	0.810
	None	100.8	41.4		
BMD L5	Complication	96.1	47.9	-8.5%	0.433
	None	105.0	48.6		

Table 2. ROC analyses to assess the ability of different univariate or multivariate models to predict postoperative complications. The multivariate model was a logistic regression model.

	Metric/Model	AUC	P value	95% CI Lower Bound	95% CI Upper Bound
L1	Bone Modulus	0.680	0.006	0.561	0.799
L2		0.666	0.010	0.547	0.784
L3		0.648	0.024	0.529	0.767
L4		0.686	0.006	0.566	0.806
L5		0.695	0.004	0.579	0.812
L1	HU	0.607	0.101	0.482	0.732
L2		0.603	0.111	0.472	0.733
L3		0.571	0.266	0.445	0.697
L4		0.573	0.274	0.437	0.71
L5		0.593	0.171	0.459	0.727
L1	BMD	0.607	0.101	0.482	0.732
L2		0.603	0.111	0.472	0.733
L3		0.571	0.266	0.445	0.697
L4		0.573	0.274	0.437	0.71
L5		0.593	0.171	0.459	0.727
L1	Modulus, BMD, age, gender, BMI	0.737	<0.001	0.623	0.851
L2		0.752	<0.001	0.641	0.863
L3		0.771	<0.001	0.663	0.879
L4		0.776	<0.001	0.669	0.883
L5		0.809	<0.001	0.709	0.909

272. Which Lenke Type Curve is most appropriate for Vertebral Body Tethering in Adolescent Idiopathic Scoliosis?

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Hypothesis

Lenke curve type 5 is the most appropriate for the indication of vertebral body tethering due to its flexibility, less rotation, better residual curve correction, and a lower chance of disk degeneration compared to L3-L4 fusion.

Design

Single-center retrospective cohort study

Introduction

VBT shows promising results as fusion-alternative to treat AIS patients. AIS patients are classified by Lenke type according to nature of their curve. Given the novelty of VBT, this is the first study of its kind which investigates the outcomes of VBT in different Lenke types. This study compares patients who underwent VBT and were classified as Lenke type 1, 3, 5, or 6.

Methods

Patients undergoing Vertebral Body Tethering for the correction of AIS were included. The cohort was separated into Lenke type 1, 3, 5, or 6. Outcome measures: Age, height, weight, BMI, Risser, Sanders. Radiographic: pre- and post-op thoracic (T) cobb angle, thoracolumbar (TL) cobb angle, coronal balance, cervical SVA (cSVA), L5 slope, thoracic kyphosis (TK), pelvic incidence lum-

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bar lordosis mismatch (PI-LL), and pelvic tilt (PT), and % of tether breakage incidence. Independent T-test and $\chi 2$ test were used, with significance set at p<0.05. Post-Hoc analysis was done when significance was found.

Results

105 VBT (Lenke 1,N=45; Lenke 3,N=23; Lenke 5,N=21; Lenke 6,N=16) patients met the cohort criteria. Age, height, weight, gender, BMI, Risser, and Sanders scores were not different between the groups. There was a smaller L5 tilt angle in the Lenke 1 group (9.94±4.80;p=0.001). The preop T cobb angle was smaller in the Lenke 5 group (36.20±10.62;p<0.001). There was a smaller TL cobb angle in the Lenke 1 group (38.91±15.94;p=0.014). There was a larger coronal imbalance in the Lenke 5 group (23.41±12.13;p=0.028). There was a smaller change in the T cobb angle in the Lenke 5 group (-20.13±16.25;p=0.011). There was a smaller change in the TL cobb angle in the Lenke 1 group (-17.68±14.85;p=0.004). There was a lower rate of tether breakage in the Lenke 1 group (1(3.7%) vs 3(37.5%) vs 5(33.3%) vs 6(55.6%).

Conclusion

Lenke type 5 is the best indication for VBT due to its flexibility, and the residual curve achieves a better correction. Type 5 patients have more cord breakage, but the revision rates are lower than the Lenke types whose structural curve is thoracic. All coronal parameters are correct and there was no loss of sagittal parameters in type 5.

	VBT (N = 105)	Lenke 1 (N = 45)	Lenke 3 (N = 23)	Lenke 5 (N = 21)	Lenke 6 (N = 16)	p-value
Demographics	Age (years)	13.93±2.23	14.00±1.69	14.42±1.78	14.66±4.66	0.874
	Gender (% female)	81.48%	100.00%	83.33%	88.89%	0.621
	Height (m)	1.599±0.122	1.63±0.08	1.62±0.077	1.61±0.08	0.913
	Weight (kg)	52.14±12.86	59.76±15.52	53.10±7.46	54.56±8.02	0.448
	BMI	20.20±3.34	22.48±4.94	20.35±2.50	21.09±2.09	0.37
	Sanders	5.56±2.08	4.62±2.77	5.36±2.46	5.00±2.82	0.808
	Risser	3.12±1.70	2.50±2.13	3.27±1.48	3.11±2.03	0.793
Pre-Op	L5 Tilt (deg)	9.94±4.80	15.10±4.70	15.69±4.29	14.96±5.03	0.001
	Pelvic Tilt (PT) (deg)	5.67±7.90	10.54±5.60	7.48±6.31	10.27±8.10	0.258
	Sagittal Vertical Axis (SVA) (mm)	23.78±9.24	25.68±6.64	27.03±11.61	21.31±7.44	0.554
	Thoracic Kyphosis (TK) (deg)	26.74±13.10	31.65±10.34	24.12±13.18	24.57±10.30	0.572
	PI-LL mismatch (deg)	-7.42±11.54	-7.15±12.45	-7.84±7.20	-3.28±10.68	0.787
	Thoracic Cobb Angle (deg)	55.76±9.24	60.12±9.94	36.20±10.62	51.00±9.55	<0.001
	Thoracic Cobb Angle Bends To (deg)	21.52±10.35	21.42±9.34	11.11±6.41	21.25±10.30	0.053
	Thoracolumbar Cobb Angle (deg)	38.91±15.94	56.00±4.65	49.50±15.57	54.00±12.63	0.014
	Thoracolumbar Cobb Angle Bend To (	9.92±8.94	12.43±3.74	15.10±7.21	14.56±13.04	0.538
	Coronal Balance (mm)	13.09±7.23	21.13±10.88	23.41±12.13	16.19±13.45	0.028
Post-Op	L5 Tilt (deg)	5.11±3.15	8.15±4.90	7.27±4.49	8.04±3.88	0.089
	Pelvic Tilt (PT) (deg)	8.75±8.59	10.19±6.26	11.43±8.89	15.15±13.13	0.348
	Sagittal Vertical Axis (SVA) (mm)	21.91±15.20	24.21±7.15	22.54±11.99	18.89±7.94	0.85
	Thoracic Kyphosis (TK) (deg)	24.66±12.55	28.72±10.95	24.06±8.86	22.31±8.66	0.682
	PI-LL mismatch (deg)	-3.68±13.10	-5.62±9.68	-0.48±9.99	-2.60±11.54	0.794
	Thoracic Cobb Angle (deg)	21.41±9.90	24.43±9.64	16.07±10.08	23.11±6.51	0.275
	Thoracolumbar Cobb Angle (deg)	21.23±10.82	20.75±7.90	15.60±5.60	21.84±9.51	0.395
	Coronal Balance (mm)	*12.78±9.99*	21.88±12.28	12.20±9.81	13.77±15.19	0.225
Change	Δ L5 Tilt (deg)	-4.82±4.53	-6.95±5.57	-8.42±3.39	-6.91±4.09	0.12
	Δ Pelvic Tilt (PT) (deg)	3.05±6.65	-0.34±2.10	3.94±4.41	5.99±14.90	0.412
	Δ Sagittal Vertical Axis (SVA) (mm)	-1.56±11.43	-1.47±6.12	-4.49±5.83	-3.38±10.70	0.824
	Δ Thoracic Kyphosis (TK) (deg)	-2.11±9.15	-2.93±7.89	-0.0652±10.63	-1.48±6.09	0.894
	Δ PI-LL mismatch (deg)	4.28±10.98	1.53±7.53	7.36±5.72	0.48±2.74	0.304
	Δ Thoracic Cobb Angle (deg)	-34.35±9.59	-35.70±7.64	-20.13±16.25	-27.89±13.42	0.011
	Δ Thoracolumbar Cobb Angle (deg)	-17.68±14.85	-35.25±9.01	-33.90±14.45	-32.15±12.88	0.004
	Δ Coronal Balance (mm)	-0.35±11.14	0.76±13.20	-11.20±13.55	-2.42±17.06	0.1
	% of Broken tethers	1 (3.7%)	3 (37.5%)	4 (33.3%)	5 (55.6%)	<0.001

273. Surgical Site Infection Risk in Neuromuscular Scoliosis Undergoing Posterior Spinal Fusion

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Hypothesis

Neuromuscular scoliosis patients undergoing posterior spinal fusion have preoperative risk factors for SSI.

Design

Retrospective cohort study utilizing prospective data

Introduction

Surgical site infections (SSI) remain a significant source of morbidity, cost, and readmission/reoperation in patients treated with posterior spinal fusion (PSF) for neuromuscular scoliosis (NMS). Identification of risk factors for SSI is crucial for counseling families and developing perioperative risk mitigation processes.

Methods

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) pediatric database was queried for patients who underwent PSF from 2017-2021. Patients with neuromuscular disease and/or cerebral palsy diagnosis with fusion of ≥13 vertebral segments (CPT 22804) were included. Patient characteristics were assessed to determine risk factors for SSI. Statistical analysis was completed utilizing likelihood ratio chi-squared test for categorical factors and median or Wilcoxon rank sum test for quantitative factors.

Results

102 of 4145 (2.5%) NMS patients developed a deep surgical site infection. Risk factors for deep SSI include ASA score ≥3 (p=0.027, odds ratio 2.4), preoperative steroid intake (p=0.049, OR 2.4), preoperative ostomy (p=0.026, OR 1.6), prolonged anesthetic time (p=0.044), and urinary tract infection (UTI)(p<0.001, OR 4.5). A trend for increased risk was noted in patients with preoperative nutritional support (p=0.074) and patients with prolonged operative time (p=0.080). There was no greater prevalence for SSI for other factors including: gender, race, BMI, diabetes, preoperative platelet count <150, albumin <3.5, white blood cell count <4000 or >11,000, supplemental oxygen, tracheostomy/ventilatory support, prior cardiac risk factors, seizure history, creatinine >1.0, or length of hospital stay (all p>0.1).

Conclusion

In the NSQIP database, neuromuscular scoliosis patients have a 2.5% incidence of deep SSI over a 5-year period from 2017-2021. Risk factors for deep SSI include ASA score ≥3, preoperative corticosteroids, presence of an ostomy, prolonged anesthetic time, and UTI. The incidence of deep SSI reported in the NSQIP database for NMS patients undergoing PSF is lower than reported in other literature or registry-based SSI calculators. Nonetheless, large multicenter database studies can help identify and stratify risk factors for SSI.

274. Minimalistic Approach to Enhanced Recovery After Pediatric Scoliosis Surgery

Scott Barnett, MD; Bryant Song, BS; Matthew Bauer, MD; Jacquelyn Valenzuela-Moss, BS; Claudia Leonardi, PhD; Michael J. Heffernan, MD

Hypothesis

We hypothesized that accelerated transition to oral pain medications and mobilization alone could shorten hospital length of stay in the absence of a formal multimodal pain regimen.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Design
Single-center, retrospective

Introduction
Prior studies of enhanced recovery protocols (ERP) have been conducted at large institutions with abundant resources, which may not apply at institutions with less resources. The purpose of this study was to assess the value of a minimalistic enhanced recovery protocol in reducing length of stay (LOS) following PSF for adolescent idiopathic scoliosis.

Methods
AIS patients who underwent PSF at a tertiary pediatric hospital were reviewed. The study population was further narrowed to consecutive patients from a single surgeon's practice that piloted the modified ERP. Reservation from key stakeholders regarding the feasibility of implementing widespread protocol change led to the minimal alterations made to the postoperative protocol following PSF. Patients were divided into either the Standard Recovery Protocol (SRP) or Enhanced Recovery Protocol (ERP). Primary variables analyzed were hospital LOS, complications, readmissions, and total narcotic requirement.

Results
A total of 92 patients met inclusion criteria. SRP and ERP groups consisted of 44 (47.8%) and 48 (52.2%) patients. There was no difference between the two groups with regards to age, sex, ASA score, fusion levels, and EBL ($p>0.05$). PCA pumps were discontinued later in the SRP group (39.5 ± 4.3 hrs) compared to the ERP group (17.4 ± 4.1 hrs, $p < 0.0001$). Narcotic requirement was similar between groups ($p=0.94$) Patients in the SRP group had longer hospital stays than patients in the ERP group ($p<0.0001$). 83% of the ERP group had LOS ≤3 days compared to 0% in the SRP group, whose mean LOS was 4.2 days. There was no difference in complications between the groups (2.2% vs. 6.0%, $p=0.62$). Readmission to the hospital within 30 days of surgery was rare in either group (2 SRP patients: 1 superior mesenteric artery syndrome, 1 bowel obstruction vs. 0 ERP patients, $p=0.23$).

Conclusion
In this cohort, minor changes to the postoperative protocol following surgery for AIS led to significant decrease in hospital length of stay. This minimalistic approach may ease implementation of an ERP in the setting of stakeholder apprehension.

275. Preoperative Coronal Decompensation to the Left is not a Contraindication to Selective Fusion if Maximal Thoracic Correction is Performed

Vidyadhar V. Upasani, MD; Michael P. Kelly, MD; Samy Gabriel, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Harms Study Group; Peter O. Newton, MD

Hypothesis
Postoperative coronal imbalance after selective fusion of thoracic major curves can be improved by maximizing deformity correction.

Design
Longitudinal

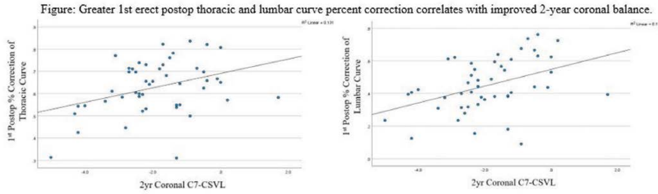
Introduction
Selective instrumentation and fusion (SF) of thoracic major curves with compensatory thoracolumbar/lumbar (TL/L) curves often results in early left-sided postop coronal imbalance (CI). While CI improves in most patients during the 1st postop year, some patients remain imbalanced to the left (> 2.5cm). The purpose of this study was to assess the radiographic outcomes after SF in AIS patients with significant left-sided preop CI to determine the variables associated with improved postop coronal balance.

Methods
A multicenter registry of surgically treated AIS cases was queried for subjects with Lenke 1-4 curves with B or C lumbar modifiers that underwent a SF with minimum 2yr follow-up. Only subjects with significant coronal imbalance (C7-CSVL) ≥ -3cm (negative value represents deviation to left) preop were included in the analysis. To determine what factors are associated with improved postop coronal balance, preop and first-erect (FE) postop radiographic variables were analyzed to determine the correlation with coronal balance at 2yr follow-up.

Results
Forty-eight subjects met inclusion. Mean age was 15±2yrs. The mean coronal imbalance preop was -3.9±2.3cm. This improved to -2.3±1.4cm at FE and -1.9±1.3cm at 2yrs. Fifteen subjects (31%) remained imbalanced at 2yrs. Better coronal balance at 2yrs postop was significantly correlated with a lower preop thoracic curve magnitude on the bending film ($r = -0.32$, $p = 0.03$), as well as the following variables at the 1st postop visit: upper thoracic curve ($r = -0.39$, $p = 0.007$), main thoracic curve ($r = -0.42$, $p = 0.003$), lumbar curve ($r = -0.41$, $p = 0.004$), % correction of the thoracic ($r = 0.362$, $p = 0.01$) and lumbar curves ($r = 0.42$, $p = 0.003$) (Figure), and coronal balance ($r = 0.42$, $p = 0.003$). LIV selection was not correlated with postop coronal balance.

Conclusion
AIS patients with major thoracic curves and compensatory TL/L curves with significant preop coronal imbalance (≥ -3cm) can be challenging to treat with a selective fusion as nearly a third of these patients remain coronally imbalanced. More flexible thoracic curves and improved coronal deformity correction moderately correlated with better coronal balance at 2 years postop.

Figure: Greater 1st erect postop thoracic and lumbar curve percent correction correlates with improved 2-year coronal balance.



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276. When is Vertebral Body Tethering in a Patient with Open Triradiate Cartilages a Good Idea?

Steven W. Hwang, MD; Amer F. Samdani, MD; Terrence G. Ishmael, MBBS; Maureen McGarry, BBE; Emily Nice, BS; Kaitlin Kirk, BS; Jason Woloff, BS; Alejandro Quinonez, BS; Joshua M. Pahys, MD

Hypothesis

VBT may be successful in patients with open triradiate cartilages (OTC) when the curves are larger or more rigid than typically ideal.

Design

Retrospective single-center

Introduction

Several VBT studies have shown a higher failure rate in patients with OTC, often from overcorrection. We sought to investigate when patients with OTC may benefit from VBT surgery.

Methods

We reviewed demographic and radiographic measures of all patients undergoing thoracic VBT with OTC with at least 2-year follow-up. Patients had pre-op, first erect, and annual x-rays thereafter. Success (Group S) was defined as curves < 35° at last follow-up without any other surgery. Failure was defined as curves ≥ 35° at last follow-up, or patients requiring reoperation. Failure was subdivided into Group Under (U: curves ≥ 35° or re-op for fusion/retethering absent of overcorrection) or Group Over (O: overcorrection curves ≥ 35° or with re-op for tether release or fusion).

Results

115 patients were identified; 64 (56%) were successful, 33 (29%) undercorrected and 18 (16%) overcorrected. Demographic and pre-op radiographic variables were similar between groups except Group U was less flexible than Group S (29 vs. 22° on bends, p<0.05) and had larger thoracic and lumbar curves (60 vs. 53° and 40 vs. 33° respectively, p<0.05). Comparing Group S to Group U, Group S had better correction of the thoracic curve on FE (28 vs. 36°, p <0.05). Patients were less likely to fail from undercorrection if they were more flexible (pre-op bends <25° OR 4.00, >60% correction on bending OR 2.83), had smaller pre-op curves (< 60° OR 2.82), or had greater initial correction (FE Cobb < 30° OR 3.49, FE % correction > 30% OR 6.00). Comparing Group S to Group O, Group S had larger lumbar curves on FE (19 vs. 12°, p <0.05) and a trend towards larger thoracic curves (28 vs. 22°, p=0.06). Operative time was longer in Group O vs. Group S (274 vs. 207 min, p=0.03), but levels instrumented and EBL were comparable (p>0.05). Patients were less likely to fail through overcorrection if the pre-op curve was >45° (p<0.03, OR 3.49), the curves were more rigid (<75% flexibility, p=0.02, OR 4.28), or they had less correction on FE (<45%, p=0.02, OR 4.64).

Conclusion

VBT in patients with OTC is still successful 56% of the time and could be improved in larger, more rigid curves or targeting less correction initially.

Demographic Information	Success	Failure - Over	Failure - Under	Success vs. Over p-value	Success vs. Under p-value
# Patients	64 (56%)	17 (15%)	34 (30%)		
Female (#)	55 (86%)	16 (94%)	29 (85%)		
Premenarchal	49 (91%)	16 (100.00%)	26 (93%)		
Average Age at Surgery (years)	11.9 ± 1.1	11.6 ± 1.1	11.5 ± 1.3	0.63	0.37
Average Years Follow Up	4.5 ± 2.1	6.0 ± 1.8	4.7 ± 2.1	0.02	0.87
Surgical Information	**Success**	**Failure - Over**	**Failure - Under**	**Success vs. Over p-value**	**Success vs. Under p-value**
Average Levels Tethered	8.0 ± 1.2	9.0 ± 2.2	8.7 ± 1.5	0.06	0.69
Average EBL (mL)	126.7 ± 261.6	148.0 ± 169.3	85.9 ± 74.3	0.93	0.63
Average OR Time (min)	207.2 ± 90.9	282.0 ± 111.3	206.7 ± 87.0	0.01	1.00
Radiographic Information	**Success**	**Failure - Over**	**Failure - Under**	**Success vs. Over p-value**	**Success vs. Under p-value**
PreOp Thoracic Cobb (°)	53.2 ± 10.2	49.5 ± 10.8	60.1 ± 8.3	0.36	<0.05
Flexibility (%)	59 ± 17%	63 ± 28%	52 ± 18%	0.80	0.14
PreOp Sanders	2.7 ± 0.5	2.7 ± 0.5	2.5 ± 0.6	0.90	0.14
Median	3	3	3		
FE Thoracic Cobb (°)	28.3 ± 11.2	21.3 ± 10.8	35.7 ± 9.2	0.06	0.01
FE % Correction	48 ± 17%	59 ± 17%	40 ± 13%	0.04	0.11
Latest Thoracic Cobb (°)	19.4 ± 10.3	15.8 ± 14.0	26.1 ± 15.3	0.53	0.04
Reoperation Information	**Success**	**Failure - Over**	**Failure - Under**	**Success vs. Over p-value**	**Success vs. Under p-value**
Number of Patients Requiring Reoperations	0 (0.00%)	17 (100.00%)	23 (67.65%)		
Total Number of Reoperations	0	19	24		
Fusion	0	2	9		
Breakage	0	0	3		
Overcorrection	0	17	0		
Adding On	0	0	9		
Progression of Curve	0	0	2		
Screw Migration	0	0	1		

277. Soft-tissue Insufficiency as a Predictor for Proximal Junctional Kyphosis and Failure in Patients with Adult Spinal Deformity *

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Hypothesis

Soft tissue health will be associated with development of Proximal Junctional Kyphosis (PJK) and failure (PJF).

Design

A prospective observational study

Introduction

Spinal soft tissues are key contributors to its stability. In adult spinal deformity (ASD), soft tissue health becomes impaired, increasing biomechanical stress at the junction of upper instrumented vertebrae (UIV) and the native spine after spinal fusion surgery. The contribution of soft tissue impairments to development of PJK (PJA) of >10deg from UIV-1 to UIV+2) and PJF (symptomatic PJK requiring revision) is unknown.

Methods

Data were collected prospectively from 73 consecutive individuals undergoing spinal fusion for ASD(>4 levels). Participants provided informed consent under an approved protocol. Demographics(age, gender, body mass index(BMI), smoking), radiograph-based alignment (proximal junctional angle;PJA, sagittal vertical axis, pelvic incidence, lumbar lordosis, pelvic tilt, PI-LL mismatch, thoracic kyphosis), bony health (DEXA, osteoporosis), MRI-based muscle health at the UIV (paraspinal fatty infiltration, cross sectional area;CSA), and biopsy-based ligament biomechanics/ biochemistry (peak force, stiffness, tensile stress/strain, collagen content, glycosaminoglycan content)were measured. Patients were monitored for 1 year for development of PJK or PJF, and measures were compared between groups.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster   * = John H. Moe Award Nominee – Best Basic Science Research Poster

Results

Mean(SD) age of participants was 67.0(13.5) years, and a majority were female (70.6%). 1-year follow up radiographs were available for 67% of participants. 28(38.4%) developed PJK within 1 year, and 10(13.6%) developed PJF. The only predictor of PJK was smaller paraspinal muscle CSA, with the PJK group demonstrating 32% smaller CSA vs those without (p=0.03). Predictors of PJF included greater pre-operative PJA (15.3(11.6) vs 7.2(6.0)deg, p=0.04), lower ligament peak force (94.8(34.7) vs 212.4(132.0)N, p<0.001), and lower BMI (23.4(2.8) vs. 26.1(5.3)kg/m2, p=0.02).

Conclusion

Paraspinal muscle atrophy is an important independent predictor of PJK, whereas pre-operative PJA, ligament strength, and BMI predicts PJF. Soft tissues should be considered when making clinical decisions for risk of PJK/PJF.

278. Mobile Device Based Surface Topography is a Better Predictor of Spinal Deformity than Scoliometer

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Hypothesis

That mobile-device based 3D scanning can accurately predict cobb angle in a population of patients being screened for AIS.

Design

cross-sectional, single center study

Introduction

Non-radiographic screening and diagnosis in adolescent idiopathic scoliosis (AIS) currently relies on scoliometer. We hypothesized that white-light based 3D scanning could generate high quality 3D representations of surface anatomy using a mobile device and would provide better deformity assessments compared to scoliometers.

Methods

Patients 10 to 18 years old presenting to an outpatient pediatric orthopaedic clinic with scoliosis radiographs within 30 days of the visit for evaluation of AIS were approached for the study. 3D scans were taken in the upright and forward bend positions. Image processing software was used to make 3D measurements of trunk shift (TS), coronal balance (CB), and clavicle angle (CL) in upright position and largest angle of trunk rotation (ATR) as detected in the lumbar and thoracic spine in bending position. 3D trunk shift, coronal balance, clavicle angle were compared to their analogous radiographic measurements. 3D ATR and ATR as measured by a scoliometer (SM) were correlated to major curve magnitude (MCM). Multivariable regressions models were created to predict likely hood of coronal cobb angle>20 based on BMI and 3D measurements vs BMI and scoliometer. Model fit was compared using Akaike information criterion (AIC).

Results

312 visits representing 258 patients were included. Mean age =was 13.7 years mean coronal MCM was 19.8+/- 13.0° for lumbar curves and 22.1+/-15.3° for thoracic curves. There was a significant correlation between 3D and radiographic CL (r = 0.65), TS (r = 0.8), and CB (r = 0.8) (p < 0.001). Correlations between cobb angle and ATR were higher for 3D lumbar ATR (r = 0.63) than scoliometer lumbar ATR (r = 0.39). Similarly, correlations between cobb angle and ATR were higher for 3D thoracic ATR (r = 0.65) than scoliometer thoracic ATR (r = 0.46). A Multivariable regressions model predicting cobb>20 including 3D data outperformed a model based on scolimeter data (AIC=206 vs 237).

Conclusion

Mobile device based 3D scanning identifies clinically relevant scoliotic deformity and is a better predictor of major curve magnitude than scoliometer measurements.

279. Staging Three Column Osteotomies: Does It Make A Difference?

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Hypothesis

Clinical and radiographic outcomes are similar when comparing single to staged three-column osteotomies (3CO).

Design

Retrospective single-center

Introduction

Three column osteotomies (3CO) are complex surgeries associated with significant risks. Anecdotally, staging 3CO is less stressful on the surgeon but involves a second anesthesia and prolonged overall stay for patients. We sought to investigate if staged 3CO are associated with comparable clinical and radiographic outcomes as single surgery 3CO.

Methods

We reviewed demographic, radiographic and clinical parameters of patients undergoing 3CO for spinal deformity. Variables were recorded pre-op, post-op and at last follow-up. Patients were grouped into staged (multiple) and single procedure groups. Graphpad Prism was used to compute student's t-tests, ANOVA tests, X-squared tests, and Fisher's Exact tests.

Results

29 patients underwent 3CO with a mean follow-up of 5 years; 19 were staged and 10 were single surgeries. Mean age was 12 years and 51% (17) were male. Mean coronal deformity angular ratio (DAR) was 15 in the staged group and 10 in the single procedure group. The mean pre-op coronal curve for staged patients was 66° which corrected to 29° (56% correction, p<0.05), while the mean pre-op coronal curve for single procedure patients was 36° which corrected to 18° (50% correction, p<0.05). Staged procedures achieved greater correction (37 vs. 18°, p<0.05). OR time and EBL were greater for the staged procedures (890 mins/2092 ml vs. 463 mins/1195mL, p<0.05); however, the 2nd

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

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stage/3CO of the staged procedures had similar OR time and EBL to single surgery. Intraoperative neuromonitoring (IONM) changes occurred in 26% (5) of the staged cases and in 20% (2) of the single stage cases (p>0.05). There was no difference in revision rates between the two groups. There were 4 (21%) complications in the staged group (1 excessive blood loss, 1 wound dehiscence, 1 SMA syndrome and 1 neurological injury) and 4 (40%) in the single procedure group (2 wound dehiscence, 1 neurological injury, 1 blister from prone position).

Conclusion

A staged approach to 3CO has comparable radiographic outcomes to single event surgery and may have fewer complications.

	Whole Group (n=29)	Staged - Part 2 (n=19)	Single Surgery (n=10)	P-value
Demographics				
Age (years)(SD)	12 (5)	13 (3)	11 (5)	0.16
Time to last F/U (years)	5 (2)	5 (2)	5 (3)	0.93
Male	17/33 (51%)	7/19 (37%)	7/10 (70%)	0.13
BMI (kg/m^2)	20 (5)	21 (4)	21 (5)	0.99
Blood Loss (mL)	988 (883)	1195 (994)	857 (645)	0.34
OR Time (min)	446 (104)	463 (86)	499 (115)	0.36
Radiographic				
DAR	13 (6)	15 (5)	10 (8)	0.06
Pre-op Major Cobb (°)	52 (29)	66 (31)	36 (32)	p<0.05
Post-op Major Cobb (°)	29 (26)	36 (26)	25 (30)	p<0.05
Major Cobb - Last Follow-up (°)	23 (21)	29 (21)	18 (24)	p<0.05
Pre-op Sagittal Kyphosis (°)	55 (32)	62 (33)	61 (34)	p<0.05
Post-op Sagittal Kyphosis (°)	43 (21)	48 (22)	36 (22)	p<0.05
Sagittal Kyphosis - Last Follow-up (°)	39 (22)	44 (23)	37 (22)	p<0.05
Outcomes				
IONM Changes	7/33 (21%)	5/19 (26%)	2/10 (20%)	0.99
Major Complications	4/33 (12%)	4/19 (21%	4/10 (40%)	0.39
Revision	3/33 (9%)	3/19 (16%)	4/10 (40%)	0.19

280. Is Preoperative Hip Status Associated with Outcomes of Posterior Spinal Fusion in Patients with Cerebral Palsy?

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Hypothesis

Preoperative hip status is associated with outcomes of PSF in patients with CP.

Design

Retrospective review of prospective multicenter registry

Introduction

Neuromuscular hip dysplasia is common in children with cerebral palsy (CP) and often occurs concurrently with spinal deformity. The purpose of this study is to examine the impact of baseline hip status as a predictor of surgical outcomes in patients with CP undergoing PSF for scoliosis.

Methods

We performed a retrospective review of a prospective multicenter registry of CP patients (GMFCS IV &V) with scoliosis treated with PSF and a minimum 2 year follow-up. Baseline characteristics such as hip status (normal, subluxed, dislocated and resected), demographics, GMFCS level and deformity measures were compared. Operative outcomes were evaluated by estimated blood loss, operative time, and construct size. Postoperative complications were also assessed and quality of life (QOL) measures evaluated.

Results

326 patients were evaluated. There were 23% GMFCS IV and 77% GMFCS V. GMFCS level IV patients were more likely to have normal hips (70% vs. 56%, p < 0.05) and less likely to have resected hips (5% vs. 15%, p < 0.05). Pre-op pelvic obliquity was lowest in normal hips (26° vs. 29° p<0.05), while preoperative Cobb angle was highest in dislocated hips and lowest in normal hips (96° and 80°, p < 0.05). Length of stay was similar for all patients. Patients with resected hips had more complications. Preoperative QOL scores were the lowest in activity of daily living and health domains in patients resected hips; comfort and emotions in dislocated hips and overall QOL was highest in normal hips. At 2 and 5 years, dislocated hip status was associated with greater percentage of major curve correction (61% and 65%, p< 0.05), in addition to lowest in positioning, transferring, and mobility at 2 years. At 5 years, patients with normal hips were found to have the highest scores in the health domain of the QOL measure.

Conclusion

Patients with abnormal hips had longer operating times, increased blood loss, higher rates of complications, and better correction than those with normal hips. While these findings suggest that pre-op hip status may be associated with better operative outcomes, deformity correction, and QOL measures, it is likely that these differences are as a result of more severe overall disease as opposed to a direct association.

Table 1 Variables	Total Cohort (n=326)	Normal Hip (n=194, 59.5%)	Subluxed Hip (n=60, 18.4%)	Dislocated Hip (n=39, 12.0%)	Resected Hip (n=41, 12.6%)
Demographics					
Female	159 (48.8%)	96 (49.5%)	1 (1.7%)	15 (38.5%)	19 (46.3%)
Male	167 (51.25)	98 (50.5%)	59 (98.3%)	24 (61.5%)	22 (53.7%)
Age at Surgery	13.6 (±2.8)	**13.8 (±2.6)***	13.2 (±3.2)	13.6 (±3.2)	12.5 (±2.6)*
GMFCS Level IV	76 (23.3%)	**53 (27.3%)***	15 (25%)	6 (15.4%)	**4 (9.8%)***
GMFCS Level V	250 (76.7%)	**141 (72.7%)***	45 (75%)	33 (84.6%)	**37 (90.2%)***
Variables	Total Cohort Mean (St. Dv.)	Normal Hip Mean (St. Dv.)	Subluxed Hip Mean (St. Dv.)	Dislocated Hip Mean (St. Dv.)	Resected Hip Mean (St. Dv.)
Pelvic Obliquity	27.8 (±15.0)	**26.4 (±15.4)***	28.3 (±14.5)	31.9 (±15.2)	30.7 (±13.3)
Major Cobb Angle	83.1 (±23.4)	**80.0 (±22.6)***	84.3 (±26.5)	**95.7 (±26.9)****	85.6 (±20.3)
Operation Time (minutes)	406.6 (±152.3)	**379.2 (±133.8)****	439.8 (±165.3)	**520.8 (±215.9)****	411.2 (±121.5)
Estimated Blood Loss (CCs)	1534.4 (±1195.2)	**1422.1 (±1124.9)***	1453.9 (±1216.1)	1870.8 (±1290.4)	**1925.9 (±1304.4)***
Variables	Total Cohort Mean (St. Dv.)	Normal Hip Mean (St. Dv.)	Subluxed Hip Mean (St. Dv.)	Dislocated Hip Mean (St. Dv.)	Resected Hip Mean (St. Dv.)
2 Year Postoperative Coronal Measure of Major Curve Cobb Angle Correction (% of Correction)	53.3 (±20.1)	**50.8 (±19.4)***	54.9 (±21.8)	**60.8 (±23.6)***	56.9 (±17.5)
5 Year Postoperative Coronal Measure of Major Curve Cobb Angle Correction (% of Correction)	52.8 (±21.0)	51.6 (±21.1)	46.3 (±21.4)	**65.1 (±19.8)***	54.7 (±16.0)
Preoperative Visit					
Activities of Daily Living	38.1 (±16.6)	37.2 (±16.5)	36.7 (±15.2)	37.0 (±18.89212)	**45.1 (±15.2)***
Comfort & Emotions	72.4 (±22.2)	73.8 (±22.2)	72.9 (±20.3)	**64.5 (±25.7)***	70.3 (±21.0)
Health	54.7 (±20.0)	55.7 (±19.7)	55.5 (±20.8)	55.8 (±21.4)	**48.3 (±18.9)***
Overall QOL	61.9 (±23.7)	**64.4 (±23.6)***	58.3 (±23.6)	56.1 (±26.1)	59.5 (±21.0)
2 Year Postoperative Visit					
Positioning, Transferring & Mobility	42.2 (±17.4)	42.3 (±17..0)	43.7 (±15.7)	**35.5 (±21.0)***	45.7 (±18.8)
Overall QOL	71.4 (±22.2)	73.2 (±22.4)	74.8 (±20.5)	65 (±22.12)	**64 (±22.1)***
5 Year Postoperative Visit					
Health	59.2 (±19.9)	**61.9 (±19.8)***	**49.3 (±20.3)***	54.5 (±19.5)	56.2 (±17.1)

* Denotes statistical significance evaluated at P < 0.05.

** Denotes statistical significance evaluated at P < 0.001.

281. Optimizing Modifiable Health Conditions Prior to Adult Cervical Deformity Surgery Associated with Fewer Complications

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Hypothesis

To determine effects of pre-operatively optimizing modifiable health conditions on perioperative and postoperative outcomes in operative cervical deformity patients

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Design
Retrospective

Introduction
While benefits to surgical outcomes from optimizing comorbidities prior to surgical adult cervical deformity correction (ACD) is hypothesized, this has not yet been studied.

Methods
ACD patients up to 2-year data were included. Preoperative optimization for osteoporosis was assessed by treatment with an FDA approved drug prior to surgery. Patients were divided into 2 groups: those who had preoperative rehabilitation [Prehab] and those who did not [no Prehab]. Prehab consisted of cognitive behavioral therapy and physical therapy with core, paraspinal and leg strengthening. Nutritional status assessed by ranking patients into quartiles (Q1-Q4) by baseline BMI. Q1 (low BMI) and Q4 (high BMI) were considered not optimized. Patients stratified by optimization in all three groups (Opt) or non-optimized. ANCOVA and logistic regression analyses assessed outcomes while accounting for surgical and demographic differences between groups.

Results
547 (average 57.9±12.1 years, 48% female, 29.0±6.82 kg/m2) included. Optimized patients had fewer levels fused (4.14±3.50 vs. 5.21±4.15, p=.002), shorter length of stay (3.96±3.94 vs. 5.12±8.18 days, p=.044), less operative time (261.9±166.6 vs. 315.8±189.7 mins, p=.002), and lower EBL (502.8±950.6 vs. 679.0±965.5 mL, p=.039). Optimized patients trended towards being younger (p=.199) and having fewer osteotomies (p=.314) but this was not significant. When comparing means for perioperative outcomes and cost, optimized patients experienced fewer minor complications (9.12% vs. 16.5%, p=.010. However, optimized patients were similar to not optimized patients when comparing mean rate of reoperations and reaching MCID for mJOA at 2 years (all p>.05). A stepwise regression model was significant higher odds of reaching MCID for NDI for optimized patients when controlling for gender, levels fused, operative time, and EBL (OR: 1.406 [1.169-1.691], p<.001. Optimized patients had lower odds of overall complications at 2 years (OR:.45 [1.02, 1.89], p=.009) with lower rates of DJK and DJF development (p<.05).

Conclusion
Patients undergoing corrective cervical deformity surgery benefit from preoperative optimization, emphasizing its importance in surgical planning.

282. Lumbar Vertebral Body Tethering: Outcomes and Reoperations in a Consecutive Series of 106 Patients

Amer F. Samdani, MD; Joshua M. Pahys, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Maureen McGarry, BBE; Jason Woloff, BS; Emily Nice, BS; Kaitlin Kirk, BS; Terrence G. Ishmael, MBBS; Steven W. Hwang, MD

Hypothesis
Lumbar VBT results in improvement in coronal curve measurement with the majority of patients avoiding a spinal fusion.

Design
Single center retrospective

Introduction
Anterior vertebral body tethering (VBT) is a viable option for children with idiopathic scoliosis. However, the promise of motion preservation offsets with the known increased reoperation rate. Maintenance of lumbar motion offers significant benefit over VBT for the thoracic region. However, a paucity of reports have addressed lumbar VBT.

Methods
A retrospectively collected data set was queried for all patients who underwent lumbar VBT (LIV 3 or 4) with minimum 2 years of follow-up. Clinical and radiographic parameters were collected including reoperations. Statistical analysis was performed utilizing students t test.

Results
From a dataset of 551 patients, we identified 106 patients (89% female) who underwent a lumbar VBT (33 lumbar only, 73 bilateral thoracic/lumbar) with mean follow up of 4.1 ± 1.6 years at which point 85% (90/106) reached skeletal maturity. Preoperatively, these patients were skeletally immature (age 12.8 ± 1.3 years, Sanders 3.3 ± 0.8, R=0.6 ± 0.9) with a lumbar coronal curve angle of 49.6° ± 11.2° which corrected to 19.9° ± 11.2° (p <0.0001) at most recent follow-up. At latest follow-up, 84% (89/106) of patients had a coronal curve angle < 35°. 20 patients (18.9%) underwent 23 reoperations with overcorrection being the most common cause (10/23, 43%). Broken tethers led to reoperation in 3 instances (3/23, 13%). Six patients in the cohort needed a PSF (6/106, 5.4%).

Conclusion
Vertebral body tethering has emerged as a viable treatment option for skeletally immature patients with idiopathic scoliosis. The high reoperation rate must be balanced with motion preservation, which is paramount in the lumbar spine. This report is the largest known for lumbar VBT highlighting 84% of patients with a curve of < 35° at latest follow-up, but with an 18.9% reoperation rate. Surgeons can use these data to ensure that patients make an informed decision regarding treatment options.

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Demographic Information	
Total Number of Lumbar Tethers	106
Number of Bilateral Thoracic and Lumbar Tethers	73
Number of Single Lumbar Tethers	33
Number of Females	94 (88.68%)
Premenarchal	54 (57.45%)
Average Age at Surgery	12.75 ± 1.27
Average Months Follow Up	4.10 ± 1.55
Average Pre-op Risser	0.62 ± 0.91
Average Pre-op Sanders	3.28 ± 0.83
% Triradiates Closed	76 (71.70%)
Average % Correction Thoracic	56.11% ± 18.49%
Average % Correction Lumbar	68.94% ± 22.54%
Latest Thoracic <35° and not fused	78 (73.58%)
Latest Lumbar <35° and not fused	89 (83.96%)
Radiographic Information	
Average Pre-op Proximal Coronal Curve	18.39 ± 10.12
Average Pre-op Thoracic Coronal Curve	47.78 ± 12.60
Average Pre-op Lumbar Coronal Curve	49.61 ± 11.18
Average FE Proximal Coronal Curve	15.98 ± 8.34
Average FE Thoracic Coronal Curve	26.63 ± 9.78
Average FE Lumbar Coronal Curve	18.73 ± 9.97
Average Latest Proximal Coronal Curve	13.83 ± 7.64
Average Latest Thoracic Coronal Curve	25.55 ± 11.32
Average Latest Lumbar Coronal Curve	19.86 ± 11.15
Reoperation Information	
Number of Patients Requiring Reoperations	20 (18.87%)
Total Number of Reoperations	23
Overcorrection	10
Fusion	6
Breakage	3
Progression of Curve	2
Adding On	1
Post Fusion I&D	1

283. Effects of BMP-2 Treatment on Human Nucleus Pulposus Cells Following Mechanical Stimulation *

Adwin Denasty, MD; Karim Elmobdy, BA; Addisu Mesfin, MD

Hypothesis

Direct administration of BMP-2 to intervertebral discs cells results in increased production of anabolic components in the extracellular matrix (ECM) of the disc which may help reverse the changes seen in Intervertebral Disc Disease (IDD).

Design

In-vitro cell study

Introduction

Our objective was to 1) utilize an in-vitro experiment to model IDD conditions acutely with mechanic compression of human Nucleus pulposus (hNP) cells 2) evaluate the effects of direct administration of BMP-2 on hNP cells post-mechanical compression.

Methods

Confluent hNP cells were centrifuged to mimic mechanical stress (compression) similar in IDD. The cells were divided into two experimental groups based on the magnitude of mechanical stress applied and were labeled “weak” (F=20g/cm2) and “strong” (F=40g/cm2). Varying concentrations of BMP-2 were then administered to uncompressed hNP cells to evaluate a dose response and find the optimal concentration for treatment. Lastly, uncompressed cells were again centrifuged at “weak” or “strong” forces and then treated with 50 ng of BMP-2. RNA was collected for all experimental groups at 0 min, 24-hr, and 48-hour post treatments. Gene expression of the above markers was evaluated via real-time RT-PCR.

Results

After the cells were spun and treated with BMP-2, the results show that the fold change for ACAN gene expression was 0.28 at weak and 0.24 at strong centrifugal force after 24 hrs and 0.12 at weak and 0.04 at strong centrifugal force after 48 hrs. The fold change for MMP9 gene expression was 0.06 at weak and 0.02 at strong centrifugal force after 24 hrs and 0.06 at weak and 0.03 at strong centrifugal force after 48 hrs. Gene expression for both anabolic and catabolic ECM markers showed a decrease from 24 to 48 hours. All values were decreased when compared to control(1.0).

Conclusion

Based on our results we can conclude that, acute BMP-2 administration was not sufficient to rescue cells post mechanical compression. However, catabolic gene expression (MMP-9) was also decreased when compared to control, BMP-2 administration caused further downregulation of the catabolic signaling post mechanical compression. The summation of these results shows that BMP-2 shifted the balance towards anabolic signaling with acute BMP-2 administration to mechanically damaged (compressed) cells, demonstrating that BMP/SMAD signaling pathway is therapeutic target to restore disc composition and function in IDD.

284. Does Multidisciplinary Team Approach Improve Patient Outcomes: Impact of High Risk Committee Inclusion on Adult Spinal Deformity Patient Outcomes

Pooja Dave, BS; Jamshaid Mir, MD; Peter Tretiakov, BS; Virginie Lafage, PhD; Renaud Lafage, MS; _Peter G. Passias, MD_

Hypothesis

investigate impact of high risk multidisciplinary committee on ASD patient outcomes after corrective surgery

Design

Retrospective

Introduction

High risk committees have recently been instituted at many hospitals, in an effort to minimize operative risk and recruit a multi-disciplinary discussion. Little consensus has been reached as to whether inclusion into high risk committees improve patient outcomes.

Methods

Operative ASD patients with 2-year data were included. Multidisciplinary Committee (HRC) criteria: BMI > 40; HgbA1c >8; Severe Scoliosis (>75 degrees); Severe Kyphosis (> 75 degrees); Anterior-posterior cervical fusion 3+ level; Anterior-posterior lumbar fusion 4+ levels; 8+ Level Instrumented Fusion; 3 Column Osteotomy, Vertebrectomy, and/or ACR; Revision of Anterior Approach to Same Level; Severe Myelopathy; Severe Osteoporosis. Patients stratified by high risk (HRC) vs not meeting criteria then propensity score matched by baseline CCI. Multivariable regression controlling for baseline deformity and frailty index assess rates of complications and revision surgery.

Results

483 met inclusion (64.5yrs±9.0, 78%F, BMI: 27.9 kg/m2 ±6.0, CCI: 1.9 ±1.7), 331 meeting HRC inclusion after matching. NHRC was more deformed in SVA (69.6 vs. 52.9mm, p=.003), PI-LL

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

(18.4° vs. 12.3°, p<.001), and PT (25.3° vs. 22.0°, p<.001), with increasing surgical invasiveness score (p<.001). HRC were significantly more likely to have a history of heart disease and myocardial infarction (OR 1.45 [1.43, 1.99], p=.04). NHRC were more likely to undergo any osteotomy (OR 1.87 [2.1, 2.77] p=.020) or 3CO (p=.045), although length of stay, SICU admissions, and discharge to rehabilitation center were comparable between groups (all p>.05). Both groups had comparable rates of mortality (p>.05). Not meeting HRC had higher rates of major (20% vs 9%), mechanical (20% vs 10%), and overall complications (65% vs 48%, all p<.05). Importantly, patients with HRC had significantly greater chances of experiencing cardiopulmonary complications 90 days after surgery (OR 2.33 [1.01, 1.68], p<.05).

Conclusion

Our study found high risk committee favored patients with less severe deformity without medical comorbidities, thus reducing the overall complexity of cases operated. Surgical planning preoperatively should focus instead on medical optimization through greater collaboration with non-surgical physicians.

285. How Low Should You Go? Is L3 or L4 More Protective Against Failure and Adding-On in Thoracolumbar Anterior Vertebral Body Tethering

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Hypothesis

A lower instrumented vertebra (LIV) of L4 vs. L3 will reduce the rate of adding-on and curve progression in thoracolumbar anterior vertebral body tethering (T/L VBT) for adolescent idiopathic scoliosis (AIS).

Design

Retrospective, single center study

Introduction

There is minimal data on the outcomes and best practices for T/L VBT in AIS. We sought to investigate the differences in surgical outcomes for T/L VBT when the LIV is L3 vs. L4.

Methods

All AIS patients who underwent T/L VBT at our institution with an LIV of L3 or L4 and a minimum 2-year follow-up were reviewed. Demographic data and preop, first erect, and radiographs every 6-12 months thereafter were reviewed. The lumbar Cobb of the tethered portion and the lumbar maximum measured coronal (MMC) Cobb were recorded at each time point.

Results

There were 88 patients with LIV=L3 LIV group (L3) vs. 18 with LIV=L4 (L4). Bilateral VBT was performed in 59/88 (67%) for L3 and 14/18 (78%) for L4, p=0.4. The mean preop thoracic and lumbar coronal curve magnitude, age, menarche status, Sanders score, and percentage of patients with open triradiate cartilage (TRC) was similar for both groups (p>0.1). There was no difference in blood loss or operative time between both groups (p>0.2). Reoperation rates were similar in both groups L3 (17%) vs. L4 (28%), p=0.3. The L3 group demonstrated a higher rate of adding-on and progression of the lumbar MMC Cobb, which was significantly larger than the lumbar Cobb of tethered portion (23.2° vs. 19.2°, p<0.0001) at latest follow-up. While L4 had a smaller difference between the lumbar MMC Cobb and the lumbar Cobb of tethered portion (16.8° vs. 15.8°, p=0.04) at latest follow-up. The latest lumbar MMC Cobb was larger than the tethered lumbar Cobb in 55/88 (63%) of L3 group vs. 8/18 (44%) of L4 group, p=0.03.

Conclusion

This study demonstrated no significant difference in operative time and blood loss when the LIV for thoracolumbar VBT was L4 vs. L3. However, the LIV=L3 group had a larger rate of adding on and maximum measured lumbar curve progression compared to the L4 group. While reoperation rates were similar, no patient in the L4 group required a fusion to date. Thus, a more caudal LIV of L4 may be potentially more protective against curve progression and adding-on if L3 is not the last substantially touched vertebra in thoracolumbar VBT.

Demographic Information	L3	L4	p-value
Total Number of Lumbar Tethers	88	18	
Number of Bilateral Tethers	59	14	0.42
Number of Lumbar Only Tethers	29	4	0.42
Number of Females	79 (89.7%)	15 (83.3%)	0.42
Premenarchal	46 (58.2%)	8 (53.3%)	0.07
Average Age at Surgery	12.7 ± 1.2	13.0 ± 1.4	0.36
Average Years Follow Up	4.3 ± 1.5	3.24 ± 1.38	0.01
Surgical information	**L3**	**L4**	
Average Levels Tethered	9.9 ± 2.3	11.3 ± 2.3	0.02
Average Estimated Blood Loss	182.4 ± 229.9	111.4 ± 70.9	0.20
Average Operative Time	333.7 ± 101.9	364.1 ± 102.3	0.25
Radiographic Information	**L3**	**L4**	
Mean PreOp Thoracic Cobb (°)	46.9 ± 11.9	52.2 ± 15.4	0.11
Mean PreOp Lumbar Cobb (°)	48.8 ± 10.6	53.3 ± 13.6	0.13
PreOp Sanders median	3	3	0.80
Percentage patients with Open Triradiate Cartilage	24 (27.2%)	6 (33.3%)	0.58
Mean Latest Thoracic Cobb (°)	26.3 ± 9.4	26.6 ± 13.9	0.55
Mean Latest Lumbar Cobb (°)	18.6 ± 10.1	18.9 ± 12.9	0.87
Outcomes	**L3**	**L4**	
Latest Coronal Cobb of Tethered Portion (°)	19.2 ± 16.2	15.8 ± 18.1	0.46
Latest Maximum Measured Coronal Cobb (MMC) (°)	23.2 ± 17.1	16.8 ± 20.1	0.64
Patients with larger MMC than Tethered Portion	55 (62.5%)	8 (44.4%)	0.03
Patients with Overcorrection	13 (14.7%)	6 (33.3%)	0.09
Reoperation Information	**L3**	**L4**	
Number of Patients Requiring Reoperations	15 (17.05%)	5 (27.78%)	0.32
Fusion	6	0	
Breakage	2	1	
Overcorrection	6	4	

286. Evaluation of Pulmonary Function after Halo-pelvic Traction for Extremely Severe and Rigid Kyphoscoliosis Utilizing Computed Tomography with 3D Reconstruction

Yong Hai, MD, PhD

Hypothesis

For individuals with severe and rigid scoliosis, more accurate and objective radiographic indicators of pulmonary function are necessary to assess treatment outcomes and estimate respiratory volume.

Design

This is a retrospective study.

Introduction

A total of 28 patients with severe and rigid scoliosis complicated

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by pulmonary dysfunction who were treated with preoperative HPT between December 2019 and December 2022 were retrospectively reviewed. Patients were treated with preoperative HPT between December 2019 and December 2022 were retrospectively reviewed. Radiographic and clinical data were collected and evaluated by two senior spine surgeons. Demographic data included sex, age, body mass index (BMI), diagnosis, height before and after traction, and duration of traction.

Methods

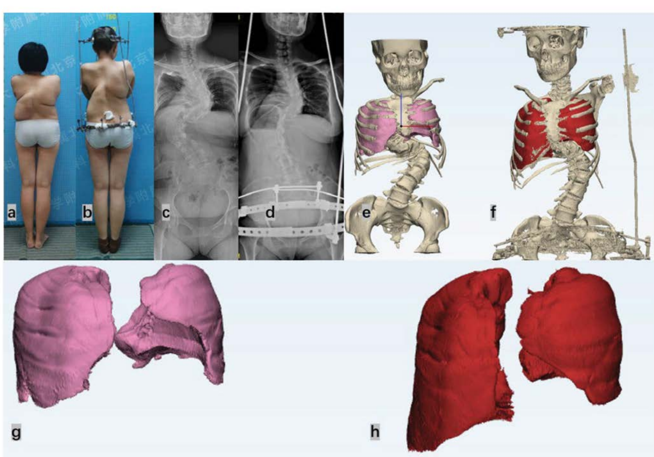
Twenty-eight patients with severe and rigid scoliosis (Cobb's angle >100°) underwent preoperative HPT and staged posterior spinal fusion. Computed tomography, radiographic assessment, and pulmonary function tests (PFTs) were included in pre- and post-traction visits. The changes in total lung volume were evaluated utilizing 3D computed tomographic reconstruction and the changes in pulmonary function were evaluated by PFT at each time point. Differences were statistically analyzed.

Results

None of the patients had pulmonary complications during the traction, and all radiographic spinal measurements improved significantly after HPT. The main Cobb angles were corrected from 143.30° ± 20.85° to 62.97° ± 10.83° between pre- and post-traction. Additionally, the distance between C7–S1 were lengthened from 280.48 ± 39.99 mm to 421.26 ± 32.08 mm between pre- and post-traction. Furthermore, 3D lung reconstruction analysis demonstrated a notable increase in total lung volume (TLV) (1.30 ± 0.25 L–1.83 ± 0.37 L) and maximum lung height (176.96 ± 27.44 mm–202.31 ± 32.45 mm) between pre- and post-traction. Moreover, PFTs showed improvement in total lung capacity (TLC) from pre- to post-traction (2.06 ± 0.32 L–2.98 ± 0.82 L), while ΔT1–T12 distance and Δmaximum lung height were correlated with changes in TLV (p = 0.0288 and p = 0.0007, respectively).

Conclusion

The application of HPT is a safe and effective method for improving pulmonary function in extremely severe and rigid scoliosis (SRS) before the final fusion surgery.



287. Preserving Pulmonary Function in Mini Open Thoracoscopic Assisted Vertebral Body Tethering

Camryn Myers, BS; Abel De Varona-Cocero, BS; Fares Ani, MD; Constance Maglaras, PhD; Juan Carlos Rodriguez-Olaverri, MD

Hypothesis

Mini-open thoracoscopic assisted vertebral body tethering (VBT) maintains pulmonary function at two year follow up.

Design

Single center retrospective cohort study.

Introduction

There are two ways to approach the spine in vertebral body tethering. Mini open thoracoscopic assisted and thoracoscopic. This study focuses on preoperative and 2 year follow up pulmonary function tests for mini open thoracoscopic assisted vertebral body tethering surgical cases. Currently there is evidence that pulmonary function does not decrease in a thoracoscopic approach. The purpose of this study is to provide evidence that mini open thoracoscopic assisted VBT surgery also maintains pulmonary function at two years follow up.

Methods

A retrospective review of patients who underwent mini open thoracoscopic assisted VBT surgery. Preoperative and 2 year follow up pulmonary function tests were performed in order to assess the pulmonary risks of VBT. Forced vital capacity (FVC), forced expiratory volume during the first second (FEV1), forced expiratory flow during the middle half of the FVC (FEF25-75%), peak expiratory flow (PEF), forced expiratory time (FET100%), forced inspiratory vital capacity (FIVC), total lung capacity (TLC), vital capacity (VC), and respiratory volume (RV) were the pulmonary function tests used to measure pulmonary function.

Results

114 patients who underwent mini open thoracoscopic assisted VBT surgery were included in this study. Pulmonary outcomes analysis revealed there were no significant decreases from preoperative to two year follow up in pulmonary function: FVC predicted (3.51 v 3.53, p=0.92), FVC Pre (3.01 v 3.02, p=0.933), FEV1 Predicted (3.11 v 3.27, p=0.349), FEV1 Pre (2.55 v 2.48, p=0.667), FEV1/FVC Predicted (88.34 v 88.88, p=0.604), FEV1/FVC Pre (77.32 v 84.89, p=0.148), FEF25-75 Predicted (3.64 v 3.81, p=0.494), FEF25-75 Pre (2.57 v 2.59, p=0.919), ISOFEF25-75% Pre (2.65 v 2.79, p=0.822), FEF75-85% Pre (1.41 v 1.36, p=0.93), PEF Predicted (6.21 v 6.79, p-0.145), PEF Pre (5.42 v 5.24, p-0.737), FET100% Pre (6.13 v 6.23, p=0.915), FIVC Predicted (3.3 v 3.32, p=0.963), FIVC Pre (2.72 v 2.2, p=0.073), TLC (4.29 v 5.56, p-0.233), VC (3.93 v 3.19, p-0.781), RV (0.76 v 1.31, p-0.258).

Conclusion

Mini open thoracoscopic assisted VBT maintains pulmonary function outcomes from baseline to two year follow up. This can be another approach option for VBT surgery.

Table 1: Preoperative vs. 2 Year Follow Up (FU) Pulmonary Function Tests for Mini Open Thoracoscopic Assisted Vertebral Body Tethering

	Preoperative PFT Scores	2 Year FU PFT Scores	P-Value
Pulmonary Function Test			
FVC Predicted (L)	3.51 ± 0.604	3.53 ± 0.629	0.92
FVC Pre (L)	3.01 ± 0.407	3.02 ± 0.746	0.933
FEV1 Predicted (L)	3.11 ± 0.512	3.27 ± 0.323	0.349
FEV1 Pre (L)	2.55 ± 0.255	2.48 ± 0.605	0.667
FEV1/FVC Predicted (%)	88.34 ± 2.461	88.88 ± 2.723	0.604
FEV1/FVC Pre (%)	77.32 ± 19.89	84.89 ± 6.035	0.148
FEF25-75 Predicted (L/sec)	3.64 ± 0.851	3.81 ± 0.277	0.494
FEF25-75 Pre (L/sec)	2.57 ± 0.518	2.59 ± 0.682	0.919
ISOFEF25-75% Pre (L/sec)	2.65 ± 0.628	2.79 ± 0.730	0.822
FEF75-85% Pre (L/sec)	1.41 ± 0.774	1.36 ± 0.470	0.93
PEF Predicted (L/sec)	6.21 ± 0.474	6.79 ± 0.699	0.145
PEF Pre (L/sec)	5.42 ± 0.990	5.24 ± 1.098	0.737
FET100% Pre (sec)	6.13 ± 1.721	6.23 ± 1.411	0.915
FIVC Predicted (L)	3.30 ± 0.436	3.32 ± 0.497	0.963
FIVC Pre (L)	2.72 ± 0.390	2.20 ± 0.493	0.073
TLC	4.29 ± 1.57	5.56 ± 0.335	0.233
VC	3.93 ± 1.676	3.19 ± 0.584	0.781
RV	0.76 ± 0.605	1.31 ± 0.375	0.258

288. The Long-Term Outcomes and Revision Strategies of Patients Treated for Adolescent Idiopathic Scoliosis with Harrington Rod Instrumentation: A Systematic Review

Tyler K. Williamson, MS, BS; Virginie Lafage, PhD; Peter G. Passias, MD

Hypothesis

Patients treated with Harrington rod instrumentation(HRI) for adolescent idiopathic scoliosis(AIS) present unique considerations during medical assessment and preoperative planning when undergoing revision.

Design

Systematic Review

Introduction

As patients treated with HRI are currently presenting as elderly adults, it is critical to evaluate the medical and surgical considerations of this prevalent population.

Methods

PubMed was searched through January 2023 for studies in which patients underwent HRI for AIS and outcomes and/or surgical techniques utilized during revision greater than 15 years following primary instrumentation were assessed. Complication rates, clinical outcomes, reoperation rates, and radiographic outcomes were recorded. Articles were evaluated for risk of bias and strength of evidence assessments.

Results

23 outcomes studies involving 3,145 patients were included. Patients suffered higher rates of adjacent segment disease (22-57.7%), with changes at the most distal unfused level correlating to lumbar pain at 25 years. An LIV at L4 or distal was associated with a higher rate of revision compared to those more proximal(36% vs. 13%), with greater curve progression than contemporaneous operative treatments. Long-term quality of life was not affected overall compared to non-instrumented fusion, bracing, or controls, but was deemed inferior when in the presence of residual sagittal malalignment(PI-LL>9 or SVA>50mm). HRI did not affect childbearing status nor increase metal ion accumulation, but was associated with impaired sexual function, minor birthing complications, and decreased ventilation capacity. 6 studies examining revision techniques for 65 patients treated with HRI were included, with recommendations given based on spine flexibility and construct integrity.

Conclusion

Moderate evidence exists regarding the long-term outcomes of Harrington rod instrumentation, with insufficient evidence providing recommendations for revision strategies. Although quality of life improvement was similar when compared other interventions, adjacent segment changes drive the higher revision rates, especially in those with primary instrumentation in the distal lumbar spine. Future research should detail the radiographic and medical characteristics of patients treated with HRI and highlight their experience to assess and treat this unique population.

289. Juvenile Scoliosis in A Competitive Gymnast: How to Maintain their Flexibility

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

Hypothesis

Posterior-based spinal tethering is a safe alternative for a juvenile kyphoscoliosis athlete

Design

Case Report

Introduction

Patient is a 9 year old with juvenile scoliosis who is a competitive gymnast with a progressive 50° curve from L1 to L5. Lateral XR showed preoperative kyphosis of 4°. Patient is a Risser 0 and has failed conservative management. Possible options presented from an outside institution were modified bracing, selective thoracic fusion, with bracing of the lumbar spine, or MCGR. Patient was looking for a treatment that would allow for her to return to competition as soon as possible. Standard PSF would significantly impact her growth and put her at risk of crankshafting. For these reasons, a posterior based, minimally invasive growth tether modulation was recommended.

Methods

Midline incision was made from T12-L5. A paraspinal incision was made through the fascia and a Wiltse approach was performed. Pedicle screws were placed using indirect technique by direct visualization as well as fluoroscopy guidance from T12 to L5. A 4.5mm rod was cut, contoured, and placed at L2 and L3. The rod was then locked and significant correction was seen. The polyethylene cord was then placed from T12 to L5 and cinched down and tensioned to allow for further correction. Compression was performed at multiple levels to gain even more correction. Finally, the cord was maximally tensioned and cut short against the caudad and cephalad screws.

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Results

There were no intraoperative complication. EBL was 100mL and the total operative time was 184min. Patient was released from the PICU on POD 1. The hospital course was otherwise unremarkable and the patient was discharged on POD 3. Patient returned to activities 2 months postop and returned to competitive gymnastics in 3 months.

Conclusion

Skeletally immature patients are at risk of crankshafting when fused too early. Minimally invasive posterior spinal tethering allows for correction while minimizing curve progression with continued growth. In this patient, this technique allowed for minimal lifestyle changes and was able to return to return to competitive sports in a timely manner.

290. Posterior-Based Spinal Tether in Combination With Guided-Growth Principles: A Novel Approach in Severe Early Onset Scoliosis

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

Hypothesis

The use of posterior tethers with rod placement allows modularity in treating challenging curves.

Design

Case Report

Introduction

Patient is a 9 year old female with severe early onset scoliosis with Pierre Robin sequence. Preoperative Cobb angle measured 64° from T11 to L4 with grade 4 Nash Moe at the apex (L2), and pelvic obliquity of 11°. Because of the size of the deformity, risser 0, and premenarchal stage and potential of significant curve progression, a posterior based, minimally invasive growth tether modulation in combination with guided-growth rod principles.

Methods

A curvilinear incision was made from T11 to L5. Subcutaneous flaps were raised on the convexity. Fascial incision was made about a fingerbreadth lateral to the midline. Thereafter, the dissection bluntly was carried between the multifidus muscle medially and longissimus laterally. With the retractors in place, the facet joints were now palpated and the pedicle screw entry point was located on fluoroscopy. Bone was not exposed. A 4.5mm rod was introduced from T11 to L5 and correction maneuver was carried out followed by direct vertebral rotation. This was done to improve coronal correction as well as vertebral rotation. The rod was locked at L1, L2, and L3, and the rod was cut proximal and distal at the junction of T12 and L1 and at the junction of L3 and L4. A posterior spine tether was introduced at T11 and T12, laid alongside the rod and continued along L4 and L5. The tether was tensioned and locked down.

Results

There were no complications intraoperatively. Total surgical time was 313 minutes. Estimated blood loss was 100mL. Patient was transitioned from PCA to oral medications on POD 1 and discharged on POD 3.

Conclusion

Posterior base spinal tethering through a minimally invasive approach allows modularity in treating challenging curves in patients with early onset scoliosis. In this patient, two different surgical principles were combined to address the deformity.

291. Hemodynamic Instability from Patient Positioning with Pectus Excavatum Leading to Procedural Discontinuance

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

Hypothesis

n/a

Design

Case Report

Introduction

Patient is a 15 year old female born prematurely at 26 weeks with micro duplication of 11P15.5 and likely syndromic etiology for findings which include: developmental delays, seizures, abnormal EEG, AVN, history of cleft palate and bilateral hip dysplasia, pectus excavatum and progressive idiopathic scoliosis. In 2019, her preoperative measurements included a Cobb angle of 50°, thoracic kyphosis of 13.4° (T5 – T12), lumbar lordosis of 45.7°, and coronal balance of 7.5 cm. Preop electrocardiogram and echocardiogram were normal. The anterior posterior distance in the patient's chest wall was minimal with aortic arch lying in close proximity to her spine as well as the sternum.

Methods

After patient was placed from supine to the prone position on a Jackson spine table, all bony prominences were padded and her head was secured in the headrest. Blood pressure dropped to 50/30 as the thoracic chest pad was pressing directly on the chest wall. However, after placing patient on a Jackson flat table with jelly rolls placed along both the right and left sides of the chest wall, blood pressure returned to baseline values. Patient was returned to prone position. However, upon attempted pedicle screw fixation of the high thoracic spine, hemodynamic instability was noted and pressor support was required. When patient was slightly lifted to decompress the anterior chest wall, pressor support was alleviated. At time of rod placement, however, pressor support was not proving to be effective, therefore, rods were removed and surgery was aborted. Hemodynamic stability became excessively labile, prompting a rapid closure. Once the patient was positioned supine, blood pressure was unable to be obtained on arterial line and a code was called.

Results

Prior to second surgery, CT scans of the screw placements were taken on POD 2 to ensure ideal positioning as there was some drift during the code due to spinal cord ischemia. Jelly bumps were placed further lateral along the sides of chest, avoiding direct compression of the sternum. In addition, rod placement was done from high thoracic to lumbar spine to avoid shunting of the extremities and avoid placing continuous pressure buildup on the chest.

Conclusion
Sunken chest phenomena should be supported with chest bumps along the sides of the chest well, near the stiffer portion of the ribs, where there is less compliance.

Key: † = Luis A. Goldstein Award Nominee – Best Clinical Research Poster * = John H. Moe Award Nominee – Best Basic Science Research Poster

Industry Workshops

The Scoliosis Research Society gratefully acknowledges 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 on Thursday, September 7 from 12:50-14:20. 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.

LEVEL 3

Location	Company
301 | Ashnola	Globus Medical
302 | Beckler	Medtronic
305 | Chelais	NuVasive

LEVEL 4

Location	Company
401 | Chelan	ZimVie
402 | Chiliwack	DePuy Synthes
405 | Kachess	SI-Bone

INDUSTRY WORKSHOPS, Thursday, September 7 | 12:50-14:20

12:50-14:20 - 402 | Chiliwack

DePuy Synthes – Optimizing Care for Pediatric and Adult Deformity - Case Discussion Workshop

Moderators: Eric Klineberg, MD, MS and Suken Shah, MD, FAAOS, FAOA

Faculty: Ali Baaj, MD, A. Noelle Larson, MD, Paul Sponseller, MD, Kota Watanabe-sensei, MD

Description: Please join our expert surgeon panel for an interactive case-based discussion focused on optimizing care for the most challenging Pediatric and Adult Complex cases. The cases presented will touch upon the unique challenges both pediatric and adult patients present and the important considerations that drive the panel's treatment plan. Covering a range of complex pathologies affecting the cervical spine to the pelvis, participants will be able to engage in conversation around treatment options and the technology that can be leveraged.

12:50-14:20 - 301 | Ashnola

Globus Medical, Inc. – Latest Non-Fusion Techniques in Deformity Correction for the Growing Spine

Faculty: Juan C. Rodriguez-Olaverri, MD, PhD, PD Dr. Per Trobisch

Description: Faculty will discuss deformity correction for skeletally immature AIS patients through the application of the innovative REFLECT™ Scoliosis Correction System, which is a U.S Humanitarian device. Attendees will have the opportunity to delve into various aspects of non-fusion deformity correction surgery, such as patient selection, preoperative planning, and surgical techniques, through the utilization of REFLECT™. The workshop will conclude with clinical case examples and a live Q&A.

Discussion Will Cover the Following Topics:

- Current techniques and trends
- Minimally invasive option for preserving motion
- Introduction of REFLECT™ to the US Market
- REFLECT™ HDE indications

12:50-14:20 - 302 | Beckler

Medtronic - Sagittal Alignment and the Evolution of Intelligence Based Planning and Execution in Deformity

Faculty: Chris Kleck, MD and Joseph Osorio, MD

Description: Discover the evolution of sagittal alignment planning and patient specific approaches to spine surgery. Learn strategies for planning sagittal alignment goals using UNiD™ASI, executing your plan in the O.R by leveraging the Mazor X Stealth™ robotic guidance system and verifying the plan intra-operatively using O-arm™ 2D Long Film.

12:50-14:20 - 305 | Chelais

NuVasive – Complex Junctional Strategies - The Good, The Bad, and The Ugly

Faculty: Han Jo Kim, MD, Tyler Koski. MD, Rajiv Sethi, MD, Chris Shaffrey, MD

Description: Please join our esteemed faculty for a case based discussion on junctional strategies when treating complex deformity. Our panel will explore insights, tips, and methods for traversing the cervicothoracic and thoracolumbar junctions while being moderated by your local host, Rajiv Sethi.

Industry Workshops

12:50-14:20 - 405 | Kachess

SI-BONE – Spinopelvic Fixation: Emerging Surgical Considerations & Techniques

Faculty: Sigurd Berven, MD; CJ Kleck, MD; David Polly, Jr., MD

Description: Pelvic fixation failure remains one of the most common complications in adult spinal deformity surgery. Failures are observed in a quarter of all cases. Join our faculty as they discuss and debate surgical planning strategies, new implant technologies, and techniques they're using to help decrease failures and improve patient outcomes.

12:50-14:20 - 401 | Chelan

ZimVie– Growth & VBT: Understanding Your Patient & When to Operate

Faculty: Daniel Hoernschemeyer, MD, Melanie Boeyer, PhD, Amer Samdani, MD, and Firoz Miyanji, MD

Workshop Outline: An understanding of growth potential is critical to predicting growth modulation. This workshop will define the Sanders scoring guide and how surgeons may utilize it as a planning tool for their VBT procedures. Reduce your VBT learning curve by attending a workshop that merges research with long-term follow-up.

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The Scoliosis Research Society gratefully acknowledges ZimVie for their grant support of the Annual Meeting Directional Signage.

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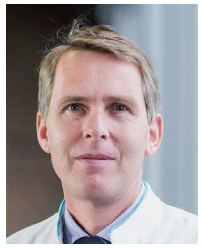

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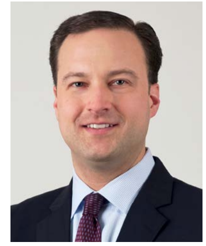

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SRS Overview

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 1,600 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 *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 *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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Save the Date | 2024 SRS Meetings

Notes

Notes

Notes

Notes

Meeting Outline

WIRELESS INTERNET
Network: SRSAM23 | Password: SCOLIOSIS
Wireless Internet is supported, in part, by Stryker

TUESDAY, SEPTEMBER 5, 2023			
07:00 - 08:00	Committee Chair Breakfast*	402 | Chiliwack	Level 4
08:00 - 17:00	Committee and Council Meetings*	Rooms 301-305	Level 3
12:00 - 17:00	Registration Open*	Foyer	Level 3
12:00 - 17:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
13:00 - 17:00	Hibbs Society Meeting	Regency Ballroom B	Level 7
18:30 - 21:30	SRS Leadership Dinner* (*by invitation only*)	Offsite	
WEDNESDAY, SEPTEMBER 6, 2023			
06:30 - 20:00	Registration Open*	Foyer	Level 3
06:30 - 19:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
07:30 - 12:00	Pre-Meeting Course	Columbia Ballroom	Level 3
The Pre-Meeting Course is supported, in part, by ZimVie.			
09:35 - 10:00	Refreshment Break*	Foyer	Level 3
12:00 - 12:20	Lunch Pick-Up*	Foyer	Level 3
12:20 - 13:20 13:20 - 13:40	Lunchtime Symposia (*3 Concurrent Sessions*) Break*	Columbia, Regency A & Regency B	Levels 3 & 7
13:40 - 15:10	Abstract Session 1	Columbia Ballroom	Level 3
15:10 - 15:30	Refreshment Break*	Foyer	Level 3
15:30 - 17:15	Abstract Session 2	Columbia Ballroom	Level 3
17:15 - 17:35	Break*		
17:35 - 18:35 18:35 - 18:50	Case Discussions (*3 Concurrent Sessions*) Break*	Columbia, Regency A & Regency B	Levels 3 & 7
18:50 - 20:00	Opening Ceremonies*	Columbia Ballroom	Level 3
20:00 - 22:00	Welcome Reception*	Foyer	Level 3
The Welcome Reception is supported, in part, by Globus Medical and ZimVie.			
THURSDAY, SEPTEMBER 7, 2023			
07:00 - 18:00	Registration Open*	Foyer	Level 3
07:00 - 18:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
08:00 - 09:50	Abstract Session 3	Columbia Ballroom	Level 3
09:50 - 10:10	Refreshment Break*	Foyer	Level 3
10:10 - 12:15	Abstract Session 4	Columbia Ballroom	Level 3
12:15 - 12:50	Lunch Pick-Up*	Foyer	Level 3
12:50 - 14:20	Industry Workshops* (*6 Concurrent Sessions*)	Rooms 301, 302, 305, 401, 402 & 405	Levels 3 & 4
14:20 - 14:40	Refreshment Break*	Foyer	Level 3
14:40 - 17:20 17:20 - 17:30	Half-Day Courses (*3 Concurrent Sessions*) Break*	Columbia, Regency A & Regency B	Levels 3 & 7
17:30 - 17:45	SRS Membership Information Session*	401 | Chelan	Level 4
17:45 - 17:50	Break*		
17:50 - 18:50	Early Career Surgeon Session	Regency Ballroom A	Level 7
The Early Career Surgeon Session is supported, in part, by Medtronic, NuVasive and Stryker.			
18:50	Early Career Surgeon Social*	Regency Ballroom A Foyer	Level 7
The Early Career Surgeon Social is hosted by Medtronic.			
FRIDAY, SEPTEMBER 8, 2023			
07:00 - 17:00	Registration Open*	Foyer	Level 3
07:00 - 17:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
08:00 - 09:50	Abstract Session 5	Columbia Ballroom	Level 3
09:50 - 10:10	Refreshment Break*	Foyer	Level 3
10:10 - 11:45	Abstract Session 6	Columbia Ballroom	Level 3
11:45 - 12:05	Lunch Pick-Up*	Foyer	Level 3
12:05 - 13:35	Member Business Meeting and Lunch*	Regency Ballroom B	Level 7
12:05 - 13:35	Lunchtime Symposium 4	Columbia Ballroom	Level 3
13:35 - 13:55	Break*		
13:55 - 15:40	Abstract Session 7A & 7B	Columbia & Regency B	Level 3 & 7
15:40 - 16:00	Refreshment Break*	Foyer	Level 3
16:00 - 17:45	Abstract Session 8	Columbia Ballroom	Level 3
18:30 - 19:30	President's Reception* (*by invitation only*)	Offsite	
19:30 - 22:00	Farewell Reception* (*ticket required*)	Offsite	
SATURDAY, SEPTEMBER 9, 2023			
07:30 - 11:00	Registration Open*	Foyer	Level 3
07:30 - 11:00	Speaker Ready Room Open*	308 | Quilcene	Level 3
08:00 - 10:10	Abstract Session 9	Columbia Ballroom	Level 3
10:10 - 10:30	Refreshment Break*	Foyer	Level 3
10:30 - 11:55	Abstract Session 10	Columbia Ballroom	Level 3
11:55	SRS 58th Annual Meeting Concludes		