



Scoliosis Research Society 44TH ANNUAL MEETING & COURSE

San Antonio
Texas

Final Program

September 23-26, 2009

MARRIOTT RIVERCENTER HOTEL • SAN ANTONIO, TEXAS, USA

Jointly sponsored by Scoliosis Research Society and American Academy of Orthopaedic Surgeons



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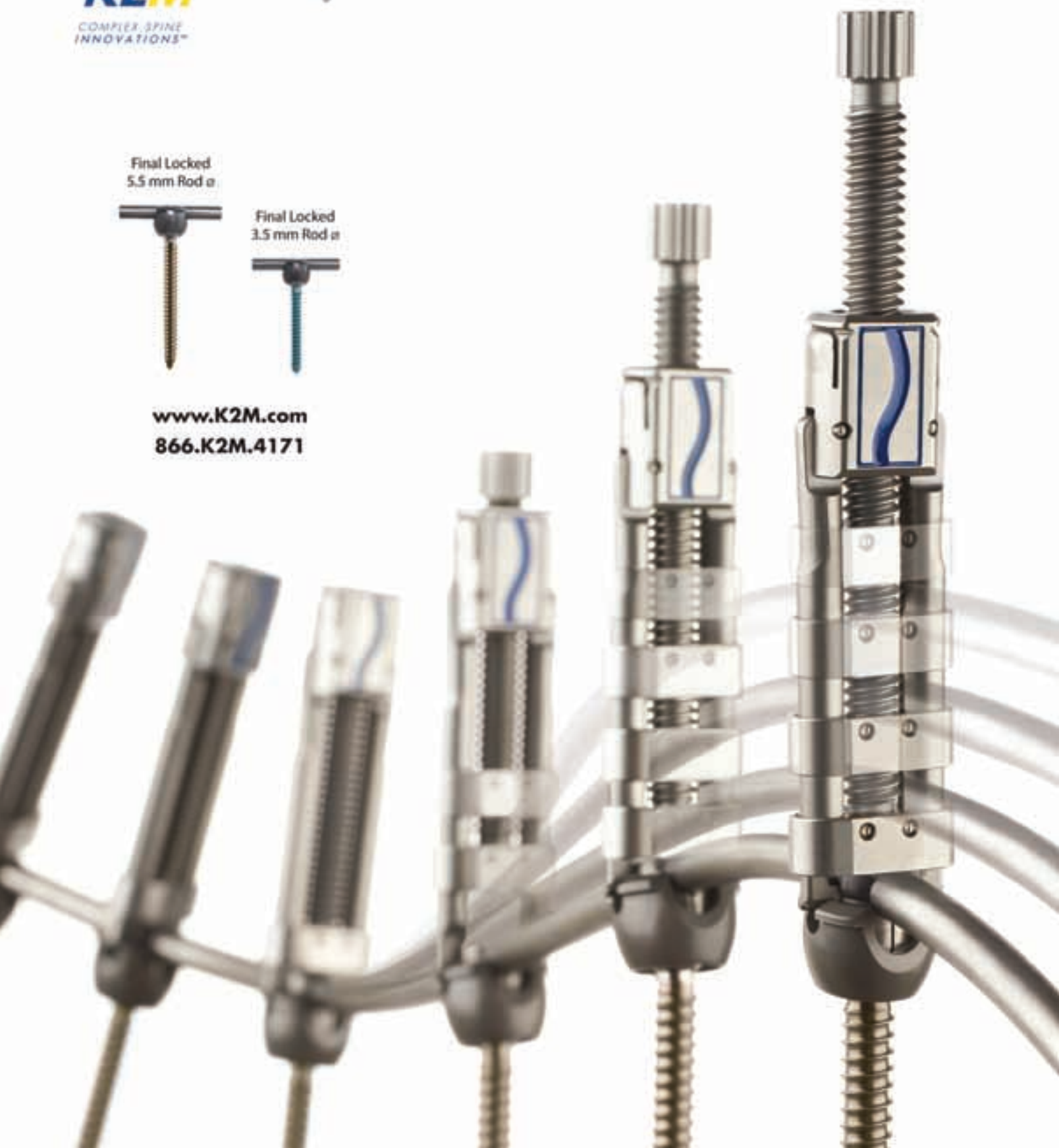
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The Scoliosis Research Society gratefully acknowledges Synthes Spine for their support of our 2009 Annual Meeting and Course at the Gold level.



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Scoliosis Research Society

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E-mail: info@srs.org
Web site: www.srs.org

SRS Mission Statement

The purpose of the Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

Future SRS Educational Events

Annual Meeting & Course

September 22-25, 2010 – Kyoto, Japan
September 14-17, 2011 – Louisville, Kentucky, USA

International Meeting on Advanced Spine Techniques (IMAST)

July 21-24, 2010 – Toronto, Canada
July 13-16, 2011 – Maspalomas, Gran Canaria

Worldwide Conferences

December 14-15, 2009 – Cairo, Egypt

SRS Office Staff

Tressa Goulding, CAE, CMP, Executive Director
Kathryn Agard, Administrative Assistant
Nadine Couto, Sr. Manager - Annual Meetings
Megan Kelley, Meetings Director - IMAST
Courtney Kissinger, Project Manager
Nilda Toro, Membership Manager

President's Message

Dear Fellows, Guests, and Friends of the Scoliosis Research Society

It is with great pleasure that I welcome you to San Antonio and the 44th Annual Meeting of the Scoliosis Research Society. It seems like it was only yesterday that we had our last meeting in Salt Lake City.

We have all experienced the turbulence of the past year, notwithstanding the economic woes and the effect it has had on everyone and every organization. The challenges also presented opportunities and the need for change in strategy. Your board of directors, council and committee chairs and the staff worked diligently to uphold the SRS mission, goals and objectives. Foremost among the goals is to continue to deliver high quality educational programs for our members worldwide.

On the heels of the 2008 annual meeting, we partnered with our members in India to hold an outstanding regional course in New Delhi. The Argentina meeting followed in late September and was very successful. Our spring 2009 regional course in Brazil, led by Larry Lenke, MD, was equally successful and as educational as the others. Our society was invited to participate in the first inaugural international meeting of the Chinese Scoliosis Research Society in Beijing in May.

Our biggest challenge was bringing IMAST in-house, to be planned and managed by SRS staff. Todd Albert, MD, as IMAST Chair and Megan Kelly, IMAST Meeting Manager, both rose to the occasion and organized one of the best IMAST meetings, held at the historic Hofburg Center in Vienna. The meeting was attended by 856 participants from all walks of life. New this year at IMAST was the introduction of the HODs (Hand On Demonstrations) which was well received by our industry partners. When all the numbers are in, we are hopeful to have a positive financial outcome. Thanks to all who participated in this year's IMAST program.

Continuing the changes we instituted last year, two esteemed members and past presidents of SRS were nominated to receive this year's lifetime achievement award— David B. Levine, MD, and Marc A. Asher, MD. Marc also happened to be last year's Harrington guest lecturer.

This year's Harrington guest lecturer will be John P. Kostuik, MD, FRSC (C), who served as SRS president in 1987. Dr. Kostuik is a household name among us and has had a long, celebrated career in spine deformity surgery especially in adult patients.

The 2009 Howard Steel lecturer will be David Oshinsky, PhD, whose topic is Polio: A Look Back at America's Most Successful Public Health Crusade.

As we have done in past years, and with the leadership of Allen Carl, MD, the education committee has organized a Wednesday pre-meeting course on the complications of pediatric and adult spine deformity surgery. There will be a morning session running concurrently, designed primarily for our neurosurgical associates, titled, Critical Concepts in Adult Deformity Surgery, to be co-chaired by Steve Glassman, MD, and Chris Shaffrey, MD. Various outstanding lunchtime symposiums have been organized for our fellows.

Under the leadership of Peter Newton, MD, the program committee has reviewed over 1,000 abstracts and selected the top papers for the scientific program podium presentations. My personal thanks go to our local host, Mrs. and Dr. Earl Stanley, MD and his local associates for organizing the meeting events and activities in this multicultural city of San Antonio.

Despite the economic hardship of the past year, we hope to come out of this year's annual meeting with a favorable financial posture. Many thanks to our Corporate Partners, especially the Double Diamond and Diamond level donors, for their support of SRS programs and activities. We do appreciate the support of all other industry donors for helping to bring us this far.

Last, on behalf of the Board of Directors I would like to express our thanks and appreciation to Tressa Goulding and the SRS staff at EDI, headed by Kay Whalen, for staying on course and working hard to keep the society afloat in these difficult times.

It has been a great honor and privilege to have had the opportunity to serve as your president this year, and I appreciate the support and encouragement I have received from each and every one of you.

Together, let's continue to lift high the SRS banner and enjoy this outstanding meeting and wonderful city.



Oheneba Boachie-Adjei MD
President, Scoliosis Research Society

2008 – 2009 Board Of Directors



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President



Richard E. McCarthy, MD
President-Elect



Lawrence G. Lenke, MD
Vice President



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Behrooz A. Akbarnia, MD
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Past President, 2005



Azmi Hamzaoglu, MD
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James W. Roach, MD
Director



Kamal Ibrahim, MD
Director



Kenneth MC Cheung, MD
Director

Annual Meeting Committees

2009 Local Organizing Host

Earl Stanley, MD

2009 Program Committee

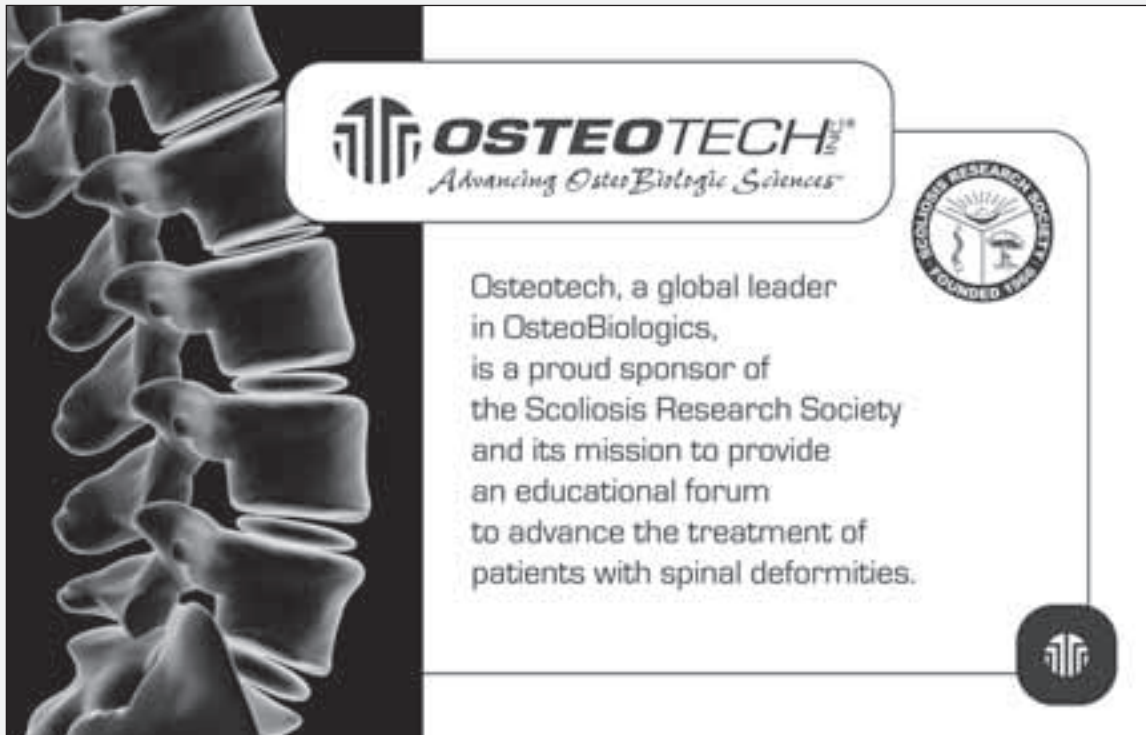
Peter O. Newton, MD, Chair
Paul D. Sponseller, MD, Past Chair
Todd J. Albert, MD, IMAST Chair
Lawrence G. Lenke, MD, IMAST Past Chair
Noriaka Kawakami, MD, 2010 Co-Chair-Elect
Michael J. Yaszemski, MD, PhD, 2010 Co-Chair-Elect
Laurel C. Blakemore, MD
Douglas C. Burton, MD
Andrew M. Casden, MD
Patrick J. Connolly, MD
Andrew G. King, MD
Marinus de Kleuver, MD

2009 Education Committee

Allen W. Carl, MD, Chair
R. Jay Cummings, MD, Past Chair
Peter O. Newton, MD, (Program Committee Chair)
Joseph H. Perra, MD, Chair-Elect
Kuniyoshi Abumi, MD
Ahmet Alanay, MD
Philip S. Anson, MD
Mark Dekutoski, MD
Ryan C. Goodwin, MD
Lawrence L. Haber, MD
Kamal N. Ibrahim, MD
Eric T. Jones, MD

2009 Program Reviewers

Michael C. Albert, MD
Michael F. Coscia, MD
Dennis G. Crandall, MD
Yasser El Miligui, MD, FRCS
Paul A. Glazer, MD
Azmi Hamzaoglu, MD
Henry J. Iwinski, MD
Hak-Sun Kim, MD
Yongjung J. Kim, MD
Timothy R. Kuklo, MD, JD
Michael O. LaGrone, MD
Alexander L'Heureux, MD, FACS
Alan Moskowitz, MD
Michael F. O'Brien, MD
Kenneth J. Paonessa, MD
B. Stephens Richards, III, MD
Michael S. Roh, MD
Arya Nick Shamie, MD
Francis H. Shen, MD
Harwant Singh, MD, PhD
Brian G. Smith, MD
Joseph M. Verska, MD
Jean Marc Vital, MD
Robert Wienecke, MD



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Osteotech, a global leader in OsteoBiologics, is a proud sponsor of the Scoliosis Research Society and its mission to provide an educational forum to advance the treatment of patients with spinal deformities.

CME and Disclaimer Information

Meeting Description

The Scoliosis Research Society Annual Meeting & Course is a forum for the realization of the Society's mission and goals, the improvement of patient care for those with spinal deformities. Presentations at the Annual Meeting & Course are given by leading experts in the field and have value for health care professionals who treat spinal deformities at all levels and in all ages. Over 100 papers will be presented on an array of topics, including adolescent idiopathic scoliosis, growing spine, kyphosis, adult deformity, trauma, neuromuscular scoliosis and tumors.

Learning Objectives

At the conclusion of the SRS Annual Meeting & Course, participants should be able to:

1. Recognize the potential for complications related to particular surgical techniques that allow them to take steps to avoid or minimize them.
2. Analyze emerging options for treatment of different spinal deformities and related conditions.
3. Assess the role of nonoperative management of spinal deformity in children and adults.
4. Accurately describe classifications for AIS and adult scoliosis, and how they guide treatment.
5. Analyze treatment options and potential complications for spinal tumors.
6. Discuss current basic research on the etiology of scoliosis.
7. Discuss treatment and results of treatments for degenerative scoliosis.
8. Understand outcomes assessment methods for spinal deformity.

Target Audience

Presentations at the SRS Annual Meeting & Course will have value for physicians and allied health personnel who treat spinal deformities at all levels and in all ages of patients. Medical students, residents, fellows and researchers with an interest in spinal deformities will also benefit from the materials presented.

Physician Accreditation

American Academy of Orthopaedic Surgeons is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to sponsor continuing medical education for physicians.

Continuing Medical Education Credit Designation

This activity has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of the American Academy of Orthopaedic Surgeons and Scoliosis Research Society. The American Academy of Orthopaedic Surgeons is accredited by the ACCME to provide continuing medical education for physicians. The American Academy of Orthopaedic Surgeons designates this educational activity for a maximum of 22.5 *AMA PRA Category 1 Credits™* (7.5 credits for the Pre-Meeting Course and 15 for the Annual Meeting). Physicians should only claim credit commensurate with the extent of their participation in the activity.

CME Certificates

In order to obtain your CME certificate, you must return your completed Annual Meeting evaluation form to the evaluation drop box, Registration Desk or mail directly to Scoliosis Research Society at 555 East Wells Street, Suite 1100, Milwaukee, WI 53202. AAOS will send out CME certificates.

CME and Disclaimer Information

Disclaimer

The material presented at the SRS Annual Meeting & Course has been made available by the Scoliosis Research Society for educational purposes only. This material is not intended to represent the only, nor necessarily best, method or procedure appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the presenter which may be helpful to others who face similar situations.

SRS disclaims any and all liability for injury or other damages resulting to any individuals attending a session for all claims which may arise out of the use of the techniques demonstrated there in by such individuals, whether these claims shall be asserted by a physician or other party.

FDA Statement

All drugs and medical devices used in the United States are administered in accordance with Food and Drug Administration (FDA) regulations. These regulations vary depending on the risks associated with the drug or medical device, the similarity of the drug or medical device to products already on the market, and the quality and scope of clinical data available.

Some drugs and medical devices demonstrated in Scoliosis Research Society meetings or described in Scoliosis Research Society print publications have FDA clearance for use for specific purposes or for use only in restricted research settings. The FDA has stated that it is the responsibility of the physician to determine the FDA status of each drug or device he or she wishes to use in clinical practice, and to use the products with appropriate patient consent and in compliance with applicable law.

Disclosure

It is the policy of American Academy of Orthopaedic Surgeons (AAOS) and Scoliosis Research Society to ensure balance, independence, objectivity, and scientific rigor in all its educational activities. All faculty participating in our programs are expected to disclose any relationships they may have with commercial companies whose products or services may be mentioned so that participants may evaluate the objectivity of the presentations. In addition, any discussion of off-label, experimental, or investigational use of drugs or devices will be disclosed by each of the faculty members. The options to disclose are as follows:

- a. Grants/Research Support
- b. Consultant
- c. Stock/Shareholder
- d. Speakers' Bureau
- e. Other Financial Support
- f. Over \$10,000

The Scoliosis Research Society does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the Annual Meeting & Course.



San Antonio
Texas

General Meeting Information

General Meeting Information

Abstract Volume

All abstracts accepted for presentation at the 44th Annual Meeting have been published in the Final Program (pages 53-206). Each attendee will receive one copy of the program along with their registration materials. Abstracts have also been posted online at www.srs.org.

Accompanying Persons Hospitality Room

Spouses, partners, and friends of SRS Annual Meeting attendees are welcome to meet and plan their days over a continental breakfast. The Hospitality Room is open Thursday, September 24 through Saturday, September 26 from 6:00 – 9:30 am. Accompanying persons must be registered with SRS to access the Hospitality Room.

Admission to Sessions

Official name badges will be required for admission to all SRS sessions. All Annual Meeting attendees receive a name badge with their registration materials. Name badges should be worn at all times inside the Marriott Rivercenter Hotel, as badges will be used to control access to sessions and activities. Attendees are cautioned against wearing their name badges while away from the hotel as badges draw unwanted attention to your status as visitors to the city.

Admission by Tickets

Instructional Course Lectures require tickets for admission. Tickets for these sessions are not included in the meeting's regular registration fees, but are available for an additional \$25 - \$75. Tickets will be collected at the door by ushers. There may still be a limited number of tickets available at the Registration Desk.

In addition, tickets will be required for admission to the Farewell Reception. The Farewell Reception will take place at the Rio Cibolo Ranch and is an additional \$50 fee. If you pre-registered, tickets may be found in your registration packets. There may still be a limited number of tickets available at the Registration Desk.

Tickets are required for optional tours and activities, and the cost of tour tickets is in addition to the delegate or accompanying Person registration fee. If you pre-registered for a tour, tickets may be found in your registration packet. There may be a limited number of tickets for tours available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour.

Area Attractions

For information about San Antonio, and the Riverwalk Area please visit the hotel concierge desk.

Attire

Business casual (polo or dress shirts, sport coats) are appropriate for meeting sessions. Casual attire is fine for the Welcome and Farewell Receptions (please no shorts).

Automated Teller Machine

An Automated Teller Machine (ATM) is available on the lower level of the Marriott Rivercenter Hotel. This is a CHASE Bank ATM and will charge a transaction fee to non-Chase card holders.

Business Center

The Marriott Rivercenter Hotel offers business services at The UPS Store. It is open 7 days a week, at various times. Services include printing, copying, faxing, shipping, etc. For information, call 210-554-6208.

Cell Phone Protocol

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

Concierge Service

The Marriott Rivercenter Hotel concierge is available 7 days a week in the Hotel Lobby.

Emergency & First Aid

The Marriott Rivercenter Hotel is fully prepared to handle emergency requests and first aid. Pick up any house phone for immediate assistance and contact an SRS staff person for support. Remember to note all emergency exits within the hotel.

Electronic Posters

Electronic Posters may be viewed on monitors located on the third floor, salons A-E of the Marriott Rivercenter Hotel. To access the E-posters from your laptop, log on to www.integratedevents.com/SRS/ using the following information:

User Name: srs2009

Passcode: texas

Evaluations

Please take time to complete the evaluation form provided for each session you attend. Your input and comments are essential in planning future Annual Meetings. When completed, evaluations may be returned to the evaluation drop box located near the Ballroom or to the SRS Registration Desk.

General Meeting Information

Guest Attendance

Adults and children over the age of 10 may register as guests to attend the social events; Welcome and Farewell Reception. Tickets for these events must be requested at the time of registration. For those guests who have pre-registered and requested social event tickets, these tickets can be found in the delegate's registration packet. Guests may register and request social event tickets at the Registration Desk. Registered guests are also able to participate in optional tours, at an additional fee, although pre-registration for tours is required. There may be a limited number of tour tickets available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour.

Hotel Information

The Marriott Rivercenter Hotel is the headquarters hotel for the 44th Annual Meeting & Course:

101 Bowie Street
San Antonio, Texas 78205
Toll-free: 1-800-648-4462
Phone: 1-210-223-1000
Fax: 1-210-223-6239
www.marriott.com/satrc

Internet Kiosks

Location: Third Floor

Attendees can use the Internet and check their e-mail at the Internet Kiosks.

Tuesday, September 22	2:00 – 6:00 pm
Wednesday, September 23	6:30 am – 5:00 pm
Thursday, September 24	6:30 am – 4:00 pm
Friday, September 25	6:30 am – 5:15 pm
Saturday, September 26	6:30 am – 1:00 pm

Language

English will be the official language of the SRS Annual Meeting & Course.

Lost & Found

Please feel free to stop by the SRS Registration Desk if you have lost or found an item during the course of the Annual Meeting. You may also wish to check with hotel security regarding lost items.

Members Business Meetings

Location: Third Floor, Salons I-J

All SRS members are invited to the Members Business Meetings on Thursday, September 24 through Saturday, September 26 from 6:30 – 7:40 am in Salons I-J. Committee Chairs will share their reports, as well as reports from the SRS Traveling Fellows and Edgar Dawson Scholarship recipients. A hot breakfast buffet will be served.

Message Board

A self-service message board (non-electronic) will be available in the Registration Area for attendees to post notes or leave messages for other attendees. Please remember to check for any messages that may be left for you. This message board is provided by a grant from Medtronic.

Non-Members Continental Breakfast

Location: Salon E Foyer

All non-members are invited to meet with their colleagues and network over coffee and a continental breakfast on Thursday, September 24 through Saturday, September 26 from 6:30 – 7:40 am in the Foyer outside of Ballroom Salon E.

Photography Policy

SRS will be taking photographs throughout the Annual Meeting & Course. 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 an SRS staff member if your picture is taken. Thank you for your cooperation.

Cameras are not permitted in any Annual Meeting & Course educational session or in the poster area.

General Meeting Information

Poster Hall Location & Hours

Location: Foyer outside Salons A-C

Wednesday, September 23 - 6:30 am – 5:00 pm

Thursday, September 24 - 6:30 am – 4:00 pm

Friday, September 25 - 6:30 am – 5:15 pm

Saturday, September 26 - 6:30 am – 12:30 pm

Registration Desk Location & Hours

Location: Third Floor, Registration Foyer

Hours:

Tuesday, September 22 2:00 – 6:00 pm

Wednesday, September 23 6:30 am – 5:00 pm

Thursday, September 24 6:30 am – 4:00 pm

Friday, September 25 6:30 am – 5:15 pm

Saturday, September 26 6:30 am – 1:00 pm

Smoking Policy

Smoking is not permitted during any meeting activity or event.

Speaker Presentation Upload

Location: Third Floor, Salon E

All speakers must deliver their presentations to the Audio Visual technicians in the back of the Ballroom, Salon E, preferably the day before their sessions or at least four hours prior to the presentation time.

Wednesday, September 23 6:30 am – 5:00 pm

Thursday, September 24 6:30 am – 4:00 pm

Friday, September 25 6:30 am – 5:15 pm

Saturday, September 26 6:30 am – 1:00 pm

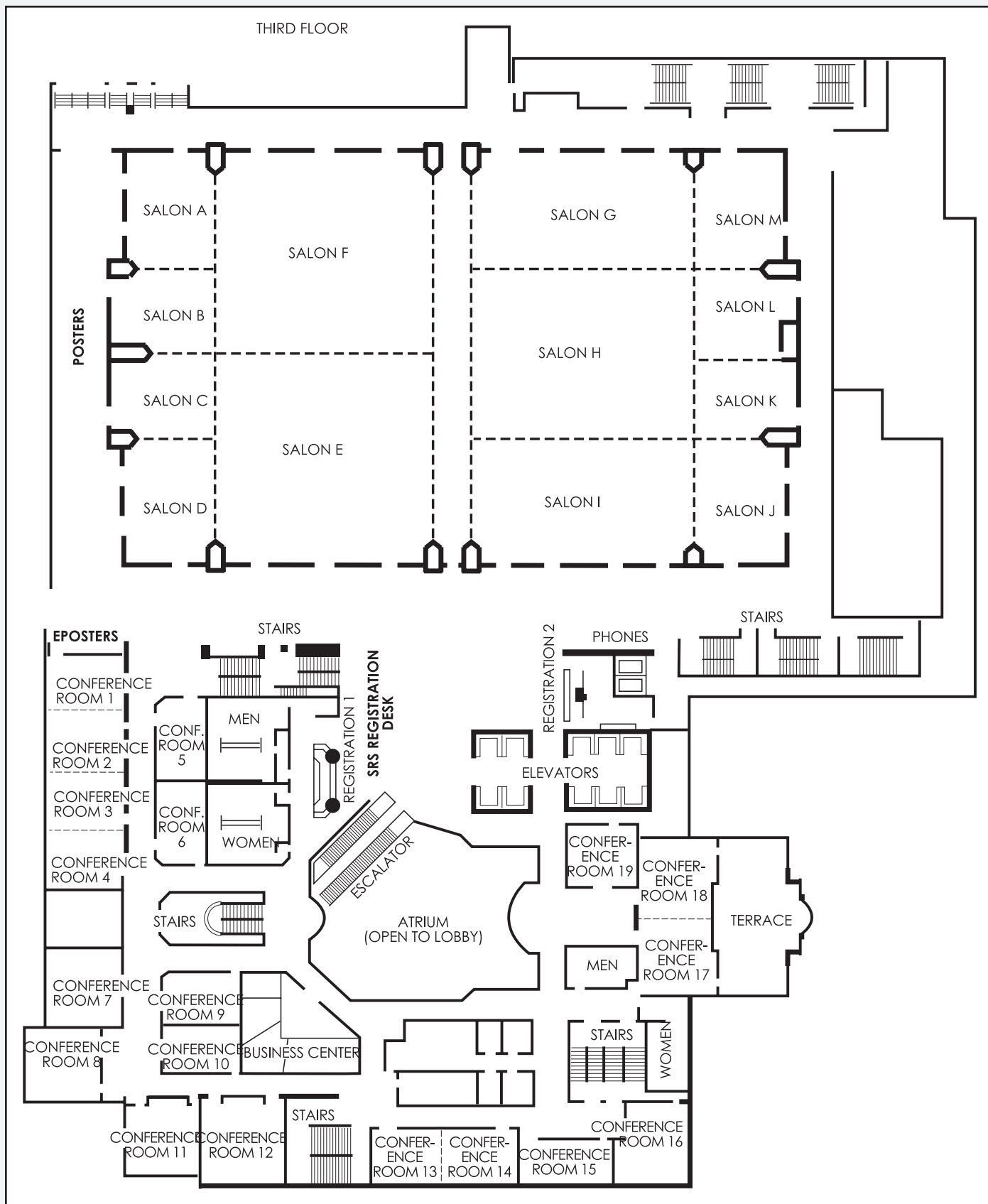
Special Needs

If you have any health issues for which you may require special accommodations or assistance, please notify the SRS staff at the Registration Desk. We will make every effort to accommodate any special needs.

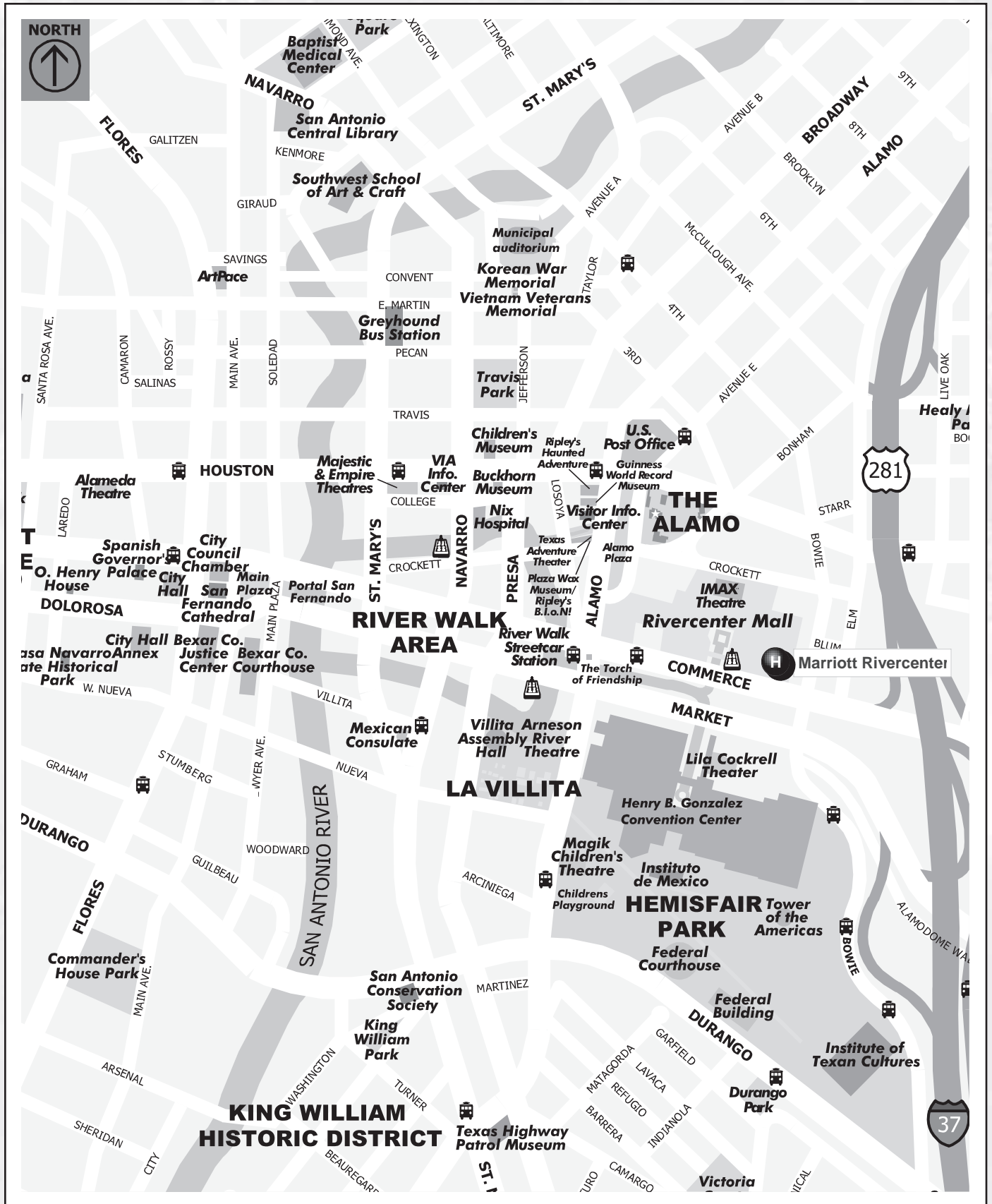
Tour Information

Delegates and accompanying persons, including adults and children ages 10 and up, are able to attend optional tours. Tickets are required to participate in the tours and must have been requested at the time of pre-registration. Any tour tickets purchased will be included with the delegate's registration packet. Additional tour tickets may be available at the Registration Desk. Tours will take place rain or shine. For more information on social events, including a complete schedule, please see page 21.

Venue Floor Plan



City Map



Meeting Outline

Monday, September 21, 2009

7:00 am – 5:00 pm	Board of Directors Meeting	Conference Rooms 17-18
12:00 – 1:00 pm	Board of Directors Lunch	Conference Room 16

Tuesday, September 22, 2009

7:00 am – 5:00 pm	SRS Committee Meetings	Conference Rooms 5, 6, 7, 10, 11
2:00 – 6:00 pm	Poster Set-Up by Authors	Salons A-C Foyers
2:00 – 6:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 – 10:00 pm	SRS Leadership Dinner (by invitation only) Southwest School of Art & Craft	Depart via River Barge Meet in Marriott Rivercenter Lobby

Wednesday, September 23, 2009

6:30 am – 5:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
7:55 am – 12:00 pm	Pre-Meeting Course: Critical Concepts in Adult Deformity Surgery	Salons A-F
7:55 am – 5:05 pm	Pre-Meeting Course: Complications in Spinal Deformity Surgery	Salon I
12:20 – 1:00 pm	Lunchtime Symposium: Growing Spine	Salons A-F
12:20 – 1:00 pm	Lunchtime Symposium: Non-Operative Management	Salon I
6:30 – 7:30 pm	Opening Ceremonies	Salons A-F
7:30 – 9:00 pm	Welcome Reception Supported by Medtronic	Salons D-E Foyer

Thursday, September 24, 2009

6:30 am – 4:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 12:18 pm	Scientific Program	Salons A-F
12:30 – 5:30 pm	Edgar Dawson Memorial Golf Tournament	Meet in Lobby at 12:20 pm
1:00 – 4:00 pm	Instructional Course Lecture: Coding	Salons A-F
1:00 – 4:00 pm	Instructional Course Lecture: Worldwide Conferences	Salon I-J
1:00 – 4:30 pm	Activity: Biking the Mission Trail	Meet in Lobby at 12:50 pm
1:00 – 5:00 pm	Tour: Highlights of San Antonio	Meet in Lobby at 12:50 pm

Meeting Outline

Friday, September 25, 2009

6:30 am – 5:15 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:15 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 5:00 pm	Scientific Program	Salons A-F
12:07 – 1:07 pm	Lunch Break	
12:10 – 1:00 pm	Lunchtime Symposium: Worldwide Conference/Global Outreach	Salons I-J
12:10 – 1:00 pm	Lunchtime Symposium: Evidence Based Outcomes	Salons A-F
1:00 – 5:00 pm	Tour: Cruisin' & Explorin' San Antonio	Meet in Lobby at 12:50 pm
1:00 – 5:00 pm	Tour: Spanish Mission Trail	Meet in Lobby at 12:50 pm
7:00 – 10:00 pm	Farewell Reception <i>Supported by K2M</i>	Rio Cibolo Ranch Depart at 6:30 pm from Lobby

Saturday, September 26, 2009

6:30 am – 1:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 1:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 12:33 pm	Scientific Program	Salons A-F
12:33 pm	Meeting Adjourns	
1:00 pm – 3:30 pm	Board of Directors Meeting	Conference Rooms 17-18

Guest Lecturers

Harrington Lecturer



John P. Kostuik, MD

Pelvic Fixation, an Unsolved Problem

Born in 1937 in Northern Canada, John P. Kostuik graduated medical school in 1961, Queen's University Kingston Ontario, Canada. Residency at University of Toronto

1961-1967. Certified in Orthopaedics in 1967. Faculty University of Toronto 1968-1991. Professor (full) 1986 University of Toronto. Johns Hopkins University, Baltimore, Professor Orthopaedics/ Neurosurgery 1991-2004 President SRS 1987. President NASS 1991.

Awards: R.I.Harris 1967 best Resident Orthopaedics University of Toronto. Mclaughlin Travelling Fellow Europe 1968-69. ABC Travelling Fellow `1975, Hibbs Award SRS 1998, Selby Award Nass, Wiltse Award NASS, Johnston Award Johns Hopkins 1999. Senior Travelling Fellow Asia SRS 1998.

Member SRS, NASS. CSRS, ISSLS, Canadian Orthopaedic Association, American Orthopaedic Association, Japanese Orthopaedic Association, Belgian Orthopaedic Association, Ecuadorian Ortopaedic Association

Published 125 peer reviewed papers. Trained 125 Felows in spine. visiting Professor 327 countries.

Howard Steel Lectuer



David M. Oshinsky, PhD

Polio: A Look Back at America's Most Successful Public Health Crusade

Pulitzer Prize winner David M. Oshinsky holds the Jack S. Blanton Chair in History at the University of Texas and is a Distinguished

Visiting Scholar at New York University. His books include A CONSPIRACY SO IMMENSE: THE WORLD OF JOE McCARTHY, which was a New York Times "Notable Book of the Year"; WORSE THAN SLAVERY, which won the Robert F. Kennedy Book Award for its "distinguished contribution to human rights," and was also a New York Times "Notable Book of the Year"; and POLIO: AN AMERICAN STORY, which won the Pulitzer Prize for History. His essays and reviews appear regularly in the New York Times and other national publications.

Lifetime Achievement Award Recipients

Lifetime Achievement Awards

The 2009 Lifetime Achievement Awards will be presented on Saturday, September 26th. The Lifetime Achievement Award Recipients were chosen from among the SRS membership, based on long and distinguished service to the Society and spinal deformity research and care. This year's winners are: Marc A. Asher, MD and David B. Levine, MD.



Marc A. Asher, MD

Marc Addason Asher was born in 1936, the only child of a south central Kansas farmer and high school mathematics teacher. In his youth he was interested in animal husbandry and soil conservation. He attended Kansas State College (University), BS 1958 and Kansas

University, MD 1962. After post graduate training (University of Oregon, Baltimore City Hospital and the Harvard Combined Orthopaedic Program), service in the United States Public Health Service and at the University of Texas, San Antonio he returned (1972) to his alma mater, where he attained the rank of University Distinguished Professor. He was chair of the Orthopaedic Knowledge Update 1: Home Study Syllabus editorial board, helped establish the Paul R. Harrington Archives, and participated in the development of the Isola Spine Implant system. He has been a POSNA Treasurer, and SRS Annual Meeting local host (1992) and President (1997).



David B. Levine, MD

David B. Levine, MD, a native of Binghamton, NY, attended Dartmouth College and obtained his medical degree from the State University of New York Medical School at Syracuse in 1957. An orthopaedic resident at Hospital for Special Surgery, he completed

a Spine Fellowship at Rancho Los Amigos Hospital in Downey, California and joined the Attending Staff of HSS becoming Chief of Scoliosis (1967-1995). In 1964, as a senior resident, at a scoliosis instructional course meeting held at the University of Minnesota, he proposed establishing a Scoliosis Research Society (SRS) and drafted the first Bylaws of the society. He had the longest tenure (15 years) of any member of the Board of Directors of the Society and served as Secretary-Treasurer (1970-72), Secretary (1972-74) and President (1978-79). He retired in 1995 to be recalled in 2003 by Dr. Thomas Sculco, HSS Surgeon-in-Chief, to become Director of Alumni Affairs and HSS Archivist. He continues in these roles and divides his time with his wife Janet in New York City and on a farm in upper New York State.

Educational Events

Pre-registration is required for Educational events and space is limited. Instructional Course Lectures require tickets for admission. Tickets for these sessions are not included in the meeting's regular registration fees. Ticket will be collected at the door by ushers. There may be a limited number of tickets available at the Registration Desk.

WEDNESDAY, SEPTEMBER 23, 2009

Lunchtime Symposium

12:20-1:00 pm

Growing Spine

Location: Salons A-F

Case Presentations and Discussion

Non-Operative Management

Location: Salon I

The Non-Operative Management committee has put together a wonderful program about the different types of bracing, when to brace and non-traditional therapies as options to surgery.

FRIDAY, SEPTEMBER 25, 2009

Lunchtime Symposium

12:10 – 1:00 pm

Worldwide Conference/Global Outreach

Location: Salons I-J

- | | |
|----------------|---|
| 12:10-12:15 pm | Report from WWC in Argentina
Christopher L. Hamill, MD |
| 12:15-12:20 pm | Report from GOP site in Indonesia
Theodore A. Wagner, MD |
| 12:20-12:25 pm | Report from WWC in India
Munish C. Gupta, MD |
| 12:25-12:30 pm | Report from GOP site in Bulgaria
Francisco Perez-Grueso, MD |
| 12:30-12:40 pm | Report from GOP/ FOCOS program in Ghana, Trinidad, Barbados
Oheneba Boachie-Adjei, MD
Vincent Arlet, MD |
| 12:40-12:45 pm | Report from WWC in Brazil
John F. Sarwark, MD |
| 12:45-12:50 pm | Report from GOP site in Columbia
Anthony S. Rinella |
| 12:50-12:55 pm | Report from WWC in China
Charles E. Johnston, II, MD |
| 12:55-1:00 pm | Q&A |

Evidence Based Outcomes

Location: Salons A-F

James W. Wright, MD, MPH, FRCSC

Charles Fisher MD MHS (Epi) FRCSC

Evidence based medicine relates to treatment of spine deformity in children and adults. Come and learn what constitutes appropriate and sufficient "evidence" and explain how this evidence may vary by circumstance.

Social Events

Wednesday, September 23, 6:30 – 9:00 pm **Opening Ceremonies & Welcome Reception**

Opening Ceremonies: Marriott Rivercenter Hotel, Salons A-F

Welcome Reception: Salons A-F, Foyer

Open to all registered delegates and their registered guests at no additional fee.

Name badges are required.

The Annual Meeting will officially begin with Opening Ceremonies and this year's Howard Steel Lecture, presented by David Oshinsky, PhD who will speak on "Polio: A Look Back at America's Most Successful Public Health Crusade." The evening will include a presentation of the Walter B. Blount Humanitarian Award, an introduction of the SRS Officers and honored Presidents from other spine societies.

All registered guests are invited and encouraged to attend. Following the Opening Ceremonies, we'll move to a hosted reception featuring heavy hors d'oeuvres, cocktails, and plenty of lively conversation and reunions with colleagues and friends.

Thursday, September 24, 12:30 – 6:00 pm **Edgar Dawson Memorial Golf Tournament**

Buses Depart from the Marriott Rivercenter Hotel, meet in the Lobby

This year's tournament will be held at Westin LaCantara Resort, nestled in beautiful Texas Hill Country. Your golf clubs should be carried with you to the bus. If you are renting clubs, they will be ready upon your arrival at the course.

Thursday, September 24, 1:00 – 4:30 pm **Biking the San Antonio Mission Trail**

Meet in the Marriott Rivercenter Hotel at 12:30 pm

One of the country's few National Parks within an urban setting, the missions tell the early story of San Antonio and European expansion in the New World. We will begin our bike ride at the most famous of the Missions, Mission San Antonio de Valero, better known as the Alamo. Each guest will ride a hybrid style bicycle modified to their height and will be provided with a helmet to wear during the ride. After arriving at the fifth and last mission, guests will board a minibus for the trip back to the Alamo. Bottled water will be offered on the tour.

Thursday, September 24, 1:00 pm - 5:00 pm **Highlights of San Antonio**

Meet in the Marriott Rivercenter Hotel at 12:50 pm

Our first stop is the IMAX Theatre in River Center Mall. "Alamo...The Price of Freedom," the feature film, is a 45-minute docudrama that tells the story of the 189 defenders, Texan and Tejano, who chose to die for freedom in the Alamo. A box lunch will be served en route to the Imax Theater, and guests will enjoy a small popcorn and soda while they see the movie presentation. After this feature film, we will visit the famous Alamo, established in 1718 it was originally known as Mission San Antonio de Valero. Next, guests will enjoy a visit to our last stop the border-style El Mercado or Mexican Market. Serving as a hub of Commerce years ago, it has retained much of its charm of the past, with its quaint shops offering local crafts, art, clothing and food. For those who wish to remain and shop, a trolley token will be handed out with instructions on how to return to the hotel whenever they wish!

Friday, September 25, 1:00 pm - 5:00 pm **Cruisin' and Explorin' San Antonio**

Meet in the Marriott Rivercenter Hotel at 12:50 pm

The San Antonio River is the site of San Antonio's beginnings and the reason for its founding. It was named by a Franciscan missionary who passed through the area in 1691. The Riverwalk is the most visited site not only in San Antonio, but all of Texas. To begin the tour, guests will be escorted to the shops of La Villita. These buildings are home to a variety of specialty shops, galleries, jewelers and a candle maker. Our tour guide will share the significance of the buildings in telling our rich story and guests will have time to shop. Next we will have the opportunity to experience the river on a privately chartered river Cruiser. Our barge captain will provide historical and entertaining commentary as we pass through the pages of San Antonio history. We will enjoy a stop at San Fernando Cathedral, which has been at the center of San Antonio since its founding on March 9, 1731. We will disembark at the Paseo del Alamo, connects the river, known as the lifeblood of the city to the Alamo, its true heart. Our tour guide will point out the Alamo Cenataph, the Alamo and take you through the lobby of the historic Menger Hotel as we wrap up the tour.

Social Events

Friday, September 25, 1:00 pm - 5:00 pm

Spanish Mission Trail

Meet in the Marriott Rivercenter Hotel at 12:50 pm

One of the country's few National Parks within an urban setting, the missions tell the early story of San Antonio and European expansion in the New World. We will begin with the most famous of the Missions, Mission San Antonio de Valero, better known as the Alamo. Established in 1718, the Alamo played a pivotal role in history. Next we will explore the largest and most restored of the Missions, Mission San Jose. Known as the "Queen of the Missions", Mission San Jose was established in 1720. Guests will also have the opportunity to view the film 'Gente de Razón' which tells the story of the native people of 18th-century south Texas, their role in colonizing New Spain and the results of entering the Spanish missions. At our last stop, we will tour Mission Concepcion, the oldest un-restored mission church in Texas, established in 1731. Twin towers and a beautiful cupola helped make it a construction project of twenty-plus years. Rare original frescoes decorate the church's side rooms. Our tour guide will tell the stories of the two remaining missions. Originally christened San Jose de Los Nazonia while in East Texas, the reestablished Mission San Juan Capistrano made its permanent home along the banks of the San Antonio River in 1731. And last, Mission Espada, which was established in 1731 but was never completed. As an everlasting memory of the beautiful mission, every guest will receive a book of the Spanish Mission Trail for them to take home and enjoy.

Friday, September 25, 7:00 pm

Farewell Reception

Buses Depart from the Marriott Rivercenter Hotel Lobby, meet in the lobby

Ticket and Name badges are required

The 44th Annual Meeting culminates with a spirited evening at the Rio Cibolo Ranch. Delegates and their guests will enjoy early American history and tradition including a full Rodeo, live music, Longhorn bulls, and much more! Live entertainment, full dinner, and refreshments will be served.



San Antonio
Texas

Presenter Disclosures

Presenter Disclosures

It is the policy of American Academy of Orthopaedic Surgeons (AAOS) and Scoliosis Research Society to ensure balance, independence, objectivity, and scientific rigor in all its educational activities. All faculty participating in our programs are expected to disclose any relationships they may have with commercial companies whose products or services may be mentioned so that participants may evaluate the objectivity of the presentations. In addition, any discussion of off-label, experimental, or investigational use of drugs or devices will be disclosed by each of the faculty members. The options to disclose are as follows:

- a. Grants/Research Support
- b. Consultant
- c. Stock/Shareholder
- d. Speakers' Bureau
- e. Other Financial Support
- f. Over \$10,000

The Scoliosis Research Society does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the Annual Meeting & Course.

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San Antonio
Texas

Scientific Program

Session I – Adolescent Idiopathic Scoliosis

Moderators: John B. Emans, MD and John S. Blanco, MD

- 8:00-8:04 am
Paper #1 * **Prospective Analysis Comparing Anterior vs. Posterior Approach for Treatment of Thoracolumbar Idiopathic Scoliosis**
Mark A. Erickson, MD; Timothy R. Kuklo, MD, JD; John B. Emans, MD; Rolando M. Puno, MD; Richard E. McCarthy, MD; Spinal Deformity Study Group
- 8:04-8:08 am
Paper #2 **Short Segment Anterior Correction of Moderate Single Primary Curve Adolescent Idiopathic Scoliosis: Our Two to 12 Year Experience (Mean Follow-Up Six Years)**
Jwalant S. Mehta, MD; Takashi Kusakabe, MD; Robert W. Gaines, MD
- 8:08-8:12 am
Paper #3 **Prospective Radiographic and Clinical Outcomes and Complications of 756 Consecutive Operative Adolescent Idiopathic Scoliosis Patients**
Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Mark A. Erickson, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; Andrew G. King, MD; Charles E. Johnston, MD; Timothy S. Oswald, MD; Timothy R. Kuklo, MD, JD; Brenda A. Sides, MA; Spinal Deformity Study Group
- 8:12-8:21 am
Discussion
- 8:22-8:26 am
Paper #4 **A Novel Method for Assessing the Axial Plane in Scoliosis Demonstrates Uniplanar Screws Outperform Polyaxial Screws**
Aliasgar H. Dalal, BS; **Peter O. Newton, MD;** Vidyadhar Upasani, MD; Suken A. Shah, MD; Harms Study Group
- 8:26-8:30 am
Paper #5 **How Many Thoracic Pedicle Screws are Needed for the Correction of Lenke Type I Adolescent Idiopathic Scoliosis Curves?**
Juan Carlos Rodriguez Olaverri, MD; Nael Shanti, MD; Andrew A. Merola, MD; Carl Paulino, MD; Robert Getter, MD; Archit Patel, MD; Ignacio Alvarez, MD
- 8:30-8:34 am
Paper #6 **Pedicle Screw Constructs Provide Superior Thoracic Rib Hump and Lumbar Prominence Correction following Adolescent Idiopathic Scoliosis Surgery**
Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Daniel J. Sucato, MD, MS; Mark A. Erickson, MD; John B. Emans, MD; B. Stephens Richards, MD; **Mohammad Diab, MD;** Keith H. Bridwell, MD; Spinal Deformity Study Group
- 8:34-8:43 am
Discussion
- 8:44-8:48 am
Paper #7 **Predicting the Outcome of Selective Thoracic Fusion in False Double Major Lumbar “C” Cases With Five to 15 Year Followup**
Michael S. Chang, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Woojin Cho, MD; Christine Baldus, RN, MPH; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Brian A. O’Shaughnessy, MD
- 8:48-8:52 am
Paper #8 **Selective vs. Nonselective Fusion for Idiopathic Scoliosis: Does Lumbo-Sacral Takeoff Change?**
Mark F. Abel, MD; Justin Smith, MD, PhD; Christopher I. Shaffrey, MD; Charles A. Sansur, MD; Stephanie K. Herndon
- 8:52-8:56 am
Paper #9 **Instrumenting Into Non-Structural Proximal Thoracic Curves may Significantly Affect Shoulder Balance after Posterior Spinal Fusion**
John M. Flynn, MD; Matthew Garner, BS; Stephanie Cody, BS; Tracey Bastrom, MA; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Michael F. O’Brien, MD; Harms Study Group
- 8:56-9:00 am
Paper #10 **Postoperative Shoulder Height Assessment in AIS by Parents and Patients: Do Their Perspectives Correlate to Radiographic and Clinical Measurements**
Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; James O. Sanders, MD; Spinal Deformity Study Group
- 9:00-9:12 am
Discussion

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

9:13-9:17 am
Paper #11 * **Pulmonary Function in Adolescent Idiopathic Scoliosis Relative to the Surgical Procedure: A 10-Year Follow-Up Analysis**
Yevgeniy Gitelman, MD; Lawrence G. Lenke, MD; Joshua D. Auerbach, MD; Brenda A. Sides, MA; Keith H. Bridwell, MD

9:17-9:21 am
Paper #12 **Right Thoracic Curves in AIS - Which Clinical and Radiographic Findings Correlate with A Preoperative Abnormal MRI?**
B. Stephens Richards, MD; Daniel J. Sucato, MD, MS; Charles E. Johnston, MD; **Mohammad Diab, MD**; John Sarwark; Timothy R. Kuklo, MD, JD; Lawrence G. Lenke, MD; Stefan Parent, MD, PhD; Spinal Deformity Study Group

9:21-9:25 am
Paper #13 **Left Thoracic Curves Are Not a Mirror Image of Right Thoracic Idiopathic Curves**
Valerie L. Ugrinow, BA; Tracey Bastrom, MA; Eric S. Varley, DO; **Burt Yaszay, MD**; Peter O. Newton, MD; Harms Study Group

9:25-9:34 am
9:35-9:39 am
Paper #14 **Discussion**
Does Brace Treatment Leave A Scar in the Mind? Body Appearance and Quality of Life in Adult AIS Patients - Comparison Between Patients Brace Treated or Observed During Adolescence
Aina J. Danielsson, MD, PhD; Ralph Hasserius, MD, PhD; Acke Ohlin, MD, PhD; Alf Nachemson

9:39-9:43 am
Paper #15 **Does Bracing Alter the Clinical Course of Adolescent Idiopathic Scoliosis (AIS)?**
James W. Ogilvie, MD; Lesa M. Nelson, BS; Rakesh Chettier, MS; Kenneth Ward, MD

9:43-9:47 am
Paper #16 **Bracing Before Posterior Spinal Fusion with Instrumentation (PSFI) for Adolescent Idiopathic Scoliosis (AIS) is Associated With Reduced Satisfaction; Lower Activity Levels and More Pain at two Years After Operation**
Melinda S. Sharkey, MD; Daniel J. Sucato, MD, MS; John B. Emans, MD; Timothy S. Oswald, MD; Lawrence G. Lenke, MD; Steven Takemoto, PhD; Mohammad Diab, MD

9:47-9:56 am **Discussion**

9:56-10:16 am **Break**

Session II – Adult Spinal Deformity

Moderators: Serena S. Hu, MD and Howard A. King, MD

10:17-10:21 am
Paper #17 * **Prophylactic Vertebroplasty Proximal to Fusion Instrumentation to Prevent Proximal Junctional Problems in Osteoporotic Spine**
Mehmet Tezer, MD; Cagatay Ozturk, MD; Mehmet Aydogan, MD; **Ahmet Alanay, MD**; Meric Enercan, MD; Azmi Hamzaoglu, MD

10:21-10:25 am
Paper #18 **Proximal Thoracic vs. Thoracolumbar Stop Following Pedicle Subtraction Osteotomy for Adult Patients with Sagittal Imbalance: Which One is Better?**
Yongjung Kim, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Christopher L. Hamill, MD; Thomas D. Cha, MD, MBA; Samuel Cho, MD

10:25-10:29 am
Paper #19 **Does a Long Fusion (T3-Sacrum) Portend a Worse Outcome than a Short Fusion (T10-Sacrum) in Primary Adult Scoliosis Surgery?**
Brian A. O'Shaughnessy, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Woojin Cho, MD; Christine Baldus, RN, MPH; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD

10:29-10:38 am **Discussion**

10:39-10:43 am
Paper #20 * **Risk-Benefit Assessment of Surgery for Adult Scoliosis: An Analysis Based on Patient Age**
Justin Smith, MD, PhD; Christopher I. Shaffrey, MD; Steven D. Glassman, MD; Sigurd Berven, MD; Christopher L. Hamill, MD; William C. Horton, MD; Stephen L. Ondra, MD; Frank J. Schwab, MD; Charles A. Sansur, MD; Keith H. Bridwell, MD

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

- 10:43-10:47 am
Paper #21
Is There A Difference in Outcome Between Patients Under and Over Age 60 Who Have Long Fusions to the Sacrum for the Primary Treatment of Adult Scoliosis?
Brian A. O'Shaughnessy, MD; *Timothy R. Kuklo, MD, JD; Lawrence G. Lenke, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Christine Baldus, RN, MPH; Keith H. Bridwell, MD*
- 10:47-10:51 am
Paper #22
Degenerative Lumbar Scoliosis in Elderly Patients: Dynamic Stabilization Without Fusion vs. Posterior Instrumented Fusion
Mario Di Silvestre, MD; *Francesco Lolli, MD; Georgios Bakaloudis, MD*
- 10:51-10:55 am
Paper #23
Deterioration of Radiographic and Clinical Outcomes with Primary Treatment Adult Spinal Deformity Surgeries from Two Years to Three to Five Years Follow-Up
Keith H. Bridwell, MD; *Christine Baldus, RN, MPH; Sigurd Berven, MD; Charles C. Edwards; Steven D. Glassman, MD; Christopher L. Hamill, MD; William C. Horton, MD; Stephen L. Ondra, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Spinal Deformity Study Group*
- 10:55-11:07 am
Discussion
- 11:08-11:12 am
Paper #24
Interbody rhBMP-2 in Long-Segment Fusions for Adult Scoliosis: CT Scan; Radiograph and Clinical Analysis
Dennis Crandall, MD; *Jan Revella, RN*
- 11:12-11:16 am
Paper #25
Evaluation of Bone Marrow Aspirate vs. Bone Morphogenetic Protein (RhBMP-2) in Multilevel Adult Spinal Deformity Surgery: Minimum Two-Year Evaluation of Anterior Fusion Rates and Clinical Outcomes.
Eric H. Buchl PA-C; *Chantelle Freeman; Richard Hostin, MD; Cameron Carmody, MD; David H. Kim, MD; Alexis P. Shelokov, MD*
- 11:16-11:20 am
Paper #26
TLIF vs ALIF: A Matched Cohort Analysis of Caudal Interbody Grafting Strategies in Adult Spinal Deformity
Patrick T. O'Leary, MD; *Brian A. O'Shaughnessy, MD; Lawrence G. Lenke, MD; Brenda A. Sides, MA; Timothy R. Kuklo, MD, JD; Jacob M. Buchowski, MD; Keith H. Bridwell, MD*
- 11:20-11:29 am
Discussion
- 11:30-11:34 am
Paper #27
Major Complications in Primary Adult Deformity Surgery: Risk Factors and Clinical Outcomes at One Institution with Two to Six Year Follow-Up
Joshua D. Auerbach, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Kathleen McKeon, MD; Lukas P. Zebala, MD; Andrew H. Milby, BS; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Christine Baldus, RN, MPH
- 11:34-11:38 am
Paper #28
Outcomes and Complications of Extension of Previous Long Fusion to the Sacro-pelvis: Does Surgical Approach Make a Difference?
Douglas C. Burton, MD; *Oheneba Boachie-Adjei, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Richard Hostin, MD; Alexis P. Shelokov, MD; R. Shay Bess, MD; Behrooz A. Akbarnia, MD; International Spine Study Group*
- 11:38-11:42 am
Paper #29
The Cost and Benefits of Nonoperative Management for Adult Scoliosis
Steven D. Glassman, MD; *Leah Y. Carreon, MD, MSc; Christopher I. Shaffrey, MD; David W. Polly, MD; Stephen L. Ondra, MD; Sigurd Berven, MD; Keith H. Bridwell, MD*
- 11:42-11:51 am
Discussion
- 11:52-11:57 am
Harrington Lecture Introduction
Oheneba Boachie-Adjei, MD
- 11:58 am-12:18 pm
Harrington Lecture
John P. Kostuik, MD

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Session III – Early Onset Scoliosis/Cervical Deformity/Spondylolisthesis

Moderators: John P. Dormans, MD and Hee-Kit Wong, MD

- 8:00-8:04 am
Paper #30 *** Growing Rod Fractures: Risk Factors and Opportunities for Prevention**
Justin S. Yang, MD; Paul D. Sponseller, MD; George H. Thompson, MD; John B. Emans, MD; Muharrem Yazici, MD; Marc A. Asher, MD; Lawrence I. Karlin, MD; David L. Skaggs, MD; Peter O. Newton, MD; Connie Poe-Kochert, CNP; R. Shay Bess, MD; Rishi V. Kadakia, MD; Ashley Goldthwait, BS; Pooria Salari; Behrooz A. Akbarnia, MD
- 8:04-8:08 am
Paper #31 **The Role of Neuromonitoring in Growing Rod and Rib based instrumentation Surgery**
Daniel M. Schwartz, MD; Anthony K. Sestokas, PhD; Vidya M. Bhalodia, MS; Cheryl R. Wiggins, AuD; John M. Flynn, MD; William G. Mackenzie, MD; Suken A. Shah, MD; Peter G. Gabos, MD; Richard E. Bowen, MD; Alvin H. Crawford, MD; Eric J. Wall, MD; John P. Dormans, MD
- 8:08-8:12 am
Paper #32 **Can Infection Associated with Rib based instrumentation be Managed without Implant Removal?**
John T. Smith, MD; Melissa S. Smith; Candace L. Conyers, RN; Sarah A. Mumford, MBA
- 8:12-8:21 am
Discussion
- 8:22-8:26 am
Paper #33 **Lengthening of Dual Growing Rods: Is There a Law of Diminishing Returns?**
Wudbhav N. Sankar, MD; David L. Skaggs, MD; Muharrem Yazici, MD; Charles E. Johnston, MD; Pooya Javidan; Rishi V. Kadakia, MD; Thomas F. Day, MD; Behrooz A. Akbarnia, MD; Study Group Growing Spine
- 8:26-8:30 am
Paper #34 **Auto-Fusion of the Skeletally Immature Spine After Growing Rod Instrumentation**
Patrick J. Cahill, MD; Sean C. Marvil, BS; Corey Schutt, MD; Jocelyn R. Idema, DO; David H. Clements, MD; M. Darryl Antonacci, MD; Jahangir Asghar, MD; Amer F. Samdani, MD; Randal R. Betz, MD
- 8:30-8:34 am
Paper #35 **In Vivo Distraction Force and Length Measurements of Growing Rods: Which Factors Influence the Ability to Lengthen?**
Suken A. Shah, MD; Enrique Garrido, MD; Stewart K. Tucker, FRCS; Hilali Noordeen, FRCS
- 8:34-8:38 am
Paper #36 **Cotrel Derotation Casting For Progressive Infantile Scoliosis**
James O. Sanders, MD; Jacques D'Astous, MD; Marcie Fitzgerald, MPAS, PA-C; Joseph Khoury, MD; Shyam Kishan, MD, MB, MS, DNB; Peter F. Sturm, MD
- 8:38-8:50 am
Discussion
- 8:51-8:55 am
Paper #37 **Intraspinal Anomalies in Infantile Idiopathic Scoliosis: Prevalence and Role of MRI**
Joshua M. Pahys, MD; Amer F. Samdani, MD; Randal R. Betz, MD
- 8:55-8:59 am
Paper #38 **Do Growth Guidance Rods Have Acceptable Complications and Fewer Surgeries?**
Richard E. McCarthy, MD; Scott J. Luhmann, MD; Lawrence G. Lenke, MD; Frances McCullough, MNsc
- 8:59-9:03 am
Paper #39 **Submuscular Growing Rods: Technique; Results and Complications of 88 Patients with Minimum Two-Year Follow-Up**
Najma Farooq, MD; Enrique Garrido, MD; Farhaan Altaf, MBBS, BSc, MRCS; Joanne Dartnell, MRCS; Stewart K. Tucker, FRCS; Hilali Noordeen, FRCS; Suken A. Shah, MD
- 9:03-9:07 am
Paper #40 **V/Q Asymmetry Changes Following Rib based instrumentation Treatment of TIS**
Greg Redding, MD; Kit M. Song, MD
- 9:07-9:19 am
Discussion
- 9:20-9:24 am
Paper #41 **A Minimum Two-Year Comparison of Safety and Efficacy of Screw/Rod Constructs in the Pediatric Cervical Spine**
Jonathan J. Carmouche, MD; John E. Lonstein, MD; Robert B. Winter, MD; James D. Schwender, MD; Joseph H. Perra, MD

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- 9:24-9:28 am
Paper #42 **Cervical Kyphotic Deformity Increases Spinal Cord Intramedullary Pressure: A Cadaveric Study**
Albert Chavanne, MD; *David B. Pettigrew, PhD; Jeffrey R. Holtz, PA-C; Neal Dollin; Charles Kuntz, MD*
- 9:28-9:33 am **Discussion**
- 9:34-9:38 am
Paper #43 **Complication Rates in Pediatric Spondylolisthesis Surgery: A Dual Center 16 Year Retrospective Review**
Patrick J. Cahill, MD; Amer F. Samdani, MD; Jason R. Smith, PA-C; Craig Finlayson, MD; Sean C. Marvil, BS; Mark E. Tantorski, DO; Kim Hammerberg, MD; Jahangir Asghar, MD; Randal R. Betz, MD; Peter F. Sturm, MD
- 9:38-9:42 am
Paper #44 **Direct Repair of Spondylolysis Presenting Following Correction of Adolescent Idiopathic Scoliosis**
Wael Koptan, MD; *Yasser ElMiligui, MD; Wael Hammad, MD*
- 9:42-9:46 am
Paper #45 **Healing Rate for 124 Adolescent Lumbar Pars Interarticularis Fractures Treated Conservatively**
John W. McClellan; *Kay Ryschon, MS; Sarah Stamm, MPA-C*
- 9:46-9:50 am
Paper #46 **Spondylolisthesis Classification Based on Spino-Pelvic Alignment**
Hubert Labelle, MD; *Pierre Roussouly, MD; Eric Berthonnaud, PhD; Jean-Marc Mac-Thiong, MD, PhD; Michael T. Hresko, MD; John R. Dimar, MD; Stefan Parent, MD, PhD; Mark Weidenbaum, MD; Courtney Brown, MD; Serena S. Hu, MD*
- 9:50-10:02 am **Discussion**
- 10:02-10:22 am **Break**
- Session IV – Miscellaneous/Neuromuscular Deformity**
Moderators: Brian G. Smith, MD and Roger F. Widman, MD
- 10:23-10:27 am
Paper #47 **Three Dimensional Correction of Severe Rigid Neurofibromatosis Scoliosis**
Wael Koptan, MD; *Yasser ElMiligui, MD; Wael Hammad, MD*
- 10:27-10:31 am
Paper #48 **Thoracolumbar Kyphosis in Mucopolysaccharidosis I (Hurler Syndrome)**
Irfan Siddique, MBChB, FRCSOrth; *Raphael H. Sacho, MBBCh, MRCS(Eng); Neil Oxborrow, MD, FRCS (Tr-Orth), MbChb (Hons), BSc (Hons) Ed Wraith MB, ChB, FRCPC; J. Bradley Williamson, FRCS*
- 10:31-10:35 am
Paper #49 **Pelvic Radius Angle: An Essential Parameter for Sagittal Spinopelvic Alignment**
Roger P. Jackson, MD; *Anne C. McManus, RN; Jill Moore; Chris Hales*
- 10:35-10:44 am **Discussion**
- 10:45-10:49 am
Paper #50 **The Natural History & Fate of SRS Presentations (2000-04)**
Nanjundappa S. Harshavardhana, MS (Orth), Dip, SICOT; *Roshana Mehdian; James L. Nutt; Hossein S. Mehdian, MD, FRCS(Ed); Ujjwal K. Debnath, FRCS, MS/Orth*
- 10:49-10:53 am
Paper #51 **Comparing Financial Disclosure Reporting at Annual Spine Conferences**
Brian L. Ju, BS; *Christopher P. Miller; Peter G. Whang, MD; Jonathan N. Grauer, MD*
- 10:53-10:57 am
Paper #52 **Musculoskeletal Injuries Among Spine Surgeons: Results of a Survey of the SRS Membership**
Joshua D. Auerbach, MD; Zachary D. Weidner; Andrew H. Milby, BS; Mohammad Diab, MD; Baron S. Lonner, MD
- 10:57-11:06 am **Discussion**
- 11:07-11:11 am
Paper #53 **Neuromuscular Scoliosis in Children with SCI as a Function of Age; Time Since Injury; Neurological Level; Motor Level; and Injury Severity**
Louis N. Hunter, PT, MS; Amer F. Samdani, MD; Randal R. Betz, MD; Lawrence C. Vogel, MD; Ross S. Chafetz, PT, DPT, MPH; John Gaughan, PhD; Mary Jane Mulcahey, PhD

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

- 11:11-11:15 am
Paper #54 **Scoliosis Surgery in Duchennes Muscular Dystrophy; Peri-Operative Medical and Surgical Considerations**
Rolando Roberto, MD; Braden Boice, BS; Anto T. Fritz, MD; Hosun Hwang, MD; Andrew Skalsky, MD; Yolanda Hagar, MS; Laurel Beckett; Craig McDonald, MD; Munish C. Gupta, MD
- 11:15-11:19 am
Paper #55 **Long Term Results of the Galveston Technique for Pelvic Fixation in Neuromuscular Scoliosis**
Amr Abdelgawad, MD; Douglas G. Armstrong, MD, FRCSC; Connie Poe-Kochert, CNP; Jochen P. Son-Hing, MD, FRCSC; **George H. Thompson, MD**
- 11:19-11:28 am **Discussion**
- 11:29-11:32 am **2010 IMAST Preview**
Todd J. Albert, MD
- 11:33-11:36 am **2010 Annual Meeting Preview**
Nobumasa Suzuki, MD
- 11:37-11:40 am **Worldwide Course Preview**
Kamal Ibrahim, MD, FRS(c), MA
- 11:41-11:46 am **Introduction of President**
- 11:47 am -12:07 pm **Presidential Address**
Oheneba Boachie-Adjei, MD
- 12:07-1:07 pm **Lunch**

Session V – Basic Science/Trauma/Tumors/Complications/Infections

Moderators: Munish C. Gupta, MD and Kenneth MC Cheung, MD

- 1:07-1:11 pm
Paper #56 † **Quantification of Intradiscal Pressures Below Thoracolumbar Spinal Fusion Constructs: Is There Evidence to Support “Saving A Level?”**
Joshua D. Auerbach, MD; Baron S. Lonner, MD; Thomas J. Errico, MD; **Andrew L. Freeman, MS;** Derek Goerke, BME; Brian P. Beaubien, MS
- 1:11-1:15 pm
Paper #57 † **Influence of GDF-5 on Osteogenic Differentiation of Adipose-Derived Stromal Cells in A Three-Dimensional Microsphere Matrix (Plaga)**
Qing Zeng MD; Gary Balian, PhD; **Francis H. Shen, MD**
- 1:15-1:19 pm
Paper #58 † **Conditional Deletion of Fibronectin Results in a Scoliosis-Like Phenotype**
Qian Chen, MD; Hong Zhao; Jie Zhao; Donna M. Pacicca, MD; Prof Reinhard Fässler; Sarah L. Dallas, MD
- 1:19-1:28 pm **Discussion**
- 1:29-1:33 pm
Paper #59 † **Disc Health Preservation after Six Months of Spinal Growth Modulation: Expanding the Treatment Options for Fusionless Scoliosis Correction**
Vidhadhar V. Upasani, MD; Christine L. Farnsworth, MS; Reid C. Chambers; Tracey P. Bastrom, MA; Gregory M. Williams, MS; Robert L. Sah, MD, ScD; **Peter O. Newton, MD**
- 1:33-1:37 pm
Paper #60 **BMP-2 Use in the Presence of Spinal Cord Injury Elicits a Robust Intrathecal Signaling Cascade Which May be Detrimental to Neurologic Recovery**
Anton E. Dmitriev MSc, PhD(c); Suzanne Farhang, BSc; Ronald A. Lehman, MD; Geoffrey Ling, MD, PhD; Aviva J. Symes, MD
- 1:37-1:41 pm
Paper #61 **A New Model of Pediatric Spinal Cord Injury in Infant Piglets: Functional Outcome, MR Imaging, and Histopathology**
Amer F. Samdani, MD; W. Dalton Dietrich, PhD; Randal R. Betz, MD; Manuel Gonzalez-Brito, DO; John Kuluz, MD
- 1:41-1:50 pm **Discussion**

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

- 1:51-1:55 pm
Paper #62
† **Early Surgical Decompression With Duraplasty in Acute Spinal Cord Injury Improves Functional Recovery in an Animal Model**
Jeremy S. Smith, MD; Ryan Anderson; Thu Pham; Nitin Bhatia, MD; Oswald Steward, PhD; Ranjan Gupta, MD
- 1:55-1:59 pm
Paper #63
Spinal Shock in Spinal Cord Injuries - Is Duration of Shock Related to Neurological Level?
Rajeshwar N. Srivastava, MS (Ortho)
- 1:59-2:03 pm
Paper #64
Predictors of Complications Following Spinal Stabilization of Thoracolumbar Spine Injuries
John R. Dimar, MD; Charles Fisher, MD; Alexander R. Vaccaro, MD; David O. Okonkwo, MD, PhD; Marcel Dvorak, MD, FRCSC; Michael Fehlings, MD, PhD; Raja Rampersaud, MD, FRCs; Leah Y. Carreon, MD, MSc
- 2:03-2:12 pm
2:13-2:17 pm
Paper #65
Discussion
Classification of Spinopelvic Resections: Oncologic and Reconstructive Implications
Michael J. Yaszemski, MD, PhD; Peter S. Rose, MD; Bradford L. Currier, MD; Mark B. Dekutoski, MD; Paul M. Huddleston, MD; Ahmad Nassr, MD; Mark A. Pichelman, MD; Franklin H. Sim, MD
- 2:17-2:21 pm
Paper #66
En-bloc Excision of Chordomas in the Cervical Spine: Review of Five Consecutive Cases with Over Four-Year Follow-Up
Patrick C. Hsieh, MD; Gary Galia, MD, PhD; Daniel Sciubba, MD; Jean-Paul Wolinsky, MD; Ziya Gokaslan, MD
- 2:21-2:27 pm
2:28-2:32 pm
Paper #67
Discussion
*** Posterior Vertebral Column Resection in Severe Spinal Deformities: A Total of 102 Cases**
Cagatay Ozturk, MD; Mehmet Aydogan, MD; Mehmet Tezer, MD; Mercan Sarier, MD; Selhan Karadereliler, MD; Azmi Hamzaoglu, MD
- 2:32-2:36 pm
Paper #68
*** Major Complications of Three-Column Osteotomies in 240 Consecutive Spinal Deformity Patients**
Joshua D. Auerbach, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jennifer K. Sehn, BS; Andrew H. Milby, BS; David Bumpass, MD; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Lukas P. Zebala, MD; Brenda A. Sides, MA
- 2:36-2:40 pm
Paper #69
Sagittal Alignment Following Anterior Debridement and Posterior Instrumentation for Multiple Levels Tuberculous Spondylodiscitis
Wael Koptan, MD; Yasser ElMiligui, MD; Motaz SalahEIDin, MD; Wael Hammad, MD
- 2:40-2:49 pm
2:50-2:54 pm
Paper #70
Discussion
Incidence of Surgical Site Infection Following Adult Spinal Surgery and Analysis and Prevalence of Risk Factors
Albert Pull ter Gunne, MD; David B. Cohen, MD
- 2:54-2:58 pm
Paper #71
Rates of Infection Following Spine Surgery Based on 108,419 Procedures: A Report from the Scoliosis Research Society Morbidity and Mortality Committee
Justin Smith, MD, PhD; Christopher I. Shaffrey, MD; Charles A. Sansur, MD; Sigurd Berven, MD; Theodore J. Choma, MD; Michael J. Goytan, MD; Hilali Noordeen, FRCs; D. Raymond Knapp, MD; Robert A. Hart, MD; Reinhard Zeller, MD; William Donaldson, MD; David W. Polly, MD; Joseph H. Perra, MD; Oheneba Boachie-Adjei, MD
- 2:58-3:02 pm
Paper #72
Analysis of Risk Factors Associated with Post-Operative Acute Myocardial Infarction [AMI] in Spine Surgery
Andrew V. Slucky, MD; Ravi S. Bains, MD; Timothy Huang, MD

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

3:02-3:06 pm **Are Postoperative Dressing Changes Necessary?**
Paper #73 Ravi S. Bains, MD; Cary Idler, MD; Andrew V. Slucky, MD; Timothy Huang, MD; Kurt Van Peteghem; Josef Gorek, MD

3:06-3:18 pm **Discussion**

3:18-3:38 pm **Break**

Session VI – Diagnostic Methods/Etiology/Genetics/Natural History

Moderators: Frances A. Farley, MD and B. Stephens Richards, MD

3:39-3:43 pm *** Validity and Reliability of Intraoperative Monitoring in Pediatric Spinal Deformity Surgery: A 23 Year Experience of 3,436 Surgical Cases**
Paper #74 Earl D. Thuet; Jacquelyn C. Winscher, BS; Anne M. Padberg, BS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Matthew B. Dobbs, MD; Mario Schootman, PhD; Scott J. Luhmann, MD

3:43-3:47 pm **Blindness and Visual Evoked Potentials: A Novel Application of an Established Technique to Monitor Intra-Operative Visual Pathways**
Paper #75 Gregory M. Mundis, MD; Siavash S. Haghighi, MD; Jason E. Billingham, MD; Behrooz A. Akbarnia, MD

3:47-3:51 pm **Neurophysiological Changes in Deformity Correction of Adolescence Idiopathic Scoliosis with Intra-Operative Skull-Femoral Traction**
Paper #76 Randolph Gray, MBBS, FRACS; Laura Holmes, BSCh CNIM; Samuel Stranzas; Christian Zaarour, MD; Stephen Lewis, MD, FRCSC, MSc

3:51-3:55 pm **Is the Cost of Neuromonitoring with Motor Evoked Potentials for Deformity Surgery Justified?**
Paper #77 Timothy R. Kuklo, MD, JD; David W. Polly, MD; Mohammad Diab, MD

3:55-4:07 pm **Discussion**

4:08-4:12 pm **Study Testing Association of Genetic Markers of Melatonin Signaling and Biosynthesis to Predict Adolescent Idiopathic Scoliosis (AIS) or Curve Severity**
Paper #78 Lesa M. Nelson, BS; Kenneth Ward, MD; James W. Ogilvie, MD

4:12-4:16 pm **High Circulating Levels of Osteopontin Are Associated with Idiopathic Scoliosis Onset and Spinal Deformity Progression**
Paper #79 Alain Moreau, MSc; Anita Franco, MSc; Bouziane Azeddine, MSc; Pierre H. Rompré, MSc; Marie-Hélène Roy-Gagnon, PhD; Keith M. Bagnall, B.Ed, MSc, PhD; Benoît Poitras, MD; Hubert Labelle, MD; Charles H. Rivard, MD; Guy Grimard, MD; Jean Ouellet, MD; Stefan Parent, MD, PhD

4:16-4:22 pm **Discussion**

4:23-4:27 pm *** Results of the SRS-22 Patient Questionnaire: In Non-Scoliosis Group vs. Minimum 20 Years Clinical Outcome After Scoliosis Surgery**
Paper #80 Takahiro Iida, MD; Nobumasa Suzuki, MD, PhD; Yasumasa Ohyama, MD; Jyunya Imura, MD; Akihisa Ato, MD; Satoru Ozeki, MD; Yutaka Nohara, MD

4:27-4:31 pm **The Nature History of Scoliosis Secondary to Chiari I Malformation and Syringomyelia after Suboccipital Decompression in Young Patients**
Paper #81 Li Wei-guo, MD; Prof. Qiu Yong; Wang Bin, MD

4:31-4:37 pm **Discussion**

4:38-4:42 pm *** Two Decade Results in Surgical Management of Congenital Scoliosis**
Paper #82 Nanjundappa S. Harshavardhana, MS(Ortho), Dip, SICOT; Ujjwal K. Debnath, FRCS, MS/Orth; Michael P. Grevitt, FRCS (Orth); Hossein S. Mehdian, MD, FRCS(Ed); James Hegarty, RGN; John K. Webb, FRCS

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4:42-4:46 pm

Paper #83

The Efficacy and Complications of Posterior Hemivertebra Resection

Jianguo Zhang, MD; Guixing Qiu, MD; Bin Yu, MD

4:46-4:50 pm

Paper #84

Combined Anterior-Posterior Approach vs. Single Posterior Approach in Corrective Surgery with Osteotomy for Congenital Scoliosis

Noriaki Kawakami, MD; Taichi Tsuji, MD; Kazuyoshi Miyasaka, MD; Tetsuya Ohara, MD; Ayato Nohara, MD; Michiyoshi Sato, MD; Kenyu Ito, MD

4:50-4:59 pm

Discussion

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Session VII – Innovative Methods/Adolescent Idiopathic Scoliosis

Moderators: Haemish A. Crawford and John E. Lonstein, MD

- 8:00-8:04 am
Paper #85
Pediatric Cervical Spine Fixation: A Comparison of Complication Rates Associated With Screw/Rod Constructs vs. Non-Screw/Rod Constructs
Jonathan J. Carmouche, MD; John E. Lonstein, MD; Robert B. Winter, MD; James D. Schwender, MD; Joseph H. Perra, MD
- 8:04-8:08 am
Paper #86
Low Profile Pelvic Fixation Using S2 Alar Iliac (S2AI) Fixation in the Pediatric Population Improves Results at Two-Year Minimum Follow-Up
Paul D. Sponseller, MD; Ryan Zimmerman; Phebe S. Ko, BS; Khaled M. Kebaish, MD; Albert Pull ter Gunne, MD; Ahmed S. Mohamed, MD; Tai-Li Chang, MD
- 8:08-8:12 am
Paper #87
Withdrawn
- 8:12-8:21 am
Discussion
- 8:22-8:26 am
Paper #88
Multicenter Study of Posterior Vertebral Column Resection for Pediatric Deformity
Harry L. Shufflebarger, MD; Seth K. Williams, MD; Peter O. Newton, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Paul D. Sponseller, MD
- 8:26-8:30 am
Paper #89
Safety and Accuracy of Pedicle Screws Placed in Infantile and Juvenile Patients
Katsumi Harimaya, MD, PhD; Jochen P. Son-Hing, MD, FRCSC; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Richard M. Schwend, MD; Scott J. Luhmann, MD; Timothy R. Kuklo, MD, JD; Linda A. Koester; Brenda A. Sides, MA
- 8:30-8:36 am
Discussion
- 8:37-8:41 am
Paper #90
A More Distal Fusion is Associated with Increased Motion at L4/L5: A Set Up for Degeneration?
Michelle C. Marks, PT, MA; Peter O. Newton, MD; Maty Petcharaporn, BS; Tracey Bastrom, MA; Suken A. Shah, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Firoz Miyajji, MD, FRCS
- 8:41-8:45 am
Paper #91
Relation of Sacral Tilt with Idiopathic Scoliosis and its Postoperative Clinical Importance
Azmi Hamzaoglu, MD; Cagatay Ozturk, MD; Haluk Berk, MD; Fatih M. Korkmaz, MD; Meric Enercan, MD; Kursat A. Ganiyusufoglu, MD
- 8:45-8:49 am
Paper #92
Loss in Spinal Motion from Inclusion of a Single Mid-Lumbar Level in Posterior Fusion for Adolescent Idiopathic Scoliosis
Mark C. Lee, MD; Brian G. Smith, MD; Jeffrey Thomson, MD; Sylvia Ounpuu, MSc; Matthew J. Solomito, BSBE
- 8:49-8:58 am
Discussion
- 8:59-9:03 am
Paper #93
The Minimum Clinically Important Difference in SRS-22 Appearance; Activity and Pain Domains After Surgical Correction of Adolescent Idiopathic Scoliosis
Leah Y. Carreon, MD, MSc; James O. Sanders, MD; Mohammad Diab, MD; Peter F. Sturm; Steven D. Glassman, MD; Daniel J. Sucato, MD, MS; Spinal Deformity Study Group
- 9:03-9:07 am
Paper #94
Can We Predict Postoperative SRS Outcomes Scores in Adolescent Idiopathic Scoliosis?
James O. Sanders, MD; Leah Y. Carreon, MD, MSc; Dan J. Sucato; Peter F. Sturm, MD; Mohammad Diab, MD
- 9:07-9:11 am
Paper #95
Instrumentation Construct and SRS Scores
John P. Lubicky, MD; Jean Hanson, MD, Elizabeth H. Riley, MIS
- 9:11-9:20 am
Discussion

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- 9:21-9:25 am**
Paper #96 **Beta Tricalcium Phosphate as a Bone Graft Substitute for the Posterior Treatment of Adolescent Idiopathic Scoliosis: Results of a Prospective Clinical Study**
Suken A. Shah, MD; Petya Iorgova, MS; Mohamed H. Mohamed Ali, MD; Kenneth J. Rogers, PhDATC
- 9:25-9:29 am**
Paper #97 **Three-Stage Correction of Severe Rigid Idiopathic Scoliosis Using Halo-Gravity Traction**
Wael Koptan, MD; Yasser ElMiligui, MD; Motaz SalahEIDin, MD; Wael Hammad, MD
- 9:29-9:33 am**
Paper #98 **Correlation of Preop Curve Severity with Pulmonary Function Tests (PFTs) in AIS**
Charles E. Johnston, MD; B. Stephens Richards, MD; Daniel J. Sucato, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD; Spinal Deformity Study Group
- 9:33-9:42 am**
9:43-9:47 am
Paper #99 **Discussion**
Correction of Thoracic Hypokyphosis in AIS by Simultaneous Translation on Two Rods. Sagittal and Coronal Correction of 72 Patients with Two Years of Follow-Up
Jean-Luc Clement, MD; Edouard Chau, MD; Anne Geoffroy, MD; Marie-José Vallade
- 9:47-9:51 am**
Paper #100 **Are We Improving Postoperative Sagittal Contour with New Posterior Instrumentation Compared to 'Old School' Instrumentation?**
David H. Clements, MD; Randal R. Betz, MD; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Harms Study Group
- 9:51-9:55 am**
Paper #101 **Comparative Analysis of Sagittal Plane Measures Following Three Different Posterior Segmental Spinal Instrumented Fusion of AIS**
Yongjung Kim, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Oheneba Boachie-Adjei, MD; Paul Kim, MD; Youngbae B Kim, MD
- 9:55-9:59 am**
Paper #102 **Pedicle Screws and Stiff Rod Instrumentation Results in Restoration of Thoracic Kyphosis with No Proximal Junctional Problems in Thoracic Adolescent Idiopathic Scoliosis (AIS)**
Prof. Se-Il Suk, MD, PhD; Jin-Hyok Kim, MD; Sung-Soo Kim, MD; Chang-Won Jeong, MD; Dong-Ju Lim, MD
- 9:59-10:13 am**
10:14-10:18 am
10:18-10:36 am **Discussion**
Transfer of Presidency
Awards Presentations
Russell A. Hibbs Awards
Louis A. Goldstein Award
John H. Moe Award
Lifetime Achievement Awards
- 10:36-10:56 am** **Break**

Session VIII – Kyphosis/Adult Spinal Deformity

Moderators: Behrooz A. Akbarnia, MD and William C. Horton, MD

- 10:57-11:01 am**
Paper #103 **The Effect of Rib based instrumentation Treatment of Thoracic Insufficiency Syndrome on Sagittal Plane Alignment**
Peter F. Sturm, MD; Sahar Hassani, MS; Kristen Zaharski; Mary Riordan; Chest Wall and Spinal Deformity Study Group
- 11:01-11:05 am**
Paper #104 **Pedicle Subtraction Osteotomy at the Spinal Cord Level for Fixed Sagittal Imbalance**
Gregory P. Graziano, MD; Karl F. Bowman, MD; Frances A. Farley, MD
- 11:05-11:09 am**
Paper #105 **Body Mass Index in Scheuermann's Kyphosis (SK): Does BMI Differ in Patients with SK vs. Adolescent Idiopathic Scoliosis (AIS)?**
Baron S. Lonner, MD; Kristin E. Kean; Paul D. Sponseller, MD; Harry L. Shufflebarger; Suken A. Shah, MD; Alvin H. Crawford, MD; Randal R. Betz, MD; Peter O. Newton, MD

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

- 11:09-11:18 am **Discussion**
- 11:19-11:23 am **Paper #106**
Should Symptomatic Iliac Screws be Electively Removed in Postoperative Adult Spinal Deformity Patients Fused to the Sacrum?
Brian A. O'Shaughnessy, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Timothy R. Kuklo, MD, JD; Woojin Cho, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Linda A. Koester
- 11:23-11:27 am **Paper #107**
Does a Consensus Algorithm for Treating Adult Thoracolumbar and Lumbar Major Spinal Deformity Help Guide Optimal Treatment?
Frank J. Schwab, MD; Virginie Lafage, PhD; Keith H. Bridwell, MD; Steven D. Glassman, MD; Christopher I. Shaffrey, MD; Jean-Pierre C. Farcy
- 11:27-11:31 am **Paper #108**
Extension of Prior Idiopathic Scoliosis Fusions to the Sacrum: A Matched Cohort Analysis of 65 Patients with Minimum Two-Year Follow-Up. Can BMP Improve Outcomes?
Charles H. Crawford, MD; Keith H. Bridwell, MD; Woojin Cho, MD; Jacob M. Buchowski, MD; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD
- 11:31-11:40 am **Discussion**
- 11:41-11:45 am **Paper #109**
Sagittal Decompensation Following Pedicle Subtraction Osteotomy for Adult Patients with Sagittal Imbalance: Incidence; Risk Factors; and SRS Outcomes Score
Yongjung Kim, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Christopher L. Hamill, MD; Samuel Cho, MD; Youngbae B. Kim, MD
- 11:45-11:49 am **Paper #110**
Pelvic Retroversion Determines A Reciprocal Relationship Between Pelvic Incidence and Sacral Slope in Advanced Degenerative Disease of the Spine
Sergio A. Mendoza-Lattes, MD; Zachary Ries, BSc; Yubo Gao, PhD; Stuart Weinstein, MD
- 11:49-11:53 am **Paper #111**
Pedicle Subtraction Osteotomy in Older Patients with Degenerative Sagittal Imbalance
Kyu-Jung Cho, MD; Ki-Tack Kim, MD, PhD; Prof. Whoan Jeang Kim; Sang-Hun Lee, MD; Jae-Hoon Jung, MD; Hyung-Suk Kim, MD
- 11:53 am-12:04 pm **Discussion**
- 12:05-12:09 pm **Paper #112**
PSO Failures Can Be Predicted by High Pre-Op SVA and Pelvic Tilt
Virginie Lafage, PhD; Frank J. Schwab, MD; Justin Smith, MD, PhD; Jean-Pierre C. Farcy, MD; Oheneba Boachie-Adjei, MD; Alexis P. Shelokov, MD; Richard Hostin, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Michael F. O'Brien, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; International Spine Study Group
- 12:09-12:13 pm **Paper #113**
Analysis of the Correlation Between Adjacent Segment Degeneration and Spino-pelvic Alignment Following Surgical Treatment in Adult Scoliosis
Kirkham B. Wood; Gang Li, MD; Peter G. Passias, MD; Michal Kozanek; Andrew J. Schoenfeld, MD; Richard S. Lee, MD; Weishi Li, MD; Shaobai Wang, SM; Qun Xia; Prof. Guoan Li;hoenfeld; Richard S. Lee; Weishi Li; Shaobai Wang; Qun Xia; Guoan Li
- 12:13-12:17 pm **Paper #114**
Thoracic Pedicle Subtraction vs. Smith-Petersen Osteotomies for Correction of Sagittal Plane Deformity: A Case-Matched Series
Brian Hsu; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD; Timothy A. Garvey, MD; Joseph H. Perra, MD; James D. Schwender, MD; Manuel Pinto, MD; Daryll C. Dykes, MD, PhD; Francis Denis, MD; John E. Lonstein, MD; Robert B. Winter, MD
- 12:17-12:21 pm **Paper #115**
Efficacy of Prophylactic Placement of Inferior Vena Cava Filter in Patients Undergoing Spinal Surgery
Mehmet Aydogan, MD; Cagatay Ozturk, MD; Levent Onat, MD; Kursat A. Ganiyusufoglu, MD; Sinan Karaca, MD; Azmi Hamzaoglu, MD
- 12:21-12:33 pm **Discussion**
- 12:33 pm **Adjourn**

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Glossary of Spinal Deformity Biomechanical Terms

(Selected and adapted from White and Panjabi: Clinical Biomechanics of the Spine. Philadelphia: J. B. Lippincott, 1978).
Proposed by SRS Terminology Committee, 1999

Axes systems, etc. (See diagram)

Local, regional (spinal) and global axis systems (See Figure 1)

Vector - A quantity that possesses both a magnitude and a direction (e.g. force; velocity; displacement).

Loading

Force - An action that causes a body to displace or deform. (SI Unit of measure = Newton, i.e., N)

Tension Force - A force that tends to elongate a structure of material.

Compression Force - A force that tends to shorten a structure or material.

Moment or Torque - The sum of the forces applied to a structure multiplied by their perpendicular distance from a reference point or axis. (SI Unit of measure = Newton-metre, i.e., Nm)

Bending Moment at a point within a structure. (See Figure 2). The moment that tends to bend a structure. It is usually the sum of the moments due to several forces.

Couple - Two equal non-collinear forces producing a torque.

3-Point Bending (See Figure 3) - A structure is loaded in 3-point bending when a single force is applied on one side and two forces are applied on the other side acting in opposite directions.

4-Point Bending - (See Figure 3) - A long structure is loaded in 4-point bending when two transverse forces are applied on one side and two on the other.

Stress - The force per unit area of a structure and a measurement of the intensity of force (SI Units are Newtons/m²=Pascals. Hence 1 N/m² = 10⁶ N/mm² = 1 MPa).

Normal Stress - The intensity of force perpendicular to the surface on which it acts.

Shear Stress - The intensity of force parallel to the surface on which it acts.

Compressive Stress - A normal stress that tends to shorten a material.

Tensile Stress - A normal stress that tends to elongate a material.

Principal Stresses - The stresses normal to the principal planes of a material are called principal stresses.

Stress Concentration - A site of stress that is high compared to that of nearby sites in a structure or material. It is often caused by a sharp change in shape.

Center of Gravity - The point in a body in which the body mass is centered.

Displacement/Deformation

Absolute Motion - Motion of a rigid body relative to the global axis system.

Relative Motion - Motion of a rigid body relative to the local axis system of an adjacent body.

Rotation (Figure 4) - Motion of a rigid body in which a certain straight line within or adjacent to the body remains motionless. (That straight line is the axis of rotation)

Translation (Figure 4) - Motion of a rigid body in which a straight line in the body always remains parallel to itself.

Plane Motion - A motion of a rigid body in which the body moves in a single plane.

Degrees of Freedom (Figure 5) - The number of independent displacements that can occur in a mechanism (e.g. the spine and instrumentation) - total of possible displacements and rotations at all of the joints.

Instantaneous Axis of Rotation (Figure 5) - When a rigid body moves at every instant there is a line in the body or some hypothetical extension of it that does not move. For plane motion the axis of rotation becomes the center of rotation. Note: This applies to absolute motion of a single body, also to the relative motion of two bodies such as two vertebrae.

Bending - Deformation of a structure in response to a bending moment.

Neutral Axis - Line or axis within a beam or other structure about which bending occurs.

Strain - (Figure 6) Deformation divided by original length or thickness.

Normal Strain is defined as the change in length divided by the original length. Normal strain can be tensile or compressive.

Shear Strain - Shear deformation divided by the thickness perpendicular to the shear.

Plastic Deformation (Figure 7) - Deformation that remains after the deforming load is removed.

Load-Displacement, Stress-Strain Relationships

Elastic Behavior:

Stiffness - Relationship between load and deformation – the force applied divided by the deformation it produces.

Modulus of Elasticity - Relationship between stress and strain. (e.g., Young's modulus = normal stress divided by normal strain)

Torsional Rigidity - The applied moment or torque divided by the rotational deformation (torsion) that it produces.

Glossary of Spinal Deformity Biomechanical Terms

Time Dependent Behavior:

Creep - Time dependent deformation of a material resulting from the application of a constant load.

Viscoelasticity - Material behavior in which the resistance to deformation depends on the amount of deformation (elastic) and the rate of deformation (viscous).

Failure

Yield Stress - (Figure 7) Magnitude of stress on the stress-strain curve at which appreciable deformation takes place without any appreciable increase in the stress.

Ductility - Property of a material in which there is a large amount of deformation possible after the yield point. This implies that a large amount of deformation energy is absorbed by the material before failure. (opposite of brittle)

Fatigue - Eventual failure after repeated cycles of sub-failure loading. This usually occurs as a result of the process of the growth of cracks in structures subjected to repetitive load cycles.

Equilibrium - State of a system in which all forces and moments are balanced, hence it does not displace.

Free Body Analysis (Figure 8) - Equilibrium analysis in which a system is split into real or imagined components (free bodies), in order to check that each part is in equilibrium. It is also used for determining the internal stresses in a structure subjected to external loads.

Statics - The branch of mechanics that deals with the equilibrium of bodies at rest or in motion with zero acceleration.

Dynamics - The branch of mechanics that deals with motion of systems in which the accelerations of masses have significant effect.

Kinematics - The branch of mechanics that deals with motion.

Stability - Behavior of a system whereby it returns to its equilibrium position after being disturbed.

Buckling - A kind of instability in which a structure suddenly bends and collapses when a certain critical load is applied. The stable equilibrium position is a position of minimum potential energy – any displacement of the structure requires a net input of energy. Although stiffness or rigidity of a structure can contribute to its stability, stiffness and stability are not the same thing. When referring to the rigidity of, for example an instrumentation construct, use the term stiffness or rigidity, not stability.

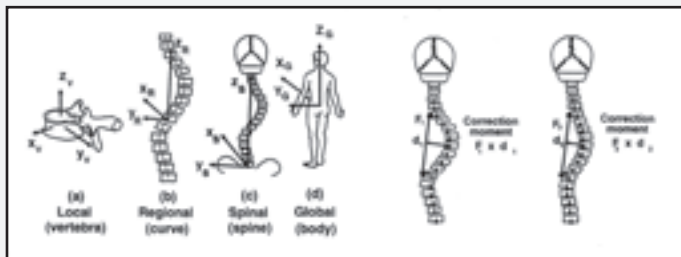


Figure 1. Local, regional (spinal) and global axis systems. Note: these are Cartesian systems, defined by three mutually perpendicular lines (axes).

Figure 2. Bending moment (produced here by the force in a Harrington rod) is the force multiplied by its perpendicular distance from a point in the structure (spine).

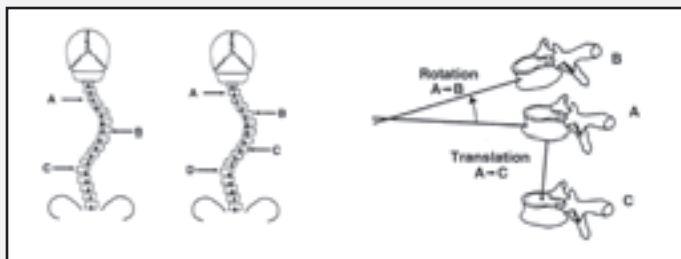


Figure 3. 3 and 4 point bending. For 3 point bending, the maximum bending moment is at point 'B'. For 4 point bending with four equal forces, the bending moment between forces 'B' and 'C' is uniform (constant).

Figure 4. Rotation and translation motion. The motion from A to B is a pure rotation, with an axis of rotation lying outside the vertebra. The motion from A to C is a pure translation.

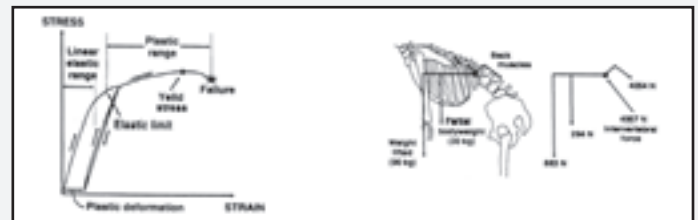


Figure 5. A motion segment has six degrees of freedom (i.e., six possible relative displacements of one vertebrae relative to its neighbor). The motion at any instant can be described as a translation along and a rotation about an instantaneous axis rotation.

Figure 6. Stress is the standardized measure of loading (force/unit area) and strain is the standardized measure of deformation (deformation divided by original length). (a) Normal stress and strain. (b) Shear stress and strain.

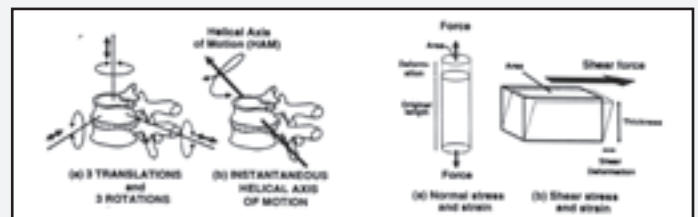


Figure 7. Stress-strain graph of a typical material. A sample was loaded past its elastic limit, unloaded to demonstrate plastic deformation, then loaded again to failure.

Figure 8. Simple static analysis (no motion occurring) of lifting mechanics to determine forces at the thoracolumbar junction. Here a free-body analysis is used. All forces acting on the upper part of the body must be in equilibrium (i.e., no net force or moment acting on the upper body) – otherwise it would be forced to accelerate.



San Antonio
Texas

Scientific Program Abstracts

Paper #1

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Prospective Analysis Comparing Anterior vs. Posterior Approach for Treatment of Thoracolumbar Idiopathic Scoliosis

Mark A. Erickson, MD (University of Colorado); Timothy R. Kuklo, MD, JD; John B. Emans, MD; Rolando M. Puno, MD; Richard E. McCarthy, MD; Spinal Deformity Study Group; Level of Evidence: III

Introduction: ASF with instrumentation is well established as an excellent method of treatment for TL/L idiopathic scoliosis. PSF with pedicle screw fixation has emerged as an option for treating these deformities. We wish to determine if comparable results can be obtained when treating these deformities by anterior or posterior approach.

Methods: Review of a large prospective multicenter database revealed 2634 AIS patients, 124 of whom have been treated for Lenke type 5 TL/L scoliosis with 2 years minimum follow up. 85 patients were treated with ASF and 39 patients with PSF. SRS scores, clinical and radiographic evaluations were performed pre and postop.

Results: The two groups were very similar in age (15.54 vs 15.26), BMI (21.02 vs 21.55), height (162.8cm vs 163.9cm), weight (55.72kg vs 57.53kg) and pre-operative curve (47.44 vs 45.28). EBL tended to be greater for PSF procedures, but did not reach statistical significance (522cc vs. 473cc, $p=0.08$). Statistical significance was reached in: total levels fused (PSF 5 vs. ASF 3.73, $p=0.005$); operative time (ASF 305 minutes vs. PSF 212 minutes, $p=0.0001$); median length of stay (ASF 5.0days vs PSF 4.0days); percent correction at two years post-op (PSF 73% vs. ASF 65%). No significant difference was noted between groups in the following pre and post-operative measures: coronal balance, sagittal balance, LIV tilt, scoliometer reading, shoulder height, and trunk shift. LIV minus LEV was evaluated between groups with a negative number implying an LIV cephalad to the LEV. For ASF patients LIV-LEV was 0(64%), -1(28%), -2(2%), -3(1%) and +1(5%). For PSF patients LIV-LEV was 0(49.5%), -1(18%), +1(30%), and +2(2.5%). SRS scores revealed no significant interactions by surgical approach, and no between groups differences were found.

Conclusion: Our data demonstrates that PSF allows for greater curve correction at the expense of more fused levels. In both groups the distal fusion level was most commonly the LEV. However, PSF procedures were more likely to be extended distal to the LEV. ASF procedures require significantly more operative time and have longer hospitalization. Surgical approach revealed no difference in SRS scores.

Significance: This multicenter study demonstrates that Lenke 5 curves can be treated by ASF or PSF with comparable results.

Paper #2

Short Segment Anterior Correction of Moderate Single Primary Curve Adolescent Idiopathic Scoliosis: Our Two to 12 Year Experience (Mean Follow-Up Six Years)

Jwalant S. Mehta, FRCS, MCh, MS (Columbia Orthopaedic Group); Takashi Kusakabe, MD; Robert W. Gaines, MD; Level of Evidence: IV

Introduction: Our short segment anterior technique produces similar results and outcomes for AIS patients with fewer levels fused than posterior segmental instrumentation. We present the results of the first consecutive 45 patients operated by the short segment bone-on-bone anterior scoliosis technique with a mean follow-up of 6 years.

Methods: The patients (28 thoracic; 17 thoracolumbar) were operated between 1996 and 2004 for single curve idiopathic scoliosis. The mean age was 19 yrs (9 - 51); 87 % were females and the mean follow-up was 72 months (range 28 - 121 months). The short segment anterior approach comprised of "total discectomy", bone-on-bone apposition and dual-rod instrumentation. We assessed the sagittal and coronal corrections on radiographs performed pre-operatively, post-operatively and at the final follow-up.

Results: A mean of 5 vertebrae (4 discs) were instrumented. The mean operative time 360 min, blood loss 877 ml and hospital stay 9.1 days. The thoraco-lumbar major curve was 50.5° (pre-op) and 18.3° (final).

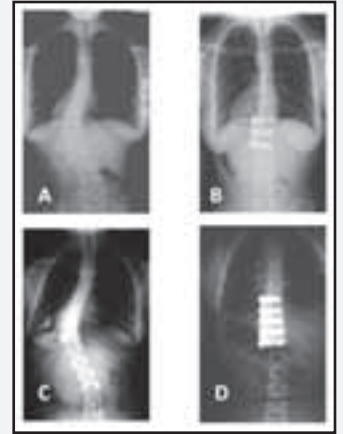
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Scientific Program Abstracts

(A, B) The lower tilt angle was 27.7° (pre-op) and 8.3° (final). The main thoracic curve was 52.5° (pre-op) and 27.9° (final). (C, D) The lower tilt angle was 20.9° (pre-op) and 11° (final). Spontaneous improvement in the compensatory curves of 37.4% (thoracic) and 47.5% (thoracolumbar). The sagittal and coronal balance was restored in all the patients. There was no loss of correction in the operated segment. There were no infections, or neurological, vascular, pulmonary or implant-related complications. Union occurred in all the patients in 2-4 months. All the patients were back to an un-restricted lifestyle within 4 months.

Conclusion: Our short segment bone-on-bone technique produces excellent, predictable correction of primary single curve adolescent idiopathic scoliosis with no loss of correction at mean 6 yrs follow-up.

Significance: When treating single major curves of AIS < 75° the short segment approach produces good clinical and radiological results with no loss of correction at 6 years. Every patient was followed over 2 years and none was lost to follow-up. This is achieved by instrumenting 5 vertebrae and 4 discs for patients with curves of 75 degrees or less.



Paper #3

Prospective Radiographic and Clinical Outcomes and Complications of 756 Consecutive Operative Adolescent Idiopathic Scoliosis Patients

Lawrence G. Lenke, MD (Washington University School of Medicine); Keith H. Bridwell, MD; Mark A. Erickson, MD; Daniel J. Sucato, MD; B. Stephens Richards, MD; Andrew G. King, MD; Charles E. Johnston, MD; Timothy S. Oswald, MD; Timothy R. Kuklo, MD, JD; Brenda A. Sides, MA; Spinal Deformity Study Group; Level of Evidence: IV

Introduction: Although multicenter analyses of the operative treatment of adolescent idiopathic scoliosis (AIS) has been performed by several groups, we are reporting the largest multicenter, prospective AIS database with consecutive patient enrollment from each site/center at a minimum 2-year follow-up.

Methods: A multicenter scoliosis prospective and consecutive database with 756 patients evaluated preoperative, first follow-up, and a minimum 2-year radiographic and clinical outcomes data as well as reported perioperative, early and late postoperative complications. Radiographs were digitized and validated software was then utilized for all radiographic measures.

Results: There were 611 females (81%) and 145 males (19%). The average age was 13.9yrs±2.2. Lenke curve patterns included: type 1 (main thoracic) n=356 (47%), type 2 (double thoracic) n=172 (23%), type 3 (double major) n=56 (7%), type 4 (triple major) n=29 (4%), type 5 (thoracolumbar/lumbar) n=94 (12%), and type 6 (thoracolumbar/lumbar-main thoracic) n=49 (6%). Lumbar modifiers: A: n=334 (44%), B: n=92 (12%), C: n=330 (44%). Sagittal modifiers: - (hypokyphosis) n=125 (16%), n (normokyphosis) n=549 (73%), and + (hyperkyphosis) n=82 (11%). Preoperative, first postop and 2-year follow-up Cobb measures averaged: proximal thoracic (PT) curve: 25°±11.9, 14°±9.3 and 15°±9.6; main thoracic (MT) curve: 56°±15.0, 20°±11.2 and 23°±11.9; and thoracolumbar/lumbar (TL/L) curve: 40°±13.3, 15°±10.9 and 15°±11.1 respectively. Complications were divided into perioperative (62 patients-8%, 3 with spinal cord deficit 0.39%); first month postop (88 patients-11.0%), and 2 years postop (105 patients-13.3%). Total SRS Outcomes scores improved from 3.91 to 4.29 postop (p<0.05). Although all domains improved significantly, the greatest improvement was in the appearance domain, which increased from 3.36 to 4.21 postop (p<0.05).

Conclusion: In this large prospective multicenter database with 756 consecutively enrolled patients. PT, MT and TL/L Cobb correction averaged 40%, 59% and 63% at 2-year follow-up. Perioperative, early postop, and 2-year postop complication rates slowly increased averaging 8%, 11.0% and 13.3% respectively. Total domain specific and SRS Outcome scores improved significantly.

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Paper #4

***A Novel Method for Assessing the Axial Plane in Scoliosis Demonstrates Uniplanar Screws Outperform Polyaxial Screws**

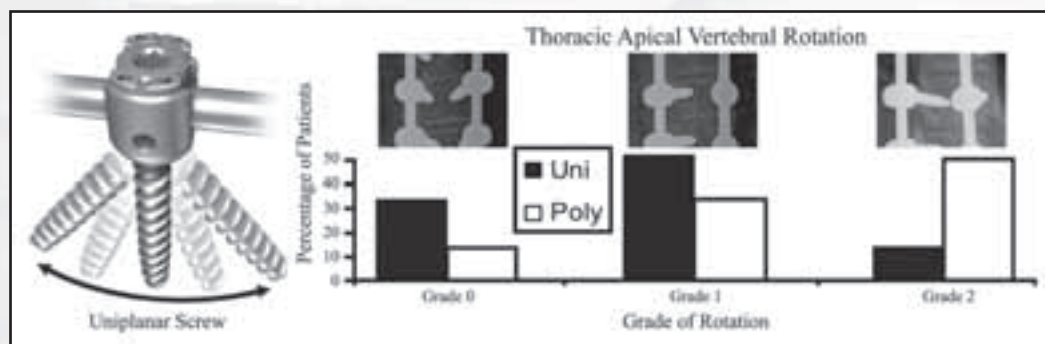
Aliasgar H. Dalal, BS; Peter O. Newton, MD (Rady Children's Hospital); Vidyadhar Upasani, MD; Suken A. Shah, MD; Harms Study Group; **Level of Evidence: III**

Introduction: The purpose of this study was to compare the correction of axial plane deformity in thoracic adolescent idiopathic scoliosis (AIS) achieved with uniplanar and polyaxial thoracic pedicle screw constructs.

Methods: A review of a multi-center database of Lenke Type 1-3 AIS patients who underwent surgical correction of thoracic AIS by posterior segmental pedicle screw instrumentation and fusion with either uniplanar or polyaxial pedicle screws and 5.5mm steel rod constructs was performed. Curves $> 100^\circ$ were excluded to control for the propensity to use polyaxial screws to correct larger curves. Apical vertebral rotation of thoracic curves was graded as 0, 1, or 2 based on an innovative CT scan validated radiographic method that uses the relative position of the screw tips to grade apical vertebral rotation at the 6 week and 1 year post-operative visit. By this method, higher grades correspond to greater residual apical vertebral rotation.

Results: 210 patients met inclusion. The uniplanar group included 95 patients while the polyaxial group had 115 patients. The mean pre-operative thoracic Cobb angle of $58 \pm 12^\circ$ and $60 \pm 13^\circ$ ($p=0.1$), first erect post-op coronal correction of 72% and 74% ($p=0.38$) and one year correction of 70% and 76% ($p=0.07$) were not significantly different between the uniplanar and polyaxial groups, respectively. At 6 weeks post-op, the uniplanar group had 34% of patients with grade 0, 52% with grade 1 and only 14% with grade 2 thoracic apical vertebral rotation. In the polyaxial group only 14% of patients were grade 0, 35% were grade 1 and 51% were the most rotated grade 2. This was a significant difference in the distribution of axial rotations ($p<0.001$), with greater axial correction with uniplanar screws. The same pattern of results was found at 1 year post-op ($p<0.001$).

Conclusion: There was little difference in the coronal plane correction of thoracic curves. However the uniplanar pedicle screw group had a larger proportion of patients with greater thoracic apical vertebral derotation (more complete axial correction) compared to the polyaxial screw group. This is likely attributed to the increase in rotational leverage afforded by uniplanar screws during intraoperative bilateral direct apical vertebral derotation maneuvers.



Paper #5

How Many Thoracic Pedicle Screws are Needed for the Correction of Lenke Type I Adolescent Idiopathic Scoliosis Curves?

Juan Carlos Rodriguez Olaverri, MD (Maimonides Medical Center); Nael Shanti, MD; Andrew A. Merola, MD; Carl B. Paulino, MD; Robert Getter, MD; Archit Patel, MD; Ignacio Alvarez, MD; **Level of Evidence: III**

Introduction: There is no clear consensus exists in the literature on how many screws are needed to get adequate correction of the curve and ultimately restore sagittal and coronal balance.

Methods: A retrospective radiographic review of 40 Lenke Type I AIS patients who underwent T4-L1 posterior instrumentation fusion was performed. Twenty were treated with thoracic pedicle screws at every

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level(Group I) and twenty were treated with thoracic pedicle screw at every level in the concave side and alternating levels in the convex side (Group II).There was a minimum 2-year follow-up. Average age at surgery was 13 years 9 months in group I and 14 years 2 months in group II. Evaluation included coronal proximal thoracic (PT), main thoracic (MT), and thoracolumbar/lumbar (TL/L) Cobb angles, the sagittal Apical rib hump (RH) deformity, the apical vertebral body ribs Ratio (AVB-R), and the apical rib spread Distance (ARSD). The overall cost of the two constructs were also calculated.

Results: There was no statistically significant difference with regard to the preoperative radiographic measurements. Postoperative follow-up in group I was 28 months and 29 months in group II. Both constructs provided excellent post-operative correction of the MT curves (66.9% vs. 66.6% for group I and II respectively; P 0.92), as well as good spontaneous correction of the PT (41.5% vs. 41.1%; P 0.92) and TL/L curves (54.8% vs. 54.3%). There was no statistical difference in the correction of the apical RH distance (13.6mm vs. 13.4 mm; P 0.092), AVB-R (65.7% vs. 65.4 %; P 0.092), and ARSD (82.5% vs. 81.8 %; P 0.091). There was an additional cost of \$4,800 on average when comparing group I to group II, for a total cost difference of \$96,000.

Conclusion: Both constructs provided excellent coronal and sagittal deformity correction. The additional expense incurred for the instrumentation, and the lack of evidence for improved radiographic outcomes demonstrated may not justified the use of pedicle screw at every segment.

Significance: By placing screws at every other segment in the convex side of the scoliotic curve we demonstrated similar sagittal and coronal correction to standard thoracic pedicle screw constructs.

Paper #6

Pedicle Screw Constructs Provide Superior Thoracic Rib Hump and Lumbar Prominence Correction following Adolescent Idiopathic Scoliosis Surgery

Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Daniel J. Sucato, MD; Mark A. Erickson, MD; John B. Emans, MD; B. Stephens Richards, MD; Mohammad Diab, MD; Keith H. Bridwell, MD; Brenda A. Sides, MA; Spinal Deformity Study Group; Level of Evidence: III

Introduction: Although pedicle screw (PS) constructs have shown superior radiographic correction vs hook and hybrid constructs, correlative clinical appearance data has been lacking. Our purpose was to evaluate the pre and postoperative clinical appearance of the thoracic rib hump and lumbar prominence via scoliometer measurements in adolescent idiopathic scoliosis (AIS) patients treated with PS, hook and hybrid constructs at a minimum 2-year follow-up.

Methods: A prospective multicenter database of 273 AIS patients was evaluated and divided into 3 groups: PS group n=132 patients, hybrid group n=114 patients, and hook group n=27 patients. All patients were treated with a posterior spinal fusion (PSF) with 26 (9.5%) having a thoracoplasty performed (hybrid-21, PS-4, hook-1). All patients had a minimum 2-year follow-up including radiographic data and thoracic and lumbar scoliometer measurements.

Results: The average preoperative major curve magnitude for the PS, hook, and hybrid constructs was: 56°, 58°, and 59° respectively (p>0.05). At 2 years postoperative, corresponding major curve Cobb magnitudes were: 18°, 23°, and 32° respectively (p<0.05 for both PS:hook and PS:hybrid comparisons). Preoperative thoracic scoliometer measurements for the PS, hook, and hybrid groups averaged: 15.5°, 14.8°, 16.1° (p=0.735); corresponding 2-year follow-up thoracic scoliometer measurements averaged: 7.3°, 11.1°, and 14.5° respectively (p=0.001, PS group smallest). Similarly, preoperative lumbar prominence averaged: 9.5°, 6.4°, and 6.7° (p=0.019 group PS largest); corresponding 2-year follow-up measurements averaged: 4.1°, 4.1°, 4.8° respectively (p=0.544 no difference between groups; however, PS improved the most; p<0.05). Furthermore, of the 26 patients undergoing thoracoplasty who averaged 15.2° on preoperative scoliometer measurement, they decreased to only 11.7° postoperative, which demonstrated a much larger residual thoracic prominence vs the PS group (7.3°) without thoracoplasty (p=0.026).

Conclusion: This study confirms superior thoracic rib hump and lumbar prominence correction via scoliometer measures in PS vs hook and hybrid constructs. Furthermore, the PS group was superior even to those hybrid and hook patients who had a thoracoplasty performed.

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Paper #7

Predicting the Outcome of Selective Thoracic Fusion in False Double Major Lumbar "C" Cases With Five to 15 Year Follow-Up

Michael S. Chang, MD; *Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Woojin Cho, MD; Christine R. Baldus, RN, MHS; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD;* **Level of Evidence: IV**

Introduction: The efficacy of selective thoracic fusion (STF) in lumbar "C" false double major curves is controversial. We examined the 5 to 15 year outcomes of patients with "C" lumbar curves who underwent STF at a single institution to determine which factors help predict successful outcome.

Methods: 32 patients (age 14.8±2.0 yrs) with a lumbar "C" modifier underwent primary selective thoracic fusion and had minimum 5 year follow up (mean 6.8 yrs). All patients were fused distally to either T12 or L1. At latest follow up, 18 were considered successful (group S), 2 required re-operation to accommodate worsening deformity (group R) and 12 were considered marginal outcomes (group M), as defined by >3cm coronal imbalance (n=5), >5mm worsening of lumbar apical vertebra translation compared with preop (n=4), >1 Nash-Moe grade worsening of lumbar apical vertebra rotation (n=1), >10 degrees of thoracolumbar junction kyphosis which was at least 5 degrees worse than pre-op (n= 5), and lumbar Cobb angle >5 degrees worse than pre-op (n=2).

Results: Of the multiple factors considered, 2 month post-op standing lumbar sagittal alignment was most predictive for long term outcome ($p < 0.019$ by Kruskal-Wallis ANOVA). Satisfactory outcomes had statistically significantly greater T12-S1 lordosis than those that were marginal (64.8° (S) vs. 52.0° (M), $p = 0.014$) or required reoperation (64.8° (S) vs. 38.0° (R), $p < 0.001$). Traditionally considered variables such as AVR, AVT, Cobb angle magnitudes, coronal and sagittal balance, and their respective thoracic to lumbar ratios were not independently significant.

Conclusion: Long term follow-up of selective thoracic fusion demonstrates efficacy in lumbar "C" modifier type curves, when careful consideration is given to ensure that lumbar lordosis is preserved.

Significance: Postoperative standing lumbar lordosis is the most predictive factor to success in selective thoracic fusions of false double major curves with a "C" lumbar modifier.

Paper #8

Selective vs. Nonselective Fusion for Idiopathic Scoliosis: Does Lumbo-Sacral Takeoff Change?

Mark F. Abel, MD (University of Virginia); *Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Charles A. Sansur, MD; Stephanie K. Herndon;* **Level of Evidence: III**

Introduction: In patients with idiopathic scoliosis having thoracic curves with compensatory lumbar curves, fusion of the thoracic curve can improve the lumbar curve, but can result in coronal decompensation or large residual lumbar curve. The LST is the angle between the central sacral vertical line and a line through the mid-points of L4-S1. LST has been suggested to remain unchanged following selective fusion using hook/rod systems, but some believe that with pedicle screw constructs, the lumbar curve correction and LST are improved. We hypothesized that selective fusion with pedicle screws will not alter LST or ALVT.

Methods: A prospective database of Lenke 1B/1C/3C idiopathic scoliosis patients was used to measure radiographic changes after deformity correction.

Results: 58 patients had selective (37) or nonselective (21) fusion. These groups did not differ with regard to preoperative thoracic or lumbar Cobb angle or LST ($P > 0.5$). Preoperative ALVT was greater for nonselective (-33mm) versus selective (-20mm) fusion groups ($P < 0.001$). At two-year follow-up, the thoracic curve was improved in both selective (62° to 29°, $P < 0.001$) and nonselective (60° to 23°, $P < 0.001$) fusion groups. The lumbar curve was improved for selective (42° to 23°, $P < 0.001$) and nonselective fusion groups (47° to 14°, $P < 0.001$). With nonselective fusion at two-year follow-up, both LST (16° to 9°, $P < 0.001$) and ALVT (-33mm to -14mm, $P < 0.001$) improved. In contrast, with selective fusion at two-year follow-up, there were no significant changes in LST (15° to 14°, $P = 0.6$) or ALVT (-20mm to -19mm, $P = 0.7$).

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Conclusion: In contrast to nonselective fusion, with selective fusion the mean ALVT and LST remain unchanged at two years, suggesting the potential of these parameters as predictors of residual lumbar deformity.

Paper #9

Instrumenting into Non-Structural Proximal Thoracic Curves may Significantly affect Shoulder Balance after Posterior Spinal Fusion

John M. Flynn, MD (Children's Hospital of Philadelphia); Matthew Garner, BS; Stephanie Cody, BS; Tracey Bastrom, MA; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Michael F. O'Brien, MD; Harms Study Group;
Level of Evidence: III

Introduction: As spinal instrumentation evolves, each generation of increasingly powerful corrective techniques (previously, CD instrumentation; now thoracic pedicle screws) has focused surgeon attention on proximal thoracic curves and shoulder balance. Observing cases of unexpected postoperative shoulder imbalance Lenke 1 & 3, we sought to answer the question: in ns-PT curves, is there a relationship between the upper instrumented vertebra, the apex of the ns-PT curve, and a change in clinical and radiographic shoulder balance measures?

Methods: From a multi-center AIS database, we identified every Lenke 1 or 3, min. 2 yr f/u, treated with posterior instrumented spinal fusion. We identified the upper instrumented vertebra, the apex of the ns-PT curve, and created 2 cohorts: those instrumented to or above the apex of the PT curve, and those instrumented below the apex of the PT curve. We then analyzed clinical and radiographic measures of shoulder balance in each cohort.

Results: In 95 patients with satisfactory clinical photographs, the change in PA shoulder angle was significantly greater if the instrumentation ended at or above the PT apex, versus below the apex (2.6° vs. 1.7° p=0.035). Analyzing radiographic measures, the T-1 rib angle was altered to a significantly greater extent in those instrumented to or above the UT apex (5.1° vs. 3.6°, p=0.05). The difference in change of radiographic shoulder height also approached statistical significance (0.10).

Conclusion: Clinical and radiographic shoulder balance is altered to a significant extent when posterior instrumented spinal fusion is extended to or above the apex of a nonstructural proximal thoracic curve.

Significance: With powerful posterior correction techniques, there is a risk of creating shoulder imbalance by instrumenting into nonstructural proximal thoracic curves.

Paper #10

Postoperative Shoulder Height Assessment in AIS by Parents and Patients: Do Their Perspectives Correlate to Radiographic and Clinical Measurements

Daniel J. Sucato, MD (Texas Scottish Rite Hospital) ; B. Stephens Richards, MD; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; James O. Sanders, MD; Spinal Deformity Study Group;
Level of Evidence: IV

Introduction: Surgeons strive to obtain level shoulders during surgical treatment for adolescent idiopathic scoliosis (AIS) relying on radiographic parameters and postop clinical appearance assessment. However, it is unclear whether parents and patients have a different perception of shoulder height symmetry than is measured by these parameters.

Methods: Multicenter prospective series of pts who underwent surgical treatment for AIS was reviewed to specifically assess shoulder height parameters preop and at 1 & 2yrs postop. Spinal appearance questionnaire (SAQ) from both parent and patient were reviewed, questions specifically pertaining to shoulder height were compared to the clinical exam and radiographic measurements.

Results: There were 2993 patients, average age of 14.8yrs. The preop/2 yr results for average PT curve were 23.5°/14.9°, main thoracic (MT) curve 54.3°/23.2°, shoulder height difference 1.7cm/1.1cm, T1 tilt 4.8°/4.8°

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and clavicle angle 2.6°/2.0°. Agreement between groups was higher at 1yr (69%) and 2yrs (65%) compared to preop (49%) (P<0.05). Both groups wanted "more even shoulders" less often at 1yr (21.2%/21.4%) and 2yr (16.0%/23.0%) compared to preop (86.2%/74.5%) (p<0.05). Preop, parent's and patients ratings of shoulder height correlated with coronal MT Cobb angle, clinical shoulder height measurements, and scoliometer readings of the PT and MT curve. (Table 1) For both groups who had rated shoulder height as the aspect of scoliosis that bothered them most, shoulder height difference correlated with MT scoliometer readings, T1 tilt and clavicle angle at 2yrs. Both groups responses to shoulder height symmetry correlated with the PT and MT Cobb, and clavicle angle; and with the clinical measurement of shoulder height and MT scoliometer reading.

Conclusion: Both groups have excellent agreement with respect to the status of shoulder height at 2yrs. Their assessment of shoulder height best correlates to PT and MT Cobb and clavicle angle and the rotational correction of the MT curve. Surgeons should always strive to maximize correction of these parameters especially for parents and patients who express preop concern about shoulder asymmetry.

Summary of ANOVA Results for Selected Radiographic and Clinical Measures (Significant p Values)			
	Baseline	One Year	Two Years
Parent - Shoulder Level Rating			
Proximal thoracic cobb angle	0.001	0.007	0.009
Main thoracic cobb angle	<.001	0.014	0.013
Thoracolumbar/lumbar cobb angle	0.011		
Thoracic sagittal alignment (T2-T5)			
Thoracic sagittal alignment (T5-T12)			<.001
Shoulder height difference (cm)	<.001		0.021
Proximal thoracic curve prominence	<.001	0.015	<.001
Main thoracic prominence (degrees)	<.001	0.028	0.012
Thoracolumbar/lumbar prominence			
T1 tilt angle (degrees)	<.001		0.020
Clavicle angle (degrees)			0.018
Child - Shoulder Level Rating			
Proximal thoracic cobb angle		0.008	0.016
Main thoracic cobb angle	<.001	<.001	<.001
Thoracolumbar/lumbar cobb angle		0.001	0.002
Thoracic sagittal alignment (T2-T5)			
Thoracic sagittal alignment (T5-T12)		0.006	
Shoulder height difference (cm)	<.001		<.001
Proximal thoracic curve prominence	<.001		
Main thoracic prominence (degrees)	<.001	<.001	0.001
Thoracolumbar/lumbar prominence			
T1 tilt angle (degrees)			
Clavicle angle (degrees)		<.001	<.001

Paper #11

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Pulmonary Function in Adolescent Idiopathic Scoliosis Relative to the Surgical Procedure: A 10-Year Follow-Up Analysis

Yevgeniy Gitelman, MD (Washington University School of Medicine); Lawrence G. Lenke, MD; Joshua D. Auerbach, MD; Brenda A. Sides, MA; Keith H. Bridwell, MD; Level of Evidence: III

Introduction: Pulmonary function is known to decline with increasing age. It is therefore of paramount importance to minimize pulmonary insult in children undergoing surgical treatment for adolescent idiopathic scoliosis (AIS) in order to maximize the remaining pulmonary reserves in adulthood. Although there are published reports on 2- and 5-year pulmonary function test (PFT) outcomes following various surgical approaches for AIS, the 10-year PFTs of these patients is unknown.

Methods: We performed a retrospective review of 49 patients divided into 2 groups who underwent surgery

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for AIS at a single institution. The mean patient age at final follow-up was 25.1 years. There were 46 females and 3 males. All Group 1 patients (n=38) had some form of chest wall disruption during their spinal fusion: Group 1a (n=17) underwent open anterior spinal fusion/instrumentation (ASFI), Group 1b (n=9) had a combined open anteroposterior spinal fusion (ASF/PSF), and Group 1c (n=12) had a PSFI with thoracoplasty. Group 2 patients (n=11) underwent PSFI with iliac crest bone graft and no chest cage disruption. We evaluated preoperative and 10-year PFT values.

Results: The mean follow-up in Group 1 was 10.7 years and in Group 2 was 10.9 years. Within-group comparison revealed that Group 1 patients experienced no change in FVC and FEV₁, but demonstrated a significant decrease in both the percent predicted FVC (85% vs 79%, p=0.0086) and FEV₁ (80% vs 76%, p=0.038). Conversely, Group 2 experienced a significant increase in both FVC (3.25 vs 3.66 L, p=0.011) and FEV₁ (2.77 vs 3.10 L, p=0.02), but no changes in percent predicted values from baseline to 10 years. No changes were noted in percent predicted values between 5- and 10-years in either group.

Conclusion: Any type of chest wall violation during surgery for AIS produced detrimental effects, as reflected by reduced percent predicted values at 10 years. Posterior-only procedures which spare the chest wall, however, showed significant improvements in absolute values of FVC and FEV₁ without any decline in percent predicted values.

Table 1: Average Change in PFT Values from Preop to Final Follow-up

	FVC (Liters)	% Predicted FVC	FEV ₁ (Liters)	% Predicted FEV ₁
Group 1 (n=38)	2.83 vs 2.95 (p=0.12)	85% vs 79% (p=0.00086)	2.45 vs 2.46 (p=0.78)	80% vs 76% (p=0.038)
Group 2 (n=11)	3.25 vs 3.66 (p=0.011)	85% vs 85% (p=0.93)	2.77 vs 3.10 (p=0.020)	84% vs 81% (p=0.92)
Difference in Change Between Groups	0.29 (p=0.062)	6.0% (p=0.16)	0.32 (p=0.018)	1.4% (p=0.74)

Paper #12

Right Thoracic Curves in AIS - Which Clinical and Radiographic Findings Correlate with a Preoperative Abnormal MRI?

B. Stephens Richards, MD (Texas Scottish Rite Hospital); Daniel J. Sucato, MD; Charles E. Johnston, MD; Mohammad Diab, MD; John F. Sarwark, MD; Timothy R. Kuklo, MD, JD; Lawrence G. Lenke, MD; Stefan Parent, MD, PhD; Spinal Deformity Study Group; Level of Evidence: III

Introduction: This study investigated preop AIS pts with right thoracic curves to determine which clinical and radiographic findings correlate with neural axis abnormalities on MRI, and which do not.

Methods: 529 AIS patients with Lenke 1-4 right thoracic curve patterns had MRI evaluation preoperatively. Thirty-six of these patients (6.8%) had abnormal MRIs (syrinx, chiari malformation, diastematomyelia, and/or tethered cord). To differentiate between those with normal MRIs (n=493) and those with abnormal MRIs (n=36), the following preop clinical parameters were evaluated: age, height, weight, asymmetric abdominal reflexes, thoracic rotation (scoliometer), coronal decompensation, trunk shift, shoulder elevation, and SRS-30 questionnaire. Radiographically, thoracic curve magnitude, thoracic rotation (Nash-Moe), coronal decompensation, trunk shift, length of thoracic curve, location of curve apex, sagittal balance, thoracic kyphosis (T2-T12), and lumbar lordosis were evaluated.

Results: Those with abnormal MRI findings were shorter in height by a mean difference 4.0 cm [p=0.04], had greater clinical thoracic rotation by a mean diff 2.40 [p=0.01], and had greater radiographic thoracic kyphosis by a mean diff 5.90 [p=0.04]. There was a trend for more asymmetric abdominal reflexes in the abnormal MRI group (6.1%) than in the normal MRI group (3.5%). There were no significant differences in: age (14.9 yrs vs 14.7 yrs), coronal decompensation (clinical or radiographic), trunk shift (clinical or radiographic), shoulder elevation, thoracic curve magnitude (61.40 normal MRI group vs 63.60 abnormal group), length of thoracic curves (7.0 segments normal group vs 7.2 segments abnormal group), location of curve apices, radiographic sagittal balance, or any domains of the preop SRS-30 questionnaire.

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Conclusion: 6.8% of preop AIS pts with right thoracic curves had neural axis abnormalities on MRI. Patients with short stature, increased clinical rotation and/or increased kyphosis are at higher risk for neural axis abnormality. Surgeons should utilize this information when contemplating whether a preop MRI is indicated in those with right thoracic AIS curve patterns. This information is not intended to be representative of the juvenile idiopathic scoliosis population.

Paper #13

Left Thoracic Curves Are Not a Mirror Image of Right Thoracic Idiopathic Curves

Valerie L. Ugrinow, BA; Tracey Bastrom, MA; Eric S. Varley, DO; **Burt Yaszay, MD (Rady Children's Hospital)**
Peter O. Newton, MD; Harms Study Group; **Level of Evidence: III**

Introduction: To determine if left thoracic adolescent idiopathic scoliosis (AIS) is merely a mirror image of the common right thoracic curve pattern.

Methods: A prospective multi-center AIS database was queried to identify 44 left (L) thoracic curves (Lenke 1, 2 or 3). These were compared to 895 right (R) thoracic curves collected over the same time period. The coronal and sagittal measures were compared with ANOVA ($p < 0.05$).

Results: The distribution of Lenke types differed slightly between groups (Lenke 1: 79% L, 71% R, Lenke 2: 9% L, 24% R, and Lenke 3: 11% L, 5% R, $p = 0.03$), with fewer double thoracic L curves. Age at surgery was similar between the groups (14.8 L, 14.6 R, $p = 0.5$). The coronal main thoracic Cobb angle at surgery was also similar between the groups (L: 55 ± 15 , R: 54 ± 11 , $p = 0.5$), suggesting a similar age of onset given the similarity in age at surgery. Sagittal plane differences were noted with thoracic kyphosis (T5-T12) significantly less in the R curves compared to L curves ($p < 0.001$). Although the two groups had similar lordosis ($p > 0.05$), the R curves also had increased pelvic incidence and sacral slope compared to L curves ($p < 0.05$, $p < 0.02$ respectively), see Table.

Conclusion: Although left and right curves appear nearly as mirror images in the coronal plane, the sagittal profiles were significantly different between these curve patterns. The decreased thoracic kyphosis found in the right thoracic curve patients (especially in the setting of increased pelvic incidence) is consistent with the theory of relative anterior thoracic spinal overgrowth as a cause for thoracic scoliosis.

Significance: The normal thoracic kyphosis and pelvic incidence found in the left thoracic curve patients is not consistent with the overgrowth theory and may signify another pathomechanism for this curve pattern development. This difference in sagittal alignment should also be kept in mind when planning surgical correction for left thoracic curves.

	Left Thoracic	Right Thoracic	P value
n	44	895	-----
Thoracic Kyphosis	$31^\circ \pm 15$	$22^\circ \pm 13$	<0.001
Lumbar Lordosis	$63^\circ \pm 15$	$60^\circ \pm 12$	0.2
Pelvic Incidence	$50^\circ \pm 13$	$55^\circ \pm 12$	<0.05
Sacral Slope	$38^\circ \pm 9$	$43^\circ \pm 9$	<0.02

Paper #14

Does Brace Treatment Leave a Scar in the Mind? Body Appearance and Quality of Life in Adult AIS Patients - Comparison Between Patients Brace Treated or Observed During Adolescence

Aina J. Danielsson, MD, PhD (Sahlgrenska University Hospital) Ralph Hasserius, MD, PhD; Acke Ohlin, MD, PhD; Alf Nachemson; **Level of Evidence: II**

Introduction: The previously published long term results of the prospective SRS brace study included two consecutive series of immature patients with AIS of moderate curve size (Cobb 25° - 35°). 77 out of the original 100 patients attended the complete follow up mean 16 years after maturity, 40 observed only and 37 brace treated patients. Both groups were equal in terms of age at FU (mean 32 y), curve size at inclusion (mean 30°) or at FU (mean 35° , 19° - 48°).

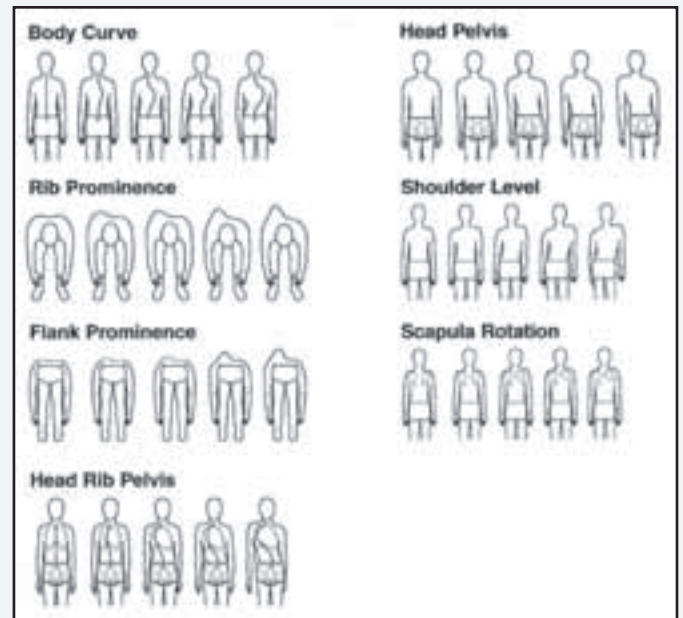
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Methods: Two quality of life questionnaires (SRS-22 and SF-36) were answered. Trunk asymmetry was measured with Bunnell scoliometer. The pictures of the Spinal Appearance Questionnaire were evaluated for the subjective opinion on body appearance, in which seven aspects of asymmetry are graded on a scale from 1-5, where 5 reflects the worst asymmetry. The points were then added (a total of seven points reflecting the least distorted appearance and 35 the most) and compared towards curve size, scoliometer readings and quality of life results.

Results: No difference was found between the groups in terms of trunk rotation, mean 10.7 (range 0-18) for observed only and 10.8 (range 5-18) for braced patients. Observed patients found their body appearance to be significantly less distorted than the braced patients, mean 12.9 (range 7-25) and 15.0 (range 7-29), $p=0.0028$ respectively. Scores for satisfaction with management and total score of SRS-22 were inversely and moderately correlated to the degree of distortion of the body appearance for both groups ($r_s = -0.50$ for braced and $r_s = -0.56$ for observed patients). The body asymmetry was not correlated to the function for any of the groups. For SF-36 domains the correlation coefficients were rather low and varied from -0.27 to 0.34 in the braced group and from -0.47 to 0.14 in the observed group.

Conclusion: Patients with less body asymmetry were more satisfied with treatment and the total score of SRS-22 was affected positively. Despite similar curve sizes as well as trunk rotation of braced and observed patients, the observed patients found their body appearance less distorted than the braced patients.



Paper #15

Does Bracing Alter the Clinical Course of AIS?

James W. Ogilvie MD; Lesa M. Nelson, BS; Rakesh Chettier, MS; Kenneth Ward, MD; Level of Evidence: III

Introduction: Bracing is a common method of treating moderate AIS in the growing patient. Outcomes are uncertain: curves do not progress in many untreated patients, while other patients will progress to the surgical range in spite of brace compliance. This study examines the effect of bracing on patients whose a priori risk of progression was calculated using DNA marker testing.

Methods: We determined the AIS progression test (AIS-PT) scores (scale of 1-200) in 2442 Caucasian females with known clinical endpoints who were never braced. We compared 308 patients who were compliant with various brace regimens and whose AIS-PT score and final outcome were known. Patients were enrolled over the last two years; consecutive patients with complete clinical records were included; a minimum of three years of follow-up data was required for inclusion. (Level II)

Results: The observed risk of progression to a severe curve, when stratified by the patients' AIS-PT, was not affected by the application of a brace. (See Figure 1 below)

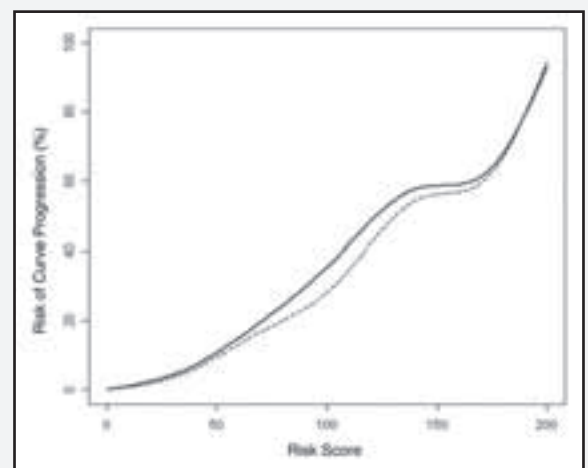


Figure 1:

- Solid Black Line= Data from "braced" plus "never braced" Caucasian females.
- Dotted Black Line= Data from Caucasian females who were never braced.

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Conclusion: In this observational study, in which genetic risk profiles are used to indicate a patient's baseline risk of progression, there is little evidence that appropriate bracing alters the risk of progressing to a severe curve. The trend toward a greater risk of progression in the braced population suggests that skilled surgeons may select higher risk cases for bracing. We cannot exclude a brace effect, but these data suggest any effect is modest at best.

Significance: Future AIS management trials needs to control for the wide gradation of baseline risk now detectable with genetic testing. Patients with a moderate curve and very different AIS-PT scores have very different a priori risks of progression; failure to account for this when studying new treatment paradigms can lead to erroneous conclusions about efficacy. Prognostic testing may allow more informed brace recommendations in the future.

Paper #16

Bracing Before Posterior Spinal Fusion with Instrumentation (PSFI) for Adolescent Idiopathic Scoliosis (AIS) is Associated with Reduced Satisfaction, Lower Activity Levels and More Pain at Two Years after Operation

Melinda S. Sharkey, MD; Daniel J. Sucato, MD; John B. Emans, MD; Timothy S. Oswald, MD; Lawrence G. Lenke, MD; Steven Takemoto, PhD; Mohammad Diab, MD; **Level of Evidence: III**

Introduction: An analysis of Scoliosis Research Society (SRS) and Spinal Appearance Questionnaire (SAQ) results was carried out for 609 patients treated with or without bracing prior to PSFI who took part in a multicenter, prospective, consecutive case series.

Methods: SRS and SAQ results for 281 braced and 328 unbraced (preoperative) patients with AIS were analyzed at 1 and 2 years after operation.

Results: There were no differences in age, gender, ethnicity, instrumentation type, preop curve type or magnitude, preop curve flexibility, curve correction, blood loss, number of levels fused and complications between braced and non-braced patients. Preoperatively, the nonbraced group was more satisfied with their treatment (3.7 v. 3.5 $p=.019$). The braced group was more likely to be bothered by their back shape compared to other body areas than the nonbraced group (54% v. 47% $p=.031$). Postoperatively, both groups had significant improvements with regard to pain (nonbraced group improved at a faster rate), activity scores, mental scores and satisfaction scores. However, patients who were braced showed lower activity scores (4.4 v. 4.3 $p=.031$), satisfaction scores (4.5 v. 4.4 $p=.007$), SRS total scores (4.4 v. 4.3 $p=.036$), and less improvement in back pain at rest at 2 years (27% v. 21% $p=.009$).

Conclusion: Although both braced and nonbraced patients with AIS showed significant improvements in quality of life measures (pain, activity, appearance, mental) 2 years after spinal fusion, braced patients appear to have a "Pre-surgical Signature" characterized by less overall satisfaction, lower activity levels and more pain compared with nonbraced patients.

Significance: This study demonstrates a difference in quality of life measures after posterior spinal fusion for AIS in patients who were and were not braced preoperatively.

Paper #17

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Prophylactic Vertebroplasty Proximal to Fusion Instrumentation to Prevent Proximal Junctional Problems in Osteoporotic Spine

Mehmet Tezer, MD; Cagatay Ozturk, MD; Mehmet Aydogan, MD; Ahmet Alanay, MD (Istanbul Spine Center); Meric Enercan, MD; Azmi Hamzaoglu, MD; **Level of Evidence: IV**

Introduction: The efficacy of proximal adjacent segment vertebroplasty to prevent proximal junctional kyphosis has been reported in some biomechanical cadaver studies. The aim of this paper is to present the mid-term clinical results of proximal segment vertebroplasty adjacent to fusion construct in term of

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prevention of proximal junctional kyphosis due to adjacent segment stress fracture.

Methods: Between the years 2003 and 2008, vertebroplasty in proximal uninstrumented segment adjacent to fusion construct was performed in 89 patients who had severe osteoporosis. Standing AP and lateral radiographs were reviewed at pre-op, immediate post-op and final follow-up. Proximal junctional kyphosis was defined as the change from immediate post-op to final follow-up in; thoracic kyphosis $\geq 10^\circ$, a change of $\geq 5^\circ$ in the supra-adjacent angle, a decrease of $\geq 20\%$ anterior height of the vertebra at proximal uninstrumented vertebra, or a decrease of $\geq 10\%$ anterior height of the vertebra. Early and late postoperative complications were recorded during follow-up.

Results: The mean postoperative follow-up was 44 (24-72) months. The average age of the patients was 67 (56-79) years. There were 54 female and 23 male patients. The instrumentation was done meanly at 7 (range; 4 to 11) segments. There were no proximal junctional segment fractures during the follow-up course. At final follow-up, none of the vertebroplasty cases required revision. In the vertebroplasty performed segments, there were no extravasation and subsequent thermal neural injury. Four superficial wound infections have been observed and they responded well to local debridement and antibiotics.

Conclusion: This is the first clinical serie which supports the previous biomechanical cadaveric studies about same issue and showing that there is benefit to do prophylactic vertebroplasty for the prevention of proximal adjacent segment stress fractures and related junctional kyphosis in osteoporotic spines. The amount of cement used should be less than normal to prevent further fractures through upper adjacent segments.

Paper #18

Proximal Thoracic vs. Thoracolumbar Stop Following Pedicle Subtraction Osteotomy for Adult Patients with Sagittal Imbalance: Which One Is Better?

Yongjung Kim, MD (Columbia University); Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Christopher L. Hamill, MD; Thomas D. Cha, MD, MBA; Samuel Cho, MD; Level of Evidence: III

Introduction: To compare the postoperative radiographic changes and revision prevalence as influenced by two different proximal levels following pedicle subtraction osteotomy for adult patients with sagittal imbalance.

Methods: A radiographic and clinical outcomes assessment in addition to revision prevalence of 121 adult lumbar deformity patients (average age 55.3 years) with a minimum 2-year follow up (average 4.3 years, range 2-12 years) who underwent pedicle subtraction osteotomy for adult patients with sagittal imbalance was performed based on their proximal fusion levels (PT Group: at or above T6, n=56; TL Group: at or below T9, n=65).

Results: Patients in PT and TL Groups had similar age at operation, follow-up, and co-morbidities. PT Group had more fused vertebrae (15.3 vs. 7.4, $p < 0.0001$) and longer operative time (11.9 hours vs. 7.7 hours, $p < 0.0001$) without significant difference in estimated blood loss (2877ml for PT vs. 2526 ml for TL, $p = 0.29$). TL Groups demonstrated a significant increase in their postoperative thoracic kyphosis (13 vs 5, $p = 0.002$) and a higher prevalence of sagittal decompensation (sagittal vertical axis $> 8\text{cm}$: 40% vs 20%, $p = 0.015$). The prevalence of pseudarthrosis was significantly higher in the PT Group (34% vs. 17%, $p = 0.031$). TL group demonstrated a trend of more revision surgery by proximal extension (9% vs 2%, $p = 0.12$). The total and subscale SRS outcomes scores were not statistically different.

Conclusion: Longer posterior spinal fusion to the PT spine resulted in less thoracic kyphosis change and obtained better sagittal balance following surgery. Pseudarthrosis occurred more with PT group. SRS outcome scores were similar at ultimate follow-up.

Significance: This is first study to compare two different proximal stops following lumbar pedicle subtraction osteotomy.

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Table 1. Radiographic Comparison Between PT and TL Groups (n=121)

	PT Group (UIV at or above T6) (n=56)	TL Group (UIV at or below T9) (n=65)	p-value
Thoracic Kyphosis (T5-T12)			
Preop	30±19.7°	24±19.2°	0.09
8 weeks postop	34±15.8°	35±15.7°	0.79
Ultimate follow-up	35±17.0°	38±18.0°	0.38
Ultimate follow-up to Preop	5±16.1°	13±12.4°	0.002
Lumbar Lordosis (T12-S1)			
Preop	-13±18.7°	-17±21.3°	0.36
8 weeks postop	-53±15.1°	-51±14.0°	0.34
Ultimate follow-up	-49±16.3°	-48±17.0°	0.58
Ultimate follow-up to Preop	-36±13.8°	-31±19.6°	0.11
Sacral slope			
Preop	20±15.1°	26±16.1°	0.037
8 weeks postop	34±11.1°	34±11.1°	0.99
Ultimate follow-up	33±11.8°	33±12.1°	0.80
Ultimate follow-up to Preop	13±8.5°	7±10.4°	0.002
Pelvic incidence			
Preop	54±13.7°	56±15.7°	0.46
8 weeks postop	55±13.6°	56±15.3°	0.80
Ultimate follow-up	57±13.1°	58±15.4°	0.69
SVA (C7 plumb to S1)			
Preop	144±59mm	143±63mm	0.91
8 weeks postop	14±48mm	40±52mm	0.004
Ultimate follow-up	41±54mm	64±66mm	0.040
SVA>8cm at ultimate	11/56 (20%)	26/65 (40%)	0.015

*Statistically significant if p<0.05

PT Group = Uppermost instrumented vertebra at or above T6

TL Group = Uppermost instrumented vertebra at or below T9

UIV=uppermost instrumented vertebra, PT=proximal thoracic, TL=thoracolumbar, Preop=preoperative, Postop=postoperative, SVA=sagittal vertical axis

Paper #19

Does a Long Fusion (T3-Sacrum) Portend a Worse Outcome than a Short Fusion (T10-Sacrum) in Primary Adult Scoliosis Surgery?

Brian A. O'Shaughnessy, MD (Washington University School of Medicine); Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Woojin Cho, MD; Christine R. Baldus, RN, MHS; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD; **Level of Evidence: III**

Introduction: We compared the upper thoracic (UT: T2-T5) and lower thoracic (LT: T9-T12) spine as the upper instrumented vertebra (UIV) in primary fusions to the sacrum for adult scoliosis. We hypothesized that: (1) UT would have an increased pseudarthrosis, more perioperative complications, and worse outcomes; (2) LT would have more proximal junctional kyphosis (PJK)

Methods: Patients who underwent primary surgery for adult scoliosis between 2002 and 2006 with a minimum 2-year f/u were studied. UT and LT were matched by age, diagnosis, BMI, comorbidities, and f/u. All patients were fused to the sacrum through a posterior approach. SRS scores and ODI were used.

Results: 58 patients (UT=20, LT=38), mean age 55.7 years, f/u 3.0±1.1 years. UT had greater preop thoracic kyphosis and coronal Cobb values (P<0.05). Diagnoses: idiopathic (75.9%) and de novo (24.1%). UT had greater fusion levels (15.8 vs 8.6) and mL of EBL (1350 vs 811). OR time, mg of rhBMP-2/level, and caudal interbody grafting (80.0%-UT vs 89.5%-LT; 90% ALIFs/10% TLIFs) were similar. All pts had iliac screws. UT had an

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increased number of perioperative complications (30.0 vs 13.2%), more pseudarthrosis (20.0 vs 5.2%), and a higher prevalence of revision surgery (20.0 vs 10.5%). LT had more PJK (20° of kyphosis 2 segments above the UIV) (18.4 vs 10.0%). SRS/ODI were improved in both cohorts in all domains (P<0.001) except function (P=0.07) and mental health (P=0.27), which were not significantly improved in the UT group.

Conclusion: With long fusions to the sacrum, one should anticipate more perioperative complications, a higher pseudarthrosis rate, and perhaps more revision surgery than short fusions. Short fusions may result in a more PJK which only rarely requires revision surgery. If patient and deformity characteristics permit, fusion to the LT spine will likely result in a better functional outcome.

Significance: In primary adult scoliosis surgery, long fusion from the upper thoracic spine to the sacrum results in a similar overall, but worse functional outcome than short fusion. We advocate the appropriate surgery for each patient based on intrinsic patient-related factors as well as the characteristics of the deformity.

Table 1. Within Group Comparisons of Clinical Outcome Measures (Preop vs Final)*

Upper Thoracic (UT; N=20)	Preop	Final	P-value
SRS Pain	2.85±0.73	3.95±0.88	<0.001
SRS Self Image	2.24±0.64	3.71±0.87	<0.001
SRS Function	3.04±0.86	3.38±0.71	0.073
SRS Mental Health	3.75±0.78	3.96±0.90	0.265
SRS Subscore	2.99±0.56	3.76±0.71	<0.001
Oswestry Disability Index	37.1±17.9	21.9±16.9	0.001
Lower Thoracic (LT; N=38)			
SRS Pain	2.73±0.89	4.03±0.71	<0.001
SRS Self Image	2.64±0.61	3.90±0.81	<0.001
SRS Function	3.03±0.81	3.66±0.81	<0.001
SRS Mental Health	3.61±0.68	4.29±0.69	<0.001
SRS Subscore	3.02±0.59	3.99±0.66	<0.001
Oswestry Disability Index	35.8±17.4	16.8±15.8	<0.001

Paper #20

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

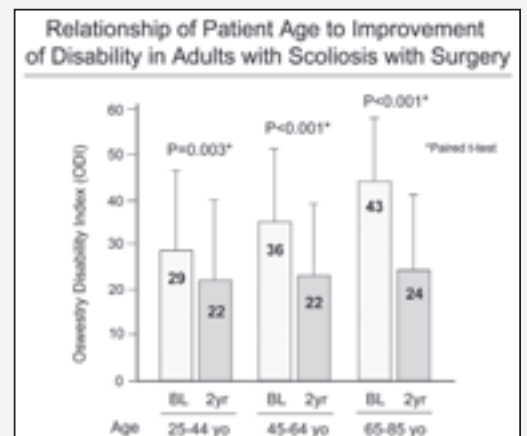
Risk-Benefit Assessment of Surgery for Adult Scoliosis: An Analysis Based on Patient Age

Justin S. Smith, MD, PhD (University of Virginia); Christopher I. Shaffrey, MD; Steven D. Glassman, MD; Sigurd Berven, MD; Christopher L. Hamill, MD; William C. Horton, MD; Stephen L. Ondra, MD; Frank J. Schwab, MD; Charles A. Sansur, MD; Keith H. Bridwell, MD; Level of Evidence: III

Introduction: Complications increase with age for adults undergoing scoliosis surgery. We assessed whether elderly patients undergoing scoliosis surgery have improvement in outcome measures that is at least comparable to younger patients, despite increased risk of complications.

Methods: This is a retrospective review of a prospective multicentered spinal deformity database (Level III). Patients complete the Oswestry Disability Index (ODI), SF-12 and SRS-22. Inclusion criteria included: age 25-85, scoliosis (Cobb angle ≥30 degrees), plan for scoliosis surgery and 2-year follow-up.

Results: Over a 5-year period, 206 of 453 patients (45%) completed 2-year follow-up, distributed among age groups as follows: 25-44 (n=47), 45-64 (n=121), and 65-85 (n=38). Perioperative



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complication rates were greater among older patients, with minor complication rates of 11%, 27% and 42% ($P=0.004$) and major complication rates of 6%, 15% and 29% ($P=0.02$) among patients aged 25-44, 45-64 and 65-85 years, respectively. At baseline older patients had greater disability (ODI, $P=0.001$) and worse health status (SF12-PCS, $P<0.001$). Mean SRS-22 did not differ significantly at baseline. Within each age group, at 2-year follow-up there were significant improvements in ODI ($P\leq 0.004$) and SRS-22 ($P\leq 0.001$). SF-12PCS did not improve significantly for patients 25-44 years old but did among those 45-64 ($P<0.001$) and 65-85 years old ($P=0.001$). Improvement in ODI was significantly greater among older patients (mean change, 25-44: -7; 45-64: -13; 65-85: -19, $P=0.003$), and there were trends for greater improvement in SF-12PCS ($P=0.08$) and SRS-22 ($P=0.047$) among older patients.

Conclusion: Elderly patients with scoliosis electing for surgical treatment have significantly greater disability and worse health status compared with younger patients. Despite increased complications, elderly patients undergoing scoliosis surgery had improvements in disability and health status that are at least comparable to younger patients.

Paper #21

Is there a Difference in Outcome between Patients Under and Over Age 60 who have Long Fusions to the Sacrum for the Primary Treatment of Adult Scoliosis?

Brian A. O'Shaughnessy, MD (Washington University School of Medicine); Timothy R. Kuklo, MD, JD; Lawrence G. Lenke, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Christine R. Baldus, RN, MHS; Keith H. Bridwell, MD; Level of Evidence: III

Introduction: The purpose of this study was to determine if there was a difference in outcome following fusion to the sacrum for the primary treatment of adult scoliosis in patients younger (Y) or older (O) than age 60.

Methods: Consecutive patients who underwent primary surgery for adult scoliosis from 2002-2006 were studied. Y and O cohorts were matched by diagnosis, BMI, comorbidities, extent of deformity, and f/u. All patients were fused to the sacrum (>6 levels) through a posterior approach. Minimum f/u for all patients was 2 years. SRS scores and ODI were used.

Results: 63 patients (Y=38, O=25), mean f/u 3.0 ± 1.1 years. Diagnoses: idiopathic ($n=45$; 71.4%) and de novo ($n=18$; 28.6%). Mean ages: Y= 51.8 ± 6.6 years; O= 65.8 ± 4.6 years. The groups had similar fusion levels (Y=10.8 vs O=11.6), mg of rhBMP-2/level (Y=6.4 vs O=8.3), mL of EBL (Y=1019 vs O=1174), and surgery time in hours (Y=7.3 vs O=7.4). Complications were higher in the O group, both perioperatively (Y=13.2% vs O=36.0%, $P=0.061$) and overall (Y=34.2% vs O=52.0%, $P=0.196$). Preop SRS function was worse in the O group (Y=3.2 vs O=2.8, $P=0.032$) and there were trends towards lower self-image, pain, subscore (4 domains minus satisfaction), and ODI ($0.05<P\text{-value}<0.10$). Both groups had improvements in all SRS domains and ODI at final f/u ($P<0.001$). Extent of improvement with surgery (i.e., change in SRS/ODI) was greater for the O cohort in: self-image ($P=0.020$), pain ($P=0.004$), subscore ($P=0.005$), and ODI ($P=0.035$). The percentage of patients who reached substantial clinical benefit from surgery (ODI increase >15) was also significantly higher in the older patients: (Y=44.7% vs O=72.0%, $P=0.041$).

Conclusion: Despite a higher rate of complications, patients over age 60 appear to sustain a greater benefit from long fusion to the sacrum for the primary treatment of adult scoliosis. This might be in part attributable to a more debilitated functional status in older patients prior to surgery based on the SRS outcomes instrument and the ODI.

Significance: This study strongly supports the benefit associated with surgical treatment of adult scoliosis in patients with an aging spine (i.e., greater than 60 years old).

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Table 1. Between Group Comparisons of Change in Clinical Outcome Measures

	Function		Self-Image		Mental Health		Pain		Subscore		ODI**	
	Y	O	Y	O	Y	O	Y	O	Y	O	Y	O
Preop	3.20	2.75	2.61	2.29	3.62	3.75	2.95	2.59	3.10	2.85	33.8	41.3
Final	3.66	3.53	3.80	4.03	4.06	4.43	3.98	4.16	3.87	4.04	18.2	17.6
Change	0.46	0.77	1.19	1.74	0.44	0.69	1.03	1.57	0.77	1.19	15.6	23.7
P-value	0.10583		0.02044		0.13644		0.00435		0.00495		0.03505	

**ODI=Oswestry Disability Index. Y=Young Group (age <60 years); O=Older Group (age >60 years).

Paper #22

Degenerative Lumbar Scoliosis in Elderly Patients: Dynamic Stabilization Without Fusion vs Posterior Instrumented Fusion

Mario Di Silvestre, MD(Istituto Ortopedico Rizzoli) ; *Francesco Lolli, MD; Georgios Bakaloudis, MD; Level of Evidence: III*

Introduction: Degenerative lumbar scoliosis is one of most common degenerative spine diseases in elderly patients. In last years the surgical treatment of these deformities included more often a posterolateral fusion with pedicle screw instrumentation in addition to decompression of neural elements, however with a high incidence of complications.

Methods: 54 elderly patients (46 F and 8 M; age 64.1 years, range 61 to 78) were included. Exclusion criteria: scoliosis angle >35°, sagittal imbalance, age <60 years, previous spinal fusion or instrumentation. Patients were divided into 2 groups according to surgical treatment made. 23 patients (DS Group) were treated with dynamic stabilization (Dynesys), 25 patients (PIF Group) with posterior instrumented fusion (always titanium instrumentation). The two groups were well matched according to age (65.3 vs 62.6 years), gender (female: 75.9% vs 72%), scoliosis Cobb angle (16.9° vs 19.2°), instrumentation extension (3.7 vs 4.3 levels).

Results: At a mean FU of 54 months (range 39 to 67), the questionnaires showed no statistically significant differences ($P > 0.05$) between 2 groups. ODI score improved in DS Group from a preop. score of 51.8% to 28% at last follow-up, in PIF Group from 52.7% to 30.2%. VAS score improved in DS Group from 6.7 to 3.4, in PIF Group from 6.5 to 3.8. There were differences according to mean surgical time (190 vs 245 min), blood loss (935 vs 1425 cc) and hospital stay (4.9 vs 7.5 days). Major complications occurred in 2 cases (6.9%) in DS Group (a sciatica due to a misplaced screw on L5, treated with screw replacement, and a junctional disc degeneration, treated with extension of fixation), in 4 cases (16%) in PIF Group (2 flat-back, treated with an extension of fixation to S1 in one case and with a correction through a PSO in the other case; a junctional kyphosis, treated with extension of fixation; a paraparesis due to a hematoma, treated by surgical drainage, but without neurological recovery).

Conclusion: These results showed that dynamic stabilization is a safe procedure in elderly patients with degenerative lumbar scoliosis. This technique resulted less invasive with minor surgical time, blood loss and complications rate (6.9% vs 16%) than posterior instrumented fusion.

Paper #23

Deterioration of Radiographic and Clinical Outcomes With Primary Treatment Adult Spinal Deformity Surgeries From Two Years to Three to Five Years Follow-up

Keith H. Bridwell, MD (Washington University School of Medicine); *Christine R. Baldus, RN, MHS; Sigurd Berven, MD; Charles C. Edwards, MD; Steven D. Glassman, MD; Christopher L. Hamill, MD; William C. Horton, MD; Stephen L. Ondra, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Spinal Deformity Study Group;*

* The FDA has not cleared a drug and/or medical device described in this presentation (i.e., the drug or medical device is being discussed in an off-label use). For full information see page 6.

Level of Evidence: IV

Introduction: Most analyses of primary presentation adult spinal deformity surgery assess 2-year follow-up (f/u). However, many events occur between the 2-year and 5-year points. Our hypothesis is that between 2-year and 3-5-year points patients will show significant reduction in outcomes by Scoliosis Research Society (SRS) and Oswestry Disability Index (ODI) and will show increasing thoracic kyphosis, loss of lumbar lordosis and loss of coronal and sagittal balance.

Methods: The cohort is 133 patients entered into a multicenter database with complete preop, 2-year and 3-5-year data. All patients had adult spinal deformity and surgical treatment represented their first surgical reconstruction. Diagnoses: 82.5% scoliosis, 10% kyphosis and 7.5% miscellaneous. Outcome measures and basic radiographic parameters (curve size, thoracic and lumbar sagittal plane, coronal and sagittal balance) were assessed at those 3 time intervals.

Results: The major curve (preop 55°, 2-year 29°, 3-5 year 23°), thoracic kyphosis T5 to T12 (32°, 32°, 32°) and lumbar lordosis T12 to sacrum (48°, 49°, 51°) did not change from the 2-year to ultimate f/u. Likewise, coronal and sagittal balance parameters were the same at 2-year and ultimate f/u. SRS total scores and modified ODI were identical at the 2-year and final f/u (SRS 3.89 to 3.90; ODI 19.5 to 18.82). Preop SRS total score was 3.08. Patterns were the same for patients aged 18 to 40, 41 to 60 and 61 and over.

Conclusion: Contrary to our hypothesis, we could not establish deterioration in radiographic or clinical outcomes between the 2-year and 3-5-year f/u points.

Significance: One should not anticipate a radiographic and clinical deterioration of the outcomes of surgically treated primary presentation adult spinal deformity patients in this studied time interval.

Paper #24

Interbody rhBMP-2 in long-segment fusions for adult scoliosis: CT scan, radiograph and clinical analysis

Dennis G. Crandall, MD; Jan Revella, RN; Level of Evidence: IV

Introduction: Achieving multi-level arthrodesis in adult scoliosis surgery is challenging. This is the first study of CT scan and clinical results in adult deformity patients treated with interbody rhBMP-2 and posterior instrumented fusions (PSF).

Methods: A retrospective review of prospectively collected data on 74 consecutive adults with scoliosis age 63 years (38-88 years) who underwent PSF at 8.8 levels (4-17 levels) using local autograft and allograft chips plus additional interbody arthrodesis using rhBMP-2, treated by one surgeon, followed 42 months (24-72 months). Prior surgery: 12 fusion, 6 laminectomy; 7 smoked. ALIF was used in 154 discs (ave 4.4) in 35 patients; structural allograft in 30, cages in 5. TLIF was used in 96 discs (ave 2.3) in 39 patients. Two had both ALIF+TLIF, 49 were fused to S1. BMP ranged 2-12mg/disk placed on absorbable collagen sponges. Oswestry (ODI) and pain scores (VAS) collected pre-op, 1 and 2 years. Radiograph measurements: scoliosis, sagittal T5-12, T10-L2, T12-S1, balance, and pelvic incidence; CT scan at 2 years on 67/74 patients were analyzed.

Results: 5 nonunions occurred in 5 patients, all at L5-S1; 2/35 with ALIF, 3/39 with TLIF. Nonunion was not associated with BMP dose: 2mg-34/34 discs fused, 4mg-52/54 fused, 6mg-46/47 fused, 8mg-12/14 fused, 12mg-5/5 fused. There were 6 adjacent fractures, 3 infections, 1 each DVT, PE, CVA, bowel obstruction. Adjacent degeneration occurred in 25. BMP related complication: 1 bony overgrowth after TLIF. ODI scores improved: 45.8 (12-94) pre-op to 25.5 (0-62) at 2 years and VAS improved: 6.3 (1-10) pre-op to 2.4 (0-8) at 2 years (P<0.05). Nonunion patients had worse ODI and VAS (P<0.03). Pre-op sagittal imbalance >10cm linked to nonunion (P<0.05).

Conclusion: Interbody rhBMP-2 use in adult scoliosis reliably leads to arthrodesis and improved outcomes in doses from 2mg/disc, ALIF or TLIF, with bone or cage support. BMP overgrowth occurred 1/250 discs. Nonunions only occurred at L5-S1 and had worse outcomes.

Significance: Interbody rhBMP-2 combined with posterior instrumented fusion is effective. The stress across L5-S1 in long fusions, especially in severe sagittal imbalance, continues to challenge arthrodesis, despite improved fusion rates with BMP.

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Paper #25

Evaluation of Bone Marrow Aspirate vs. Bone Morphogenetic Protein (RhBMP-2) in Multilevel Adult Spinal Deformity Surgery: Minimum Two-Year Evaluation of Anterior Fusion Rates and Clinical Outcomes

Eric H. Buchl, PA-C (Consulting Orthopedists); Chantelle Freeman; Richard Hostin, MD; Cameron Carmody, MD; David H. Kim, MD; Alexis P. Shelokov, MD; Level of Evidence: III

Introduction: Iliac crest bone graft remains the gold standard for achieving solid fusion in the adult deformity patient. However, poor local bone and long fusion constructs are obstacles in obtaining solid fusion. In recent years, a plethora of biological substitutes have been developed. To date, no direct comparison has been done in the adult deformity patient. The objective of this study was to evaluate fusion rates and outcome data of two commonly used biological substitutes for iliac bone graft in the adult deformity patient.

Methods: Retrospective consecutive patient cohort of primary surgical patients at a single site with adult deformity (avg age 52.2; range 24.9-66.1) who underwent anterior (avg 4.8; range 2-6) and posterior (avg 10.1; range 4-17) correction with instrumentation to the S1/pelvis, with a min of 2 year follow up were included (avg 2.2 yr; range 2.0-2.5). Patients were subdivided into two cohorts: Group 1: bone marrow aspirate and proceed through CELLECT® system then filter through HEALOS® sponges. Group 2: RhBMP-2 at 4 mg/level on an absorbable collagen sponge. One year and 2 year radiographs were graded by an independent blinded orthopedic deformity surgeon and a neuroradiologist. Preoperative and post-op Scoliosis Research Society (SRS) and Oswestry Disability Index (ODI) were used as outcome tools.

Results: Thirty five patients met inclusion criteria, 33 females, and 2 males. One patient was dropped for revision surgery prior to one year post op. Group 1 consisted of 25 females and no males with a total of 113 (avg 4.5 per patient) anterior lumbar interbody fusions (ALIF). Group 2 consisted of 8 females and 2 males with a total of 48 (avg 4.8 per patient) ALIFs. No statistical difference between the groups in age, anterior levels, posterior levels, pre-op deformity, post-op correction, final fusion rates (see chart# 1), and pre-op or post-op outcome questionnaires (chart# 2)

Conclusion: In adult spinal deformity patients, bone marrow aspirate as a biological substitute for iliac crest bone graft is equivalent to the use of bone morphogenetic protein (RhBMP-2) in fusion rates and patient outcome scores.

Significance: Bone marrow aspirate is equivalent to bone morphogenetic protein for fusion in the adult spine deformity patient.

Paper #26

*** TLIF vs ALIF: A Matched Cohort Analysis of Caudal Interbody Grafting Strategies in Adult Spinal Deformity**

Patrick T. O'Leary, MD; Brian A. O'Shaughnessy, MD; Lawrence G. Lenke, MD; Brenda A. Sides, MA; Timothy R. Kuklo, MD, JD; Jacob M. Buchowski, MD, MS; Keith H. Bridwell, MD; Level of Evidence: III

Introduction: Interbody grafting at the bottom of a long fusion is commonly performed in order to off-load posterior instrumentation and promote fusion. We hypothesized that TLIF would be an acceptable alternative to ALIF resulting in equally high fusion rates with no additional morbidity.

Methods: Consecutive adult patients who underwent TLIF at the base of a long deformity construct at a single institution between 2004 and 2007 having a minimum 2-year f/u were analyzed. TLIF patients were compared to a 21 patient ALIF cohort matched by age, diagnosis, comorbidities, f/u, and extent of deformity. SRS scores and ODI were utilized to assess clinical outcome.

Results: 34 patients, mean age 52.5±12.8 years, had 42 TLIFs performed (1.24±0.43 levels/pt). Mean f/u 2.32±0.6 years. Mean posterior fusion levels: 12.3±4.3. Diagnoses: idiopathic (n=23, 67.7%); degenerative (n=11, 32.3%). TLIFs were performed with titanium boomerang cages (n=25; 75.3%), mesh cages (n=3; 8.8%), and PEEK spacers (n=6; 17.7%). Graft was a combination of rhBMP-2+local autograft in 31/34 (91.2%)

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Chart 1

BMA One Year Fusion Grade						
Grade	1	2	3	4	5	Total
T11-T12	50%	50%	0%	0%	0%	100%
T12-L1	50%	50%	0%	0%	0%	100%
L1-L2	43.75%	53.13%	0%	3.13%	0%	100%
L2-L3	43.75%	56.25%	0%	0%	0%	100%
L3-L4	74.36%	25.64%	0%	0%	0%	100%
L4-L5	86.36%	13.64%	0%	0%	0%	100%
L5-S1	93.18%	6.82%	0%	0%	0%	100%
BMA two year Fusion Grade						
Grade	1	2	3	4	5	Total
T11-T12	100%	0%	0%	0%	0%	100%
T12-L1	75%	25%	0%	0%	0%	100%
L1-L2	53.85%	42.31%	0%	0%	3.85%	100%
L2-L3	61.54%	34.62%	0%	0%	3.85%	100%
L3-L4	78.57%	17.86%	0%	0%	3.57%	100%
L4-L5	84.38%	12.50%	0%	0%	3.13%	100%
L5-S1	93.75%	3.13%	0%	0%	3.13%	100%
BMP One Year Fusion Grade						
Grade	1	2	3	4	5	Total
T11-T12	N/A	N/A	N/A	N/A	N/A	N/A
T12-L1	0%	66.67%	0%	0%	33.33%	100%
L1-L2	50%	50%	0%	0%	0%	100%
L2-L3	62.50%	37.50%	0%	0%	0%	100%
L3-L4	90%	10%	0%	0%	0%	100%
L4-L5	100%	0%	0%	0%	0%	100%
L5-S1	100%	0%	0%	0%	0%	100%
BMP Two Year Fusion Grade						
Grade	1	2	3	4	5	Total
T11-T12	N/A	N/A	N/A	N/A	N/A	N/A
T12-L1	50%	50	0	0	0%	100%
L1-L2	40%	60	0	0	0%	100%
L2-L3	80%	20	0	0	0%	100%
L3-L4	100%	0	0	0	0%	100%
L4-L5	100%	0	0	0	0%	100%
L5-S1	100	0	0	0	0%	100%

Anterior fusion Grading system: 1 = Definite fusion, 2 = Probably fusion, 3 = Probably not fused, 4 = Not fused, 5= Could not be assessed

Chart 2

	BMA	BMP	p
SRS			
Pain			
preoperative	2.85	2.32	0.14
1 year	3.59	3.22	0.36
2 year	3.89	3.57	0.64
Function			
preoperative	3.43	3.3	0.72
1 year	3.8	3.73	0.85
2 year	4.14	3.94	0.68
Self Image			
preoperative	2.46	2.28	0.5
1 year	3.78	3.71	0.86
2 year	4.06	3.96	0.79
Mental health			
preoperative	3.49	3.37	0.65
1 year	3.99	3.96	0.9
2 year	4.05	4.05	0.99
Satisfaction			
preoperative	2.6	2.5	0.85
1 year	4.09	3.94	0.76
2 year	4.5	3.88	0.2
Total			
preoperative	3	2.83	0.47
1 year	3.84	3.68	0.63
2 year	4.08	3.89	0.63
ODI			
preoperative	29.55	40.6	0.11
1 year	17.73	24.67	0.33
2 year	17.6	18.5	0.93

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cases, local autograft and allograft in 3/34 (8.8%). Improvement in lumbar lordosis was similar between the 2 groups (TLIF=10.4°±24.4 vs ALIF=10.3°±13.9, P=0.988). Focal segmental and global sagittal vertical axis correction was also similar. The TLIF cohort was associated with shorter OR time in min (TLIF=525.4 vs ALIF=595.3), reduced hospital stay in days (TLIF=8.4 vs ALIF=13.6, P<0.001), and greater EBL in mL controlling for PSOs and VCRs (TLIF=1648.2 vs ALIF=1110.3, P=0.020). At final f/u all TLIFs and ALIFs were graded as fused by 2 independent surgeons. SRS/ODI outcomes were also significantly improved in both groups. 1 patient in the TLIF cohort had transient leg dysesthesia postop that resolved at 6 months. There was no case of graft migration in either group.

Conclusion: Both TLIF and ALIF are viable options for caudal segment interbody grafting as part of long fusions in adult spinal deformity. Advantages of TLIF include: one incision, a shorter hospitalization, and perhaps less total operative time. Moreover, the potential morbidity of an anterior retroperitoneal exposure is avoided.

Paper #27

Major Complications in Primary Adult Deformity Surgery: Risk Factors and Clinical Outcomes at One Institution with Two to Six Year Follow-Up

Joshua D. Auerbach, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Kathleen McKeon, MD; **Lukas P. Zebala, MD (Washington University School of Medicine)**; Andrew H. Milby, BS; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Christine R. Baldus, RN, MHS; **Level of Evidence: IV**

Introduction: We hypothesize the following: 1) there exist certain identifiable patient and surgery-related risk factors for developing a major complication, and 2) patients who sustain a major complication are at greater risk for less clinical improvement at 2-6yrs post-operatively compared with minor-only and no complications groups.

Methods: Assessment of 124 consecutive, primary adult deformity patients with a minimum age of 40yrs treated at a single institution from 2002-2006. All complications were identified and classified as either major or minor (Glassman, Spine, 2007). Risk factors for complications and their effect on ODI and SRS clinical outcomes were assessed.

Results: 120 females (age:56yrs, range 40-81) and 4 males met inclusion criteria. Diagnosis was adult scoliosis in 85% (105/124), degenerative scoliosis in 11% (14/124), hi-grade spondylolisthesis in 3% (4/124), and 1 kyphosis. There was 1 surgery-related death, no blindness or major neurologic deficits. The prevalence of complications was: 15% major (19/124) and 15% minor-only (19/124). Risk factors for major complications included age>60yrs (p=0.002), ≥3 comorbidities (p=0.006), osteoporosis (p=0.01), history of cancer (p=0.03), and fusion to sacrum (p=0.01). All groups (major, minor, and no complications) experienced statistically equivalent and significant improvement in SRS and ODI clinical outcomes from baseline (Table 1). Patients with major complications had similar SRS and ODI scores at baseline and at 2-6yrs follow-up were not statistically different than the minor-only and no complications groups (p>0.05).

Conclusion: Major complications can be expected in 15% of patients undergoing spinal fusion for primary adult deformity surgery. Older patients with osteoporosis, a history of cancer, ≥3 comorbidities, or fused to sacrum are predisposed to developing a major complication. The occurrence of a major complication does not have a negative impact on ultimate clinical outcome.

Significance: Surgeons should inform older patients with osteoporosis, a history of cancer, ≥3 comorbidities, or who will be fused to sacrum that their risk for major complications is higher, but that they ultimately do no worse than those who avoid major complications, provided there is no blindness or permanent neurologic deficit.

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Table 1. Within group comparisons (preop vs final)*

Major		Preop	Ultimate Follow-up (2-6 years)	P value
	Pain	2.80 ± 0.84	3.39 ± 0.84	0.02
	Self Image	2.29 ± 0.53	3.97 ± 0.76	<0.001
	Function	2.92 ± 0.79	4.26 ± 0.47	<0.001
	Mental Health	3.72 ± 0.73	3.63 ± 0.97	0.90
	Subscore	2.95 ± 0.55	3.82 ± 0.61	0.001
	ODI	37.22 ± 16.05	24.34 ± 16.27	0.005
Minor only				
	Pain	2.98 ± 0.92	3.36 ± 0.82	0.15
	Self Image	2.48 ± 0.64	3.52 ± 0.94	0.006
	Function	3.23 ± 0.84	3.58 ± 1.01	0.13
	Mental Health	3.39 ± 0.68	3.65 ± 0.90	0.35
	Subscore	3.04 ± 0.58	3.54 ± 0.78	0.007
	ODI	35.95 ± 20.11	26.89 ± 19.69	0.04
None				
	Pain	2.89 ± 0.80	3.65 ± 0.71	<0.001
	Self Image	2.58 ± 0.67	3.85 ± 0.72	<0.001
	Function	3.10 ± 0.79	4.03 ± 0.70	<0.001
	Mental Health	3.63 ± 0.73	3.88 ± 0.88	0.05
	Subscore	3.07 ± 0.58	3.87 ± 0.64	<0.001
	ODI	36.31 ± 17.39	19.66 ± 17.58	<0.001

*Plus-minus values are means±SD.

Paper #28

Outcomes and Complications of Extension of Previous Long Fusion to the Sacro-pelvis: Does Surgical Approach Make a Difference?

Douglas C. Burton, MD (University of Kansas Medical Center); *Oheneba Boachie-Adjei, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Richard Hostin, MD; Alexis P. Shelokov, MD; R. Shay Bess, MD; Behrooz A. Akbarnia, MD; International Spine Study Group; Level of Evidence: III*

Introduction: Few studies have reported the results and complication rates for extension of previous long scoliosis fusions terminating at L3, L4, or L5 to the sacro-pelvis. The purpose of this study was to evaluate the efficacy and complications of different surgical approaches to optimize spinal alignment correction in patients requiring revision spinal surgery with extension of fusion to the sacro-pelvis.

Methods: Retrospective, consecutive (1995-2006), multicenter, chart, HRQL, and radiographic review of adult deformity pts previously fused distally to L3, L4, or L5 receiving revision surgery to extend the fusion to the sacro-pelvis. Pts were divided into APSF (n=30) and PSF (n=14; 10 of 14 had either a PLIF or TLIF) approach groups. Pts were evaluated for pedicle subtraction osteotomy (PSO; n=13) or no PSO (n=31). Radiographic evaluation included coronal and sagittal spino-pelvic measures. Perioperative complications were noted.

Results: 44 pts of 54 eligible pts, mean age 49.0 yrs (21-73 yrs), had 2 yr radiographic data. Mean follow-up was 41.9 months (23-135 months). 41 of 54 pts had 2 yr SRS 22 scores. No statistically significant preoperative differences existed between the APSF and PSF groups, except the APSF group had a larger TL curve (p=0.011). Only pts receiving PSO had significant sagittal vertical axis (SVA) correction postoperatively

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($p=0.002$). Although not statistically significant, more complications occurred in APSF compared to PSF (14 vs 1; $p=0.092$; Table 1). Table 1 indicates that there was no difference in: 1) total complications PSO vs no PSO, 2) total pseudarthroses PSF vs APSF, and 3) post-op HRQL outcomes between pts with or without complications.

Conclusion: Posterior approach with osteotomy achieved equivalent sagittal spinal alignment and post-op HRQL scores without an increase in pseudarthrosis rates compared to APSF in pts undergoing revision surgery with extension of fusion to the sacro-pelvis. PSO achieved a statistically significant improvement in SVA correction without increasing complications. Post-op HRQL outcomes were equivalent to the published literature of primary surgery to the pelvis.

Approach Group	PSO Group	SVA ³ Correction (cm)	Post-Op SVA (cm)	Post-Op SRS 22	Complications	Pseudo
Anterior/Posterior (n=30)	PSO ¹ n=9	Mean = 8.00 Median = 5.55 (0.02 – 17.90)	Mean = 1.05 Median = 2.50 (-6.9 – 6.0)	Mean = 3.68 Median = 3.88 (2.60 – 4.60)	2 (in 2 patients)	2
	No PSO ² n=21	Mean = 3.34 Median = 2.70 (-3.68 – 15.00)	Mean = 2.83 Median = 1.70 (-3.5 – 10.0)	Mean = 3.70 Median = 3.94 (2.00 – 4.64)	12 (in 8 patients)	2
Posterior Only (n=14)	PSO ¹ n=4	Mean = 5.92 Median = 4.34 (1.55 – 13.45)	Mean = 1.51 Median = 1.55 (-0.5 – 3.4)	Mean = 3.80 Median = 3.80 (3.80 – 3.80)	0	0
	No PSO ² n=10	Mean = 0.34 Median = 0.25 (-7.91 – 8.40)	Mean = 4.14 Median = 4.30 (0.0 – 9.0)	Mean = 3.77 Median = 3.70 (2.70 – 4.80)	1 (in 1 patient)	0

¹PSO: patients that had a pedicle subtraction osteotomy
²No PSO: patients that had Smith-Petersen osteotomy or no osteotomy
³Sagittal Vertical Axis (C7-S1 offset)

Paper #29

The Cost and Benefits of Nonoperative Management for Adult Scoliosis

Steven D. Glassman, MD (Kenton D. Leatherman Spine Center); Leah Y. Carreon, MD, MSc; Christopher I. Shaffrey, MD; David W. Polly, MD; Stephen L. Ondra, MD; Sigurd Berven, MD; Keith H. Bridwell, MD; **Level of Evidence: II**

Introduction: Scoliosis is a frequent finding in adults, and these patients often use non-operative resources. A 2007 systematic review of nonsurgical treatment in adult scoliosis concluded that evidence for nonoperative care was lacking. This study quantifies the use, cost, and effectiveness of nonoperative treatment for adult scoliosis.

Methods: Adult scoliosis patients treated nonoperatively, were prospectively enrolled in a multi-center database in which SRS-22, SF-12, and ODI were collected. Outcomes were measured as change in HRQL from baseline, and as percentage of patients reaching a minimal clinically important difference (MCID) for ODI and SF-12 PCS at two year follow-up. Duration of use and frequency of visits were collected for eight modalities: medication use, physical therapy, exercise, injections/blocks, chiropractic care, pain management visits, bracing, and bed rest. Direct costs were determined using the Medicare Fee schedule. Indirect costs were not included. Statistical analysis was performed for treated and untreated groups as well as for high (ODI>40), mid (ODI = 21 to 40) and low (ODI≤20) symptom patients. Differences were evaluated using ANOVA.

Results: In the 123 patients (90% females, mean age = 53.3 years), 55 patients had no treatment and

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68 had various nonoperative treatments. In the untreated patients, the only significant change was an improvement in SRS Satisfaction (0.3, $p = 0.014$). In the treated patients, there was no significant change in any HRQOL measure. After two years, only 4 of 55 untreated patients (7.3%) and 3 of 68 treated patients (4.4%) improved above a 12.8 point MCID ODI threshold. Mean treatment cost over two years was \$10,815 for all treated patients; \$9,704 in the low, \$11,116 in the mid and \$14,022 in the high symptom group.

Conclusion: This study raises significant questions as to the value of nonoperative treatment commonly used for adult scoliosis. Costs were substantial and no improvement in health status was seen. An important caveat is that treatment was not randomized and therefore the treatment group might have deteriorated if not for the treatment they received. Better controlled studies evaluating more targeted use of nonsurgical treatment in adult scoliosis patients are needed.

Table 1. Mean change in SRS domain scores between patients who received treatment and those who did not.

Domain	No Treatment	Treatment	p-value
SRS Activity	0.06	-0.14	0.038
SRS Pain	-0.01	-0.08	0.506
SRS Appearance	0.08	0.00	0.443
SRS Satisfaction	0.21	0.09	0.500
SRS Total	0.06	-0.06	0.084
SF-36 MCS	0.99	-1.17	0.231
SF-36 PCS	1.27	-1.27	0.177
ODI	0.52	-2.45	0.158

Paper #30

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

***Growing Rod Fractures: Risk Factors and Opportunities for Prevention**

Justin S. Yang, MD; Paul D. Sponseller, MD (Johns Hopkins Medical Institutions); George H. Thompson, MD; John B. Emans, MD; Muharrem Yazici, MD; Marc A. Asher, MD; Lawrence I. Karlin, MD; David L. Skaggs, MD; Peter O. Newton, MD; Connie Poe-Kochert, CNP; R. Shay Bess, MD; Rishi V. Kadakia, MD; Ashley Goldthwait, BS; Pooria Salari; Behrooz A. Akbarnia, MD; Growing Spine Study Group; **Level of Evidence: III**

Introduction: Rod fracture is a common complication of growing rod treatment. The project sought to analyze risk factors for rod breakage and develop preventive strategies.

Methods: Records of 322 patients in a prospectively-collected growing rod database were studied. All patients with fractures reached 2 yr min follow-up. Multivariate analysis was performed.

Results: 70 rod fractures occurred in 43 patients (13%). 13 patients had repeat fractures with five patients having more than two fractures (max six). The avg time to fracture after initial insertion was 25 ± 22 mos. The most common fracture locations were above or below the tandem connectors (31/70) and near the thoracolumbar junction (21/70). Syndromic diagnoses had the highest rate of fracture; sig. greater than neuromuscular diagnoses (14%vs2%, $P=0.01$). Patients who were ambulatory had a higher fracture rate (28%vs12%, $P=0.009$). Single rods had a higher fracture rate than dual rods(34%vs11%, $P<0.001$). 10/13 patients with repeat fractures had a single rod construct. In the dual rod group, the incidence of both rods breaking at the same time was 15% (5/33) and the three repeat fractures occurred ipsilaterally. Stainless steel rods had a higher fracture rate than titanium rods (19%vs12%, $P=0.03$). The non-fx group contained larger diameter rods than the fx group($P=0.01$). The fx group had smaller tandem connectors than the non-fx group ($P<0.001$). Tandem and side-to-side lengthening connectors had similar fracture rates (18%vs16%, $P=0.92$). Neither the size of pre-op scoliosis($P=0.2$) nor kyphosis($P=0.4$) was a risk factor for fracture. Number of lengthenings per year ($P=0.8$), length of instrumentation ($P=0.9$), anchor type ($P=0.6$), and pelvic fixation($P=0.38$) had no significant effect on fracture rates. Eight wound complications were reported, including three cases of skin breakdown at the rod fracture.

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Conclusion: Risk factors for rod fractures include prior fracture, ambulation, single rods, stainless steel rods, small diameters and small tandem connectors. Patients with dual rods usually maintain one intact rod until repair. Surgeons should consider these factors when designing growing rod constructs. Rod replacement, with a larger diameter if appropriate, may be a preferred strategy over connecting the broken rods.

	Fracture Group	Non-Fracture group	P value
Rod diameter	4.1 mm	4.8 mm	0.01
Tandem connector length	62mm	74 mm	<0.001
Age at initial surgery	79 mos	82 mos	0.78
Gender	39% male	42% male	0.4
Pre-Op scoliosis	71°	74°	0.2
Pre-Op kyphosis	43°	48°	0.4
# of Lengthenings per year	1.18	1.26	0.8
Length of instrumentation	14 levels	15 levels	0.9

Paper #31

The Role of Neuromonitoring in Growing Rod and VEPTR Surgery

Daniel M. Schwartz, MD (Surgical Monitoring Associates); Anthony K. Sestokas, PhD; Vidya M. Bhalodia, MS; Cheryl R. Wiggins, AuD; John M. Flynn, MD; William G. Mackenzie, MD; Suken A. Shah, MD; Peter G. Gabos, MD; Richard E. Bowen, MD; Alvin H. Crawford, MD; Eric J. Wall, MD; John P. Dormans, MD;

Level of Evidence: I

Introduction: Data addressing the need for intraoperative neuromonitoring (IONM) during growing rod (GR) or VEPTR surgery is both sparse and conflicting. While these constructs might appear to pose few risks for neural injury, this possibility should not be underestimated. Misdirected pedicle screws may contuse spinal roots or cord. Abnormal vasculature, lesions or hypotension may predispose the cord to hypoxic injury during GR extension. Expansion of the chest wall or positioning may inadvertently stretch the brachial plexus. This study evaluated the role of IONM during placement, extension and/or revision of GR/VEPTR constructs.

Methods: Multi-modality IONM was performed at 3 pediatric spine centers during 415 consecutive GR or VEPTR surgeries. All IONM was performed and interpreted by experienced neurophysiologists from one private practice utilizing the same standardized anesthesia and IONM protocols.

Results: Table 1 summarizes the number and type of IONM alerts by surgical category. Spinal cord alerts were based on significant loss of transcranial electric motor evoked potential (tceMEP) amplitude, whereas pedicle cortex breach was identified by low stimulated EMG thresholds. Brachial plexus alerts were based on tceMEP and/or ulnar nerve SSEP attenuation. 16 patients had spinal cord alerts during GR revision and/or lengthening procedures, 7 of which were surgically provoked. Of 5 GR patients with unresolved tceMEP loss, 4 awoke with at least transient deficit; the remaining child could not be evaluated adequately in the immediate post-operative period for meaningful correlation. In the remaining 9 cases, IONM changes were resolved either with surgical or hemodynamic intervention. There were 8 pedicle breach alerts for the GR group. The incidence of brachial plexus alerts was slightly higher in VEPTR than GR surgeries. All resolved with surgical or positional intervention.

Conclusion: The potential for neural injury during GR and VEPTR surgery should not be underestimated. IONM plays an important role in early detection and mitigation of evolving neural injury and should not be discounted.

Significance: Risk of neural injury in GR and VEPTR surgery should not be underestimated. IONM helps prevent/limit neurologic sequelae.

Surgery Type	N	Spinal Cord	Brachial Plexus	Pedicle Breach
GR Placement	77	2	2	5
GR Lengthening	183	5	2	0
GR Revision	41	7	0	3
VEPTR Placement	30	2	0	0
VEPTR Expansion	70	0	2	0
VEPTR Revision	14	0	0	0
Total	415	16	6	8

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Paper #32

Can Infection Associated with Rib based instrumentation be Managed without Implant Removal?

John T. Smith, MD (University of Utah); Melissa S. Smith, RN; Candace L. Conyers; Sarah A. Mumford, MBA;
Level of Evidence: IV

Introduction: VEPTR has gained wide acceptance for the management of thoracic insufficiency syndrome and progressive complex spinal deformity in children. Many children in this population have significant co-morbidities and low BMI making them high risk for infection and other complications. Typically, the protocol for treating all but early infection of spinal instrumentation recommends that the implants be removed to resolve the infection. The purpose of this study is to determine if a Rib based instrumentation infection can be managed effectively without implant removal.

Methods: This is an IRB-approved retrospective review of medical records of all patients who had VEPTR procedures and developed infections at PCMC from 2002 to 2008.

Results: 97 patients underwent 678 VEPTR procedures (Initial implant: 97; Expansion: 403; Exchange: 95; Revision: 83). 19 infections developed in 16 patients, with an overall 2% rate of infection per procedure. The average age at the time of infection was 5 years. The BMI (16.2) and ANC (8.2) were predictably low for this population. The diagnosis was varied. Infection was associated with initial implantation (31%), Expansion (47%), Exchange (5%), and Revision (21%). 17/19 infections followed a wound dehiscence. 13 infections were classified as superficial and 6 deep. All patients were treated with initial irrigation and debridement and IV antibiotics. The average duration of IV therapy was 58 days (range 10-150) and followed by oral suppressive therapy for 34 days (2-126). 3 patients required more than one debridement to control the infection. Two patients were initially managed with oral antibiotics alone and failed. No patient has required VEPTR removal to resolve the infection.

Conclusion: These data suggest that infections involving Rib based instrumentation instrumentation without fusion procedures can be effectively managed without implant removal. Nutrition and improved soft tissue management may be significant in reducing the incidence of infection in this patient population.

Significance: This information may be useful when working with infectious disease consultants who continue to recommend implant removal when infection involves spinal instrumentation.

Paper #33

*** Lengthening of Dual Growing Rods: Is There a Law of Diminishing Returns?**

Wudbhav N. Sankar, MD; David L. Skaggs, MD (Children's Hospital Los Angeles); Muharrem Yazici, MD; Charles E. Johnston, MD; Pooya Javidan; Rishi V. Kadakia, MD; Thomas F. Day, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group; Level of Evidence: IV

Introduction: The purpose of our study was to evaluate the effect of repeated surgical lengthenings and time on spinal growth (as measured by T1-S1 length) and Cobb angle in children with early onset scoliosis and dual growing rods.

Methods: A multi-center study was performed in which initial radiographs, post-implantation radiographs, and radiographs from before and after each lengthening were measured for T1-S1 distance and Cobb angle. Inclusion criteria included children with early onset scoliosis treated with dual growing rods, minimum 2 year follow-up and a minimum of three lengthening procedures. Linear regression and ANOVA were used for statistical analysis.

Results: 38 patients from 5 centers met the inclusion criteria. The average age of our patients was 5.6 years (range 1.7-8.9), and the mean follow-up was 3.3 years (range 2-7). The average interval between lengthenings was 6.8 months. Cobb angle decreased from a mean value of 74° preoperatively to 36° after the primary implantation and did not change significantly with repeated lengthenings ($p=0.96$). The T1-S1 gain after lengthening decreased significantly with repeated lengthenings ($p=0.007$). (Figure 1 - in which lengthening#1 is the first lengthening after the primary implant) When the effect of time was considered, there was also a significant decrease in T1-S1 gain over time ($p=0.014$).

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Conclusion: It appears as though the "Law of Diminishing Returns" applies to T1-S1 length over multiple surgical lengthenings of dual growing rods. Repeated lengthenings still result in a net T1-S1 increase, however, this gain tends to decrease with each subsequent lengthening and over time.

Significance: In children with dual growing rod spinal instrumentation, curve correction occurs after the initial surgery and the Cobb angle remains stable over repeated lengthenings. The gain in T1-S1 length achieved after a lengthening procedure decreases with each subsequent lengthening and over time, yet continued spinal lengthening persists at least through the 7th lengthening.

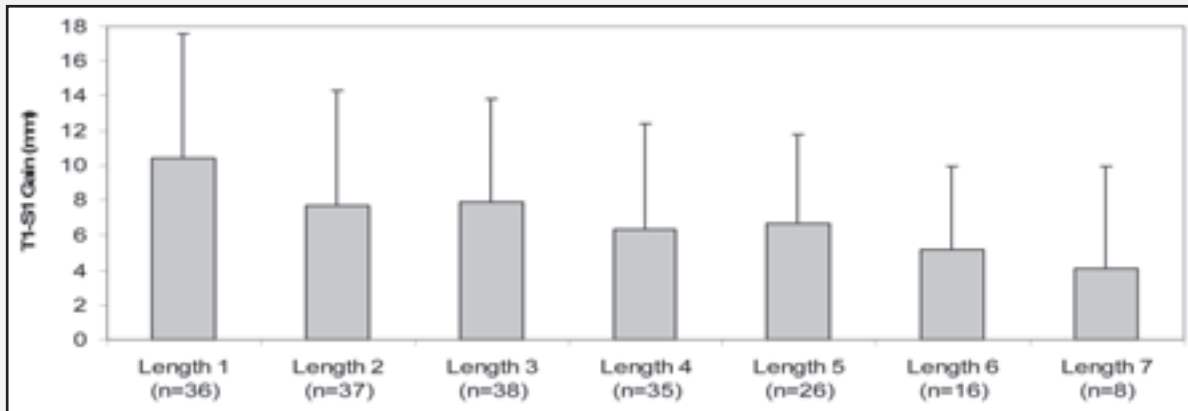


Figure-1 T1-S1 gain with repeated lengthenings

Paper #34

Auto-Fusion of the Skeletally Immature Spine After Growing Rod Instrumentation

Patrick J. Cahill, MD (Shriner's Hospital for Children, Philadelphia); Sean C. Marvil, BS; Corey Schutt, MD; Jocelyn R. Idema, DO; David H. Clements, MD; M. Darryl Antonacci, MD; Jahangir Asghar, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Level of Evidence: IV

Introduction: The safety and use of growing rods for curve correction and maintenance in the growing spine population has been established in published reports. While auto-fusion has been reported, the prevalence and sequelae are not known. The purpose of this paper is: to identify the rate of auto-fusion in the growing spine with the use of growing rods and to quantify how much correction can be attained with definitive instrumented fusion after long-term treatment with growing rods.

Methods: Nine skeletally immature children with scoliosis were identified who had been treated using growing rods. A retrospective review of the medical records and radiographs was conducted. The following data were collected: complications, pre- and postoperative Cobb angles at time of initial surgery (growing rod placement,) pre- and postoperative Cobb angles at time of final surgery (growing rod removal and definitive fusion), total spine length as measured from T1-S1, % correction since initiation of treatment and at definitive fusion, total number of surgeries, and number of patients found to have auto-fusion at the time of device removal.

Results: The rate of auto-fusion in children treated with growing rods was 89%. The average percent of the Cobb angle correction obtained at definitive fusion was 44%. On average, seven osteotomies per patient were required at the time of definitive fusion due to auto-fusion.

Conclusion: Although growing rods do show moderate efficacy in the control of deformity within the growing spine, they also have adverse effects on the spine. Immature spines treated with a growing rod have high rates of unintended auto-fusion which can possibly lead to difficult and only moderate correction at the time of definitive fusion.

Significance: Growing rods have been previously described as a fusionless device. However, we have demonstrated that fusion does occur and that subsequent definitive surgery is more difficult and deformity correction may be diminished.

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Paper #35

In Vivo Distraction Force and Length Measurements of Growing Rods: Which Factors Influence the Ability to Lengthen?

Suken A. Shah, MD (Alfred I. duPont Hospital for Children); Enrique Garrido, MD; Stewart K. Tucker, FRCS; Hilali Noordeen, FRCS; Level of Evidence: II

Introduction: The goal of the growing rod technique is to achieve deformity correction while maintaining spinal growth. Gradual stiffening of the spine can interfere with the ability to lengthen, and authors have noted increased forces required to lengthen, decreased length achieved and spontaneous fusion already evident at the time of conversion to definitive arthrodesis. The purpose of this study was to measure the forces and amount of distraction over time in a consecutive series of patients with growing rods.

Methods: Distraction forces were measured prospectively during 60 consecutive lengthening procedures in 26 patients by 1 of 2 surgeons. All patients had single submuscular rod constructs with side-to-side connectors. For each measurement, output from a transducer on a dedicated pair of distraction calipers was recorded at zero load status and at every 1mm lengthening. Resting load prior to any distraction was recorded. Length obtained at each event was recorded in mm.

Results: Mean peak forces were significantly higher than previously reported (see graph) and increased sequentially with each lengthening. The force required to distract the spine doubled at the 5th lengthening procedure (mean 368N +/- 54N) and the distraction force was significantly higher at the 5th lengthening compared to the previous lengthening ($p < 0.01$). Distraction forces were on average 40% higher in patients who had undergone an apical fusion at the time of primary implantation of the growing rod versus those who had no apical fusion ($p < 0.05$). Mean length achieved at each distraction decreased over time such that by the 5th lengthening, consistently less than 8 mm was achieved.

Conclusion: Distraction forces increase significantly after repeated lengthening of growing rod constructs and the length obtained at each procedure exhibits a decreasing trend. The higher distraction forces measured in patients who had an apical fusion may explain the increased incidence of instrumentation failure reported in the literature.

Significance: This is the first study to quantify the significant increase in distraction forces in growing rod constructs with subsequent lengthening. Instrumentation design must accommodate these forces to minimize failure.

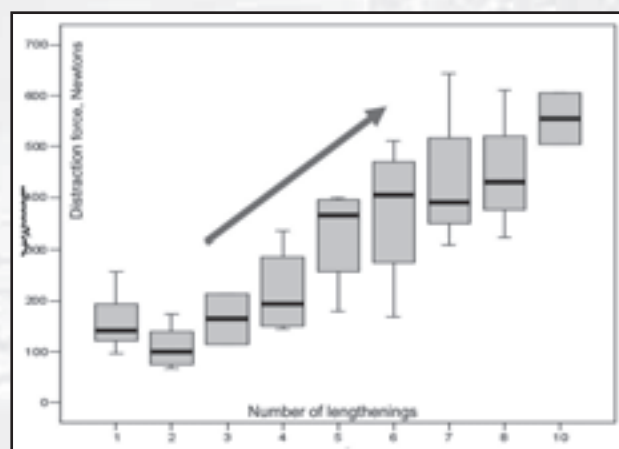


Figure 1. Distraction force increased with each subsequent lengthening and doubled by the 5th procedure

Paper #36

Cotrel Derotation Casting For Progressive Infantile Scoliosis

James O. Sanders, MD (University of Rochester); Jacques D'Astous, MD; Marcie Fitzgerald, MPAS, PA-C; Joseph Khoury, MD; Shyam Kishan, MD, MB, MS, DNB; Peter F. Sturm, MD; Level of Evidence: IV

Introduction: Serial casting using the Cotrel derotation technique is one of several potential treatments for progressive infantile scoliosis. This study reviews our early experience to identify which, if any, patients are likely to benefit from or fail this technique.

Methods: We followed all patients treated at our institutions for progressive infantile scoliosis since 2003 prospectively at one institution and retrospectively at the other two. Data, including etiology, Cobb angles, RVAD, Moe-Nash rotation, and space available for the lung (SAL), were recorded over time.

Results: 47 patients with progressive infantile scoliosis had more than two years of follow-up from the

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initiation of casting. The diagnosis of progressive scoliosis was made based upon either a progressive Cobb angle or a RVAD of more than 20 degrees at presentation. All but six patients responded to the casting. Nine patients have undergone surgery to date, six because of worsening and three by parent choice. As shown in the table, initiation of casting at a younger age, moderate curve size (<60 degrees) and an idiopathic diagnosis carry a better prognosis than an older age of initiation, curve > 60 degrees and a non-idiopathic diagnosis. The SAL improved from 0.89 to 0.93. No patient experienced worsening rib deformities.

Conclusion: Serial casting for infantile scoliosis often results in full correction in infants with idiopathic curves less than 60 degrees if started before 20 months of age. Casting for older patients with larger curves or non-idiopathic diagnosis still frequently results in curve improvement along with improvement in chest and body shape.

Significance: Derotational casting appears to play a role in the treatment of progressive infantile scoliosis with cures in young patients and reductions in curve size with a delay in surgery in older and syndromic patients.

Follow up Cobb Angle	count	Start Age	Start Cobb	Start RVAD	Start Nash	% idiopathic
10 or less	14	1.1	36	24	1.8	86%
11 to 21	5	2.5	42	20	2.5	80%
21 to 40	13	2.6	56	30	2.6	62%
>40	15	2.5	60	31	2.2	47%
Total	47	1.8	50	28	2.2	66%

Paper #37

Intraspinal Anomalies in Infantile Idiopathic Scoliosis: Prevalence and Role of MRI

Joshua M. Pahys, MD (Shriner's Hospital for Children, Philadelphia); Amer F. Samdani, MD; Randal R. Betz, MD; Level of Evidence: III

Introduction: Idiopathic scoliosis in patients under ten years of age has been shown to carry a higher prevalence of concordant intraspinal anomalies, up to 20%, in juveniles, when compared to the adolescent age group. Few studies exist assessing the prevalence of intraspinal anomalies in the IIS patient population. Dobbs et al (2002) reported a 21.7% prevalence of neural axis abnormalities in 46 patients with presumed IIS across three combined spinal deformity clinics and recommended a screening MRI for all IIS patients with a curve > 20 degrees. The purpose of this retrospective case series is to identify the prevalence of intraspinal anomalies in patients with presumed IIS at a single, large volume institution and further define the role for a screening MRI.

Methods: A retrospective review of the medical records of 54 consecutive patients at a single institution with a presumed diagnosis of IIS was performed. All patients satisfied the strict inclusion criteria of: curve > 20 degrees, age < 36 months at diagnosis, normal neurologic exam (i.e. normal tone, motor strength, reflexes, etc.), absence of any concomitant syndromes or congenital anomalies, and an MRI of the spine from skull to coccyx.

Results: MRI revealed a neural axis abnormality in seven (13%) of 54 patients who underwent an MRI. In this subset of seven patients, five (71.4%) required neurosurgical intervention. Tethered cord requiring surgical release was identified in three patients, Chiari malformation requiring surgical decompression was found in two patients, and a small nonoperative syrinx was found in two patients.

Conclusion: This study represents the largest evaluation of intraspinal anomalies in IIS to date. Our patient population exhibited a smaller percentage (13%) of neural axis abnormalities than previously reported. Based on these findings, close observation may be a reasonable alternative to an immediate screening MRI in patients presenting with presumed IIS and a curve >20 degrees.

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Paper #38

***Do Growth Guidance Rods Have Acceptable Complications and Fewer Surgeries?**

Richard E. McCarthy, MD (Arkansas Childrens Hospital); Scott J. Luhmann, MD; Lawrence G. Lenke, MD; Frances McCullough, MNSc; **Level of Evidence: IV**

Introduction: Twenty-two pts with the growth guidance system for correction of spinal deformities in early onset scoliosis (EOS) were evaluated at 2 yr follow-up at 2 centers. We wanted to determine if the number of returns to surgery and complications were comparable to traditional distraction based growing rods.

Methods: The favorable results of treatment of > than 50 degree EOS with the growth guidance procedure have been previously reported. We are critically analyzing the complications of 22 pts. with > than 2 yr (2-3.6) follow-up at 2 centers with 3 surgeons. The diagnoses were Idiopathic (9), Neuromuscular (10), Congenital (2), and Intrathecal tumor (1).

Results: The complications were divided into groups: Implant related-11pts (7 with prominent implants, 4 with broken rods) Wound related- 4 pts. (3 washouts or plastic proc., 1 implant removal) Alignment -3 pts. (All corrected at final fusion) General-1 pt. Pleural effusion (CT). Total number of complications was 30 with 26 unplanned operative procedures. Three pts completed sufficient growth for final fusion. There were no neurologic changes in any pts.

Conclusion: Thirty complications in this complex group of EOS patients is comparable to Akbarnia's reports with distraction growing rods, however, their patients underwent planned operative lengthenings. If our group of patients had lengthenings every six months they would have had an additional 115 procedures from which they were spared due to the growth guidance without operative lengthening of the Shilla. Eight of our patients had more than one complication implying they were predisposed to problems due to underlying illness, i.e. Spina Bifida or level of activity. Rod breakage occurred more frequently in active, ambulatory children with smaller rods (3.5mm).

Significance: The growth guidance patients had complications at a level comparable to what has been reported in the literature for growing rods while being spared an additional 115 procedures for spinal lengthening.

Paper #39

***Submuscular Growing Rods: Technique, Results and Complications of 88 Patients with Minimum Two-Year Follow-Up**

Najma Farooq, MD; Enrique Garrido, MD; Farhaan Altaf, MBBS, BSc, MRCS; Joanne Dartnell, MRCS; Stewart K. Tucker, FRCS; Hilali Noordeen, FRCS (Royal National Orthopaedic Hospital); Suken A. Shah, MD; **Level of Evidence: IV**

Introduction: The challenges of treating children with early onset scoliosis mandate control of the deformity and maintenance of pulmonary function while allowing spinal and truncal growth. Previous publications have demonstrated safety and effectiveness of the growing rod technique in a limited number of patients. The purpose of this study was to report on a large series of patients managed with growing rods from a single center.

Methods: This is a retrospective review of 88 consecutive patients lengthened from 1999 to 2006 with minimum 2-year follow up. Diagnoses included infantile and juvenile scoliosis (26), congenital (19), neurofibromatosis (4), syndromic (15) and neuromuscular (24). Number and frequency of lengthening, changes in scoliosis Cobb angle and complications were recorded.

Results: 88 pts with average age of 6.7 yrs (range 2.1 - 11) underwent single submuscular growing rod insertion. 27 patients had a simultaneous short apical fusion. The mean follow up was 3.8 yrs (2 - 9.5 yrs); pts underwent an average of 4.4 lengthenings with a mean interval of 8.1 months. 30 pts went on to final fusion at a mean age of 12 yrs. The preop scoliosis improved from 70° (range 50 - 110) to 37° (range 14 - 81) after insertion, 39° (7 - 75) at last lengthening and 32° at final fusion (18 - 70). In the group without apical fusion, 5.5 cm of length was obtained, compared to 3.8 cm with apical fusion (p<0.05). Complications included 3 deep

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infections; one patient required removal of instrumentation. Six pts had proximal anchor loss and 2 had distal pedicle screw migration. 14 pts (16%) had rod fractures, with the highest incidence after the 5th lengthening and more commonly in the apical fusion group. Two pts were converted to early fusion due to severe junctional kyphosis. FVC in the idiopathic group of pts was 62% predicted preoperatively and 64% at last follow up. FVC in pts with congenital scoliosis was 54% predicted preoperatively and 45% at last follow up.

Conclusion: Single submuscular growing rod constructs were effective in maintaining spinal growth and correcting deformities in early onset scoliosis. Considering the number of procedures performed per patient, the complication rate was acceptable and favorable to dual rod instrumentation series.

Paper #40

***V/Q asymmetry changes following Rib based instrumentation treatment of TIS**

Greg Redding, MD; Kit M. Song, MD (Seattle Childrens Hospital); Level of Evidence: IV

Introduction: Scoliotic and chest wall deformities in children have been presumed to cause restrictive lung disease due to constriction of volume of the thorax. Treatment has been directed to structurally expand and improve volume, but correlates to functional changes have been lacking. We hypothesized that asymmetric lung function (ALF) as measured by V/Q asymmetry would be improved after structural interventions for the TIS.

Methods: 30 children being evaluated for TIS had V/Q scans as a part of their evaluation. 17 had V/Q scans before and after either conventional Rib based instrumentation stabilization or a Rib based instrumentation "growing rod construct" (spine to spine). Instrumentation constructs were designed to distract across the concavity of deformity in all cases. Space available for lung and Cobb angle changes were recorded for all cases. A "normal" V/Q scan was defined as a ratio of 55% right/45% left for children greater than 1 year of age and 50%:50% ratio for infants less than 1 year old.

Results: 7/17 had normal preoperative right/left ventilation distributions. 4/7 became abnormal after surgery. 10/17 had significant preoperative asymmetry. 7 had under ventilation of the concave side and 3 under ventilation of the convex side. Six of these patients had more asymmetry after treatment independent of which side was under ventilated, 1 was unchanged, and 4 decreased their asymmetry after treatment. Fifteen of 17 patients had improvement in their SAL as defined by movement of their concave/convex ratio towards 1. Cobb angle at the time of evaluation was not correlated to severity of V/Q asymmetry and angle correction was not correlated to the degree or direction of change of ventilatory function.

Conclusion: Surgical treatment of TIS by Rib based instrumentation or "growing rod" constructs created a larger space and correction of biplanar deformity, but did not improve ALF

Significance: Changes in regional lung volume after surgery are not the same as changes in the distribution of ventilation or perfusion between the concave and convex lungs. While lung volumes might increase after Rib based instrumentation, regional ventilation and perfusion do not do so despite improvement in SAL and Cobb angle.

Paper #41

***A Minimum Two-Year Comparison of Safety and Efficacy of Screw/Rod Constructs in the Pediatric Cervical Spine**

Jonathan J. Carmouche, MD (Roanoke Orthopaedic Center) John E. Lonstein, MD; Robert B. Winter, MD; James D. Schwender, MD; Joseph H. Perra, MD; Level of Evidence: III

Introduction: Pediatric cervical fusions are demanding procedures with high complication rates. Rigid fixation improves fusion rates and decreases halo usage and complications.

Methods: 19 patients, mean age 10 + 2 (yrs + mo) (range 2 + 3 to 17 + 10) underwent 20 posterior cervical procedures using screw and rod constructs (Group A). 57 patients, mean age 9 + 4 (range 1 + 5 to 16 + 5) underwent 63 procedures with non-screw/rod constructs (Group B). Charts and radiographs were reviewed.

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Results: In Group A, two cases (10%) had delayed wound healing. Screw placement was aborted in two cases (10%). A halo was used in 4 cases (20%). In Group B, the total complication rate was 44%. A halo was used in 33 cases (52%). Complications were halo associated (42%), pseudoarthrosis (16%), wound infection (1.6%), paraplegia (1.6%) and ascending fusion (3.2%).

Conclusion: Group A had lower halo usage, pseudoarthrosis and complications. Pediatric cervical fixation with screw and rod constructs was safe and effective.

Significance: Pediatric screw/rod instrumentation is technically demanding but results are superior to older techniques.

Paper #42

Cervical Kyphotic Deformity Increases Spinal Cord Intramedullary Pressure: A Cadaveric Study

Albert Chavanne, MD (The UC Neuroscience Institute: Department of Neurosurgery, University of Cincinnati; The Mayfield Clinic and Spine Institute) David B. Pettigrew, PhD; Jeffrey R. Holtz, PA-C; Neal Dollin; Charles Kuntz, MD; Level of Evidence: N/A

Introduction: Previous studies of asymptomatic volunteers have revealed that the greatest variation in regional sagittal curves occurs in the cervical spine with "normal" cervical alignment ranging up to +15-20° kyphosis. We sought to determine if pressure within the spinal cord parenchyma (IMP) increases in response to cervical kyphosis.

Methods: Eight fresh-frozen cadavers were dissected. The anterior 2/3 disc was removed and wedge vertebral osteotomies were performed from C2-C3 to C6-C7. Posterior facet capsules, interspinous ligaments, and ligamenta flava were released. Posterior segmental fixation was placed from occiput to C7. Cadavers were positioned sitting with physiologic cervical lordosis; head halo ring stabilized. The posterior arch of C1 was removed, dura opened, and 3 pressure sensors were advanced caudally to C7, C4-C5, and C2 within the cord parenchyma. A step-wise kyphotic deformity was then induced by sequentially releasing, distracting, and retightening the halo and short segment rods. At each level, fluoroscopic images and pressure measurements were obtained. The C2-C7 angle was measured using the Gore method. The horizontal distance between the C7 vertebral body and odontoid plumb line (C2-C7 SVA) was measured.

Results: Minor IMP increases of 2-5 mm Hg were observed in 4 of 5 instances (80%) in which the Gore angle was $> +7.5^\circ$ and $< +21^\circ$ (compared with 1 in 13 (7.7%) in which the Gore angle $< +7.5^\circ$). Gore angles from $+21^\circ$ to $+78^\circ$ resulted in exponential increases in IMP ranging to > 40 mm Hg. IMP was increased in 30 of 32 instances (94%) in which the C2-C7 SVA exceeded 75 mm (compared with 0 of 11 in which the C2-C7 SVA was < 75 mm). At maximal kyphotic deformity, laminectomy from C2 to C7 resulted in a mean 21% reduction in IMP.

Conclusion: Minor cervical kyphosis from $+7.5^\circ$ to $+21^\circ$ resulted in less than 5 mm Hg increase in IMP. As the magnitude of cervical kyphotic deformity increased greater than $+21^\circ$, IMP increased exponentially. Cervical laminectomy resulted in minimal decreases in IMP.

Significance: Cervical kyphotic deformity increases IMP.

Paper #43

Complication Rates in Pediatric Spondylolisthesis Surgery: A Dual Center 16 Year Retrospective Review

Patrick J. Cahill, MD (Shriners Hospital for Children, Philadelphia); Amer Samdani, MD; Jason R. Smith, PA-C; Craig Finlayson, MD; Sean C. Marvil, BS; Mark E. Tantorski, DO; Kim Hammerberg, MD; Jahangir Asghar, MD; Randal R. Betz, MD; Peter F. Sturm, MD; Level of Evidence: IV

Introduction: The indications for spondylolisthesis surgery in children are different than in adults with attention needing to be paid to future growth and the development of long term deformity. No previous study has

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examined the complication rates in spondylolisthesis surgery in children alone. Complications fall into one of these general categories: pseudarthrosis, neurological deficit, painful instrumentation, and wound problems (infections, seromas, and dural tears).

Methods: We retrospectively reviewed 43 patients who underwent surgery for spondylolisthesis or spondylolysis from 1984 to 2005 at 2 institutions. A minimum 2 year follow up was required for inclusion. The radiographs and medical records were reviewed.

Results: The overall complication rate was 47% (20/43). The overall re-operation rate is 37%. The female to male ratio was 4:1. The average age was 14.4 years (range 6-19). The mean follow up period was 4 years 11 months. The most common complication was pseudoarthrosis in 16% (7/43). These seven patients required an average of 1.6 repeat surgeries. Four of the 7 (57%) continued to experience back pain at 24 months. Another common complication was a post-operative neurological deficit involving 12% (5/43). Only 1 of these patients had a reduction at the index procedure. Two of 5 (40%) had subsequent reduction procedures. Four of these five (80%) had a persistent neurologic deficit at final follow-up. Furthermore, 3 of 5 (60%) required subsequent tendon transfers. Three of 43 (7%) sustained an incidental durotomy repaired at the time of the index procedure and another 2 (5%) had pain due to prominent instrumentation requiring operative intervention. Two of 43 (5%) had wound infections requiring a total of 3 additional procedures. One developed a seroma that did not require surgical intervention.

Conclusion: Pseudoarthrosis, neurologic deficits, and wound problems were the most common complications from spondylolisthesis surgery in children. Reoperation is not uncommon.

Significance: Complications from spondylolisthesis surgery in pediatric patients occur. The information on rates of untoward events can help physicians and parents with pre-operative discussions and expectations.

	total number	rate (as percent of entire series)
Pseudarthrosis	7	16
Neurologic	5	12
persistent	4	
transient	1	
Wound	6	14
infection	2	
seroma	1	
durotomy	3	
Painful instrumentation	2	5
total	20	47

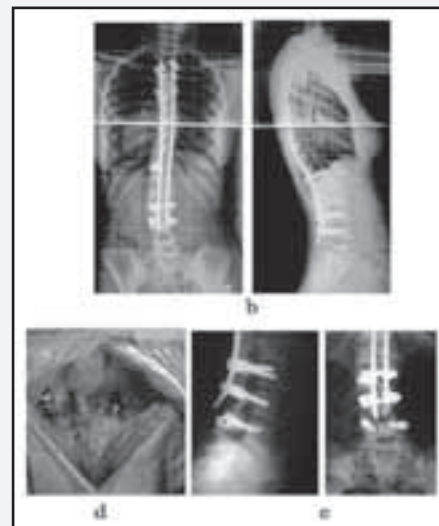
Paper #44

Direct Repair of Spondylolysis Presenting Following Correction of Adolescent Idiopathic Scoliosis

Wael Koptan, MD (Cairo University Hospital); Yasser ElMiligui, MD; Wael Hammad, MD; Level of Evidence: IV

Introduction: Although spondylolysis is found in 6 % of idiopathic scoliosis patients, very little was reported on management of pars defects in this group. These patients with painful spondylolysis are most eligible for direct repair of the defect rather than lumbosacral fusion in an attempt to save motion segments. The aim of this work is to analyze the clinical and radiological outcome of this technique and evaluate its possible complications.

Methods: A prospective study included ten consecutive patients with spondylolysis presenting after an average of 3m (range 2-7m) from correction of their idiopathic scoliosis with low back pain not responding to conservative therapy and interfering with everyday life and sports activities. The surgical technique consisted of thorough debridement of the defect, impacting the gap created with a tricortical iliac crest graft and rigid fixation by either pedicle screws and a V-shaped rod (5 patients)



A female patient 15 y old with spondylolysis presenting after correction of her idiopathic scoliosis. Pars repair was performed (b) pre-op, (d) intra-op and (e) follow-op X-rays.

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or a cable screw construct (5 patients). The mean age at operation was 16 years (range 14 - 19 years). All patients were followed-up for a minimum of 2 years; an average of 3.5y (range 2 - 5y).

Results: Nine patients had an excellent result, returned to normal everyday life and participated in sports when desired. The mean ODI and SRS total scores were (12 [0 to 36] and 89 [61 to 103]). Follow up radiographs and CT scans revealed healing of all defects in 9 cases and no signs of disc degeneration in any. There was no outcome difference between the two construct types and no implant related complications were encountered in either.

Conclusion: The results of direct repair of spondylolysis in idiopathic scoliosis patients were very satisfactory both clinically and radiologically. Direct repair appears to be a logical alternative to spinal fusion. Lumbar spine mobility was preserved and precocious motion segments were saved with a relatively simple operation.

Paper #45

Healing Rate for 124 Adolescent Lumbar Pars Interarticularis Fractures Treated Conservatively

John W. McClellan, MD (Nebraska Spine Center); Kay Ryschon, MS; Sarah Stamm, MPA-C; Level of Evidence: IV

Introduction: Adolescent pars interarticularis (pars) fractures are a common source of lumbar back pain. Current conservative management often includes activity restriction and brace management. Most are returned to normal activity including sports as symptoms resolve. The healing rate of pars fractures has not been well studied. We report the healing rate in 124 adolescents with lumbar pars fractures.

Methods: The study population consisted of 124 adolescents diagnosed with pars fracture by CT. Patients were all treated with limitation of activity and avoidance of nonsteroidal anti-inflammatory agents.

Results: Patients were reevaluated at 3 months for signs of healing. The pars fracture healed in only 3 cases (2.4%).

Conclusion: Orthopaedic spine surgeons can not assume that the lumbar pars fracture has healed as patient's symptoms resolve. We found an alarming low rate (2.4%) of healing in our patients.

Significance: Follow-up studies should be considered in all patients to confirm whether the pars fracture has healed. Appropriate patient education relies on the providers knowing whether the fractures have healed.

Paper #46

Spondylolisthesis Classification Based on Spino-Pelvic Alignment

Hubert Labelle, MD (CHU Sainte-Justine) Pierre Roussouly, MD; Eric Berthonnaud, PhD; Jean-Marc Mac-Thiong, MD, PhD; Michael T. Hresko, MD; John R. Dimar, MD; Stefan Parent, MD, PhD; Mark Weidenbaum, MD; Courtney Brown, MD; Serena S. Hu, MD; Level of Evidence: II

Introduction: Sagittal plane alignment has increasingly been recognized as a key factor in planning treatment for spondylolisthesis. Since existing classifications do not include assessment of sagittal alignment and cannot be used to guide surgical treatment, this study assessed the usefulness of these criteria in surgical planning.

Methods: A multi-center database containing the digitized standing lateral radiographs of 816 subjects (mean age 18.5, 37% male, 63% female) with L5-S1 spondylolisthesis was analyzed with a custom software to determine the sagittal alignment of the spine and pelvis. K-means cluster analysis was performed to identify natural groups based on spino-pelvic alignment measures including pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), L5 incidence, lumbar lordosis, thoracic kyphosis and C7 plumbline.

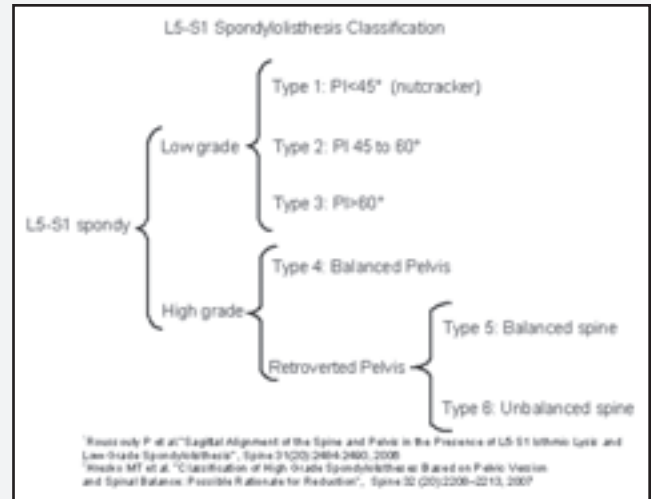
Results: Four significantly different clusters were identified. In 540 low grade subjects, PI was the main contributor to 2 cluster groups, averaging $52^{\circ}\pm 9$ (normal) in cluster 1 (n=317) and $74^{\circ}\pm 12$ (above normal) in cluster 2 (n=223). In 276 high grade subjects, PT and SS were the main contributors to 2 clusters, with high

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PT/low SS values in cluster 3 (n=142) and low PT/high SS values in cluster 4 (n=134), while PI was above normal in both. C7 plumbline was significantly higher (>3cm) in cluster 4 compared to the others.

Conclusion: Mechanical strain at the lumbo-sacral junction will vary in each cluster. Cluster 1 includes a subset of subjects with below-average PI (<45°) previously identified as caused by a nutcracker mechanism rather than shear. Since PI is always above normal in high grade slips, normal PI values in cluster 1 suggest that progression to a high slip is unlikely in this group as opposed to cluster 2. The results for high grade slips confirm a previous report which labeled cluster 3 as having a balanced pelvis and cluster 4 a retroverted position. Sagittal imbalance of the spine was detected only in cluster 4.

Significance: A classification based on sagittal spino-pelvic alignment is presented. Subjects with type 1 and 2 spondylolisthesis (cluster 1) are at lower risk of progression compared to type 3 (cluster 2). In high grade slips, reduction techniques should preferably be considered for types 5 and 6 (cluster 4).



Paper #47

Three Dimensional Correction of Severe Rigid Neurofibromatosis Scoliosis

Wael Koptan, MD (Cairo University Hospital); Yasser ElMiligui, MD; Wael Hammad, MD; Level of Evidence: IV

Introduction: The surgical management of severe rigid dystrophic neurofibromatosis curves is a demanding procedure with uncertain results. Several difficulties are present in such patients including a poor bone stock, sharp angulation of these curves and the delicate nature of the dural sac. The aim of this work is to review the clinical and radiographic outcome of three-dimensional correction of severe rigid neurofibromatosis curves analyzing its efficacy, safety and possible complications.

Methods: The results of 36 patients with severe rigid neurofibromatosis deformities surgically treated between 1997 and 2005 were retrospectively reviewed. Thirty-two patients were followed-up for a minimum of 3 years; an average of 6.5y (range 3 - 9y). The average age was 14 years (range 11 - 19y). All patients had typical dystrophic curves and the apex of the deformity was dorsal (13 patients); dorsolumbar (14 patients) and lumbar (5 patients). An MRI was performed and no intra/extra spinal anomalies or neurofibromas were found. All patients had a two staged procedure; an anterior release followed latter by posterior instrumentation augmented by sublaminar wires. The wires were placed immediately below the proximal anchor and several sublaminar wires at the apex of the deformity. There were a total of 142 wires with an average of 6.5 wires/ patient (range 5 - 8 wires).

Results: The mean Cobb angle of the main curve was 102.2° before surgery corrected to an average of 39° and the loss of correction had an average of 4°. Sagittal alignment improved from an average of 12° to an average of 47° and rotation was corrected by an average of 34%. There were no dural tears during passage of the sublaminar wires and no neurological or implant related complications.



The main curve was 113° before surgery corrected to 40°

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Conclusion: The use of extensive and vigorous anterior release with posterior hybrid instrumentation has proved useful and effective in the treatment of these difficult cases; sublaminar wires allow safe gradual correction and even distribution of forces over multiple anchor points improving the correction achieved and decreasing implant related complications.

Paper #48

Thoracolumbar Kyphosis in Mucopolysaccharidosis I (Hurler Syndrome)

Irfan Siddique, MBChB, FRCSOrth (Royal Manchester Children's Hospital); Raphael H. Sacho, MBChB, MRCS(Eng); Neil J. Oxborrow, MD, FRCS (Tr-Orth), MbChb (Hons), BSc (Hons); Ed Wraith, MB, ChB, FRCPC; J. Bradley Williamson, FRCS; Level of Evidence: IV

Introduction: Thoracolumbar kyphosis is a skeletal manifestation of Mucopolysaccharidosis I (MPS-I), Hurler syndrome. We present the largest case series in the published literature to date in order to define its natural history and management.

Methods: Forty two patients with MPS-I had treatment with bone-marrow transplantation and/or enzyme replacement therapy between June 1995 and October 2007. These patients had regular systematic clinical review and were seen at least annually. Standing lateral radiographs of the thoracolumbar spine taken at these visits were retrieved, digitized, enhanced using computer software (Adobe Photoshop CS4, Adobe Systems Inc.) and the Cobb angle measured (Screen Protractor 4.0, Iconico). Statistical analysis was performed using mean values, standard deviation (SD), 95% confidence intervals (95% CI) and repeated measures ANOVA.

Results: All patients had been followed up for a mean of 2years 8months. At initial examination (average age 1year 1month) the thoracolumbar kyphosis measured a mean of 40 degrees (SD 12 degrees). Five patients underwent anterior vascularised rib graft at an average age of 3 years for progressive deformity - mean Cobb angle pre-operatively was 53 degrees and at final follow-up (average 8years 10months) was 44 degrees. Analysis of non-operatively treated patients revealed that patients with an initial Cobb angle (at an average age of 1year 2months) of less than 40 degrees were statistically significantly ($p=0.005$) less likely to develop progressive kyphosis over the average follow-up period of 3.5 years (mean initial Cobb angle 30 degrees and at final follow-up 34 degrees) than those with an initial Cobb angle greater than 40 degrees (mean Cobb angle initially 46 degrees and at final follow-up 61 degrees).

Conclusion: Thoracolumbar kyphosis is of variable severity in Hurler's syndrome and those who present with a Cobb angle of greater than forty degrees are significantly more likely to develop progressive kyphosis. Treatment in the form of vascularised rib graft in these patients appears to arrest progression of the deformity.

Significance: This study outlines the previously undefined natural history of thoracolumbar kyphosis in Hurler syndrome, its clinical management and results of treatment.

Paper #49

Pelvic Radius Angle: An Essential Parameter for Sagittal Spinopelvic Alignment

Roger P. Jackson, MD (North Kansas City Hospital); Anne C. McManus, RN; Jill Moore; Chris Hales; Level of Evidence: II

Introduction: Evaluation of sagittal sacropelvic morphology and its association with lumbopelvic alignment is an important and clinically relevant issue. Radiographic assessment of this morphology is often difficult due to anatomic variation of the proximal sacrum. An efficient and reliable technique to assess this morphology, which avoids registration of the entire sacral endplate, is needed.

Methods: 200 adult volunteers had standing 36" radiographs of the spine and pelvis that included both hips. The Pelvic Radius Angle (PRA) was measured from the PR line (as defined in the literature) to the horizontal. Vertebral endplate slopes (VES) were measured from the horizontal. $PRA = \text{sacral endplate slope} + \text{the fixed pelvic contribution to lordosis (Pelvic Lordosis)}$. $\text{Lumbo-Pelvic Lordosis (LPL)} = PRA \pm \text{a specific VES}$. PI

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was determined. A clinically relevant group of 24 high grade lytic spondylolisthesis patients was used to determine reliability and efficiency of the PRA and PI methodologies.

Results: PRA was always $<90^\circ$, but $>55^\circ$. L4 slope was approximately neutral (range: 16° to -24°). T12 slope was always positive (4° to 37°). Lordosis varied greatly (34° to 80°), but total LPL (PR line to T12 slope) was approximately 90° and always $>70^\circ$. Distal LPL (PR line to L4 slope) was always $>45^\circ$. PRA was better correlated with the lordosis measurements ($r = -.72$) compared to PI ($r = -.52$). In the volunteers, intra- and inter-observer reliabilities were very high for both PRA and PI measurements ($r \geq .95$ for all). But when applied clinically in the patients, intra- and inter-observer reliabilities were better for PRA vs. PI ($r = .93$ and $.89$ vs. $r = .79$ and $.68$, respectively). Measurement times for PRA were faster vs. those for PI (i.e. 50% less time to measure PRA).

Conclusion: The PRA and VES can determine minimum lordosis requirements, which are dependent on individual pelvic morphology, without having to register the entire sacral endplate. This methodology can be both efficiently and reliably applied within the clinical setting. When fixing lordosis by surgical fusion, the minimum requirements should be met.

Significance: Assessment and understanding of sagittal balance is fundamental in our management of spinal disorders.

Paper #50

The Natural History & Fate of SRS Presentations (2000-04)

Nanjundappa S. Harshavardhana, MS (Orth); Dip; SICOT (Queen's Medical Center, Nottingham University Hospitals NHS Trust); Roshana Mehdian; James L. Nutt; Hossein S. Mehdian, MD, FRCS(Ed); Ujjwal K. Debnath, FRCS, MS/Orth; Level of Evidence: N/A

Introduction: Abstracts submitted to scientific meetings may not contain adequate information to assess validity of a research topic. Our objective was to determine PPCR in peer-reviewed indexed journals of abstracts presented at SRS annual meetings and to evaluate for consistency between abstracts & subsequently published FTA.

Methods: We reviewed all presentations (podium & posters) of past SRS annual meeting proceedings (2000-04) and undertook a comprehensive PubMed search to determine if the abstract was followed by a publication subsequent to its presentation as FTA up to the beginning of Dec 2008. The published FTA was compared with OAb and evaluated for consistency with respect to study cohort/design, conclusion and authorship against a structured proforma.

Results: A total of 1063 abstracts (452 podium & 611 posters) were identified. 560 (295 podium & 265 posters) were published as FTA in 51 journals. The overall PPCR was 52.68% (65.26 for podium and 43.37% for posters).

Sl No	Year	All presentations						Free-papers (Podium Presentations)						Poster Presentations					
		Total	Pub	Not Pub	100% match	Conv Rate	100%M CR	Total	Pub	Not Pub	100% match	Conv Rate	100%M CR	Total	Pub	Not Pub	100% match	Conv Rate	100%M CR
1	2000	210	98	112	30	46.67	30.61 (14.28%)	87	62	25	18	71.26	29.03 (20.69%)	123	36	87	12	29.27	33.33 (9.75%)
2	2001	166	97	69	33	58.43	34.02 (19.76%)	88	62	26	23	70.45	37.09 (26.13%)	78	35	43	10	44.87	28.57 (12.82%)
3	2002	214	106	108	47	49.53	44.34 (21.96%)	87	53	34	22	60.92	41.51 (25.29%)	127	53	74	25	41.73	47.17 (19.68%)
4	2003	259	137	122	37	52.89	27.00 (14.28%)	89	53	36	17	59.55	32.07 (19.10%)	170	84	86	20	49.41	23.81 (11.76%)
5	2004	214	122	92	37	57.00	30.32 (17.28%)	101	65	36	18	64.35	27.69 (17.82%)	113	57	56	19	50.44	33.33 (16.81%)
Grand TOTAL		1063	560	503	184	52.68	32.85 (17.3%)	452	295	157	98	65.26	33.22 (21.7%)	611	265	346	86	43.37	24.85 (14.0%)

Abbreviations explained:-

100%M CR – 100% match conversion rate with no discrepancy to study cohort/design, sample size, author names/order and conclusion

Figures in brackets indicate the value with all SRS presentations (published & unpublished) as denominator

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The PPCR was highest for 2001 (58.4%) closely followed by 2004 (57%). Two-thirds of them were published in Spine (361 FTA) and JBJS(Am) accounted for 6.25% of publications (35 FTA). 87.32% of them were published within 3 years of presentation (489/560). Interestingly 16 presentations were already published as FTA before their submission (2.85%). The PPCR was 1.5 times higher for free-papers as compared to posters and was statistically significant ($p < 0.0001$) and Odd's Ratio(OR)=2.45(1.90-3.15).

Conclusion: The PPCR of SRS presentations is better than AAOS (34.2%; Bhandari et al, JBJS(Am) 2002: 84(4), 615-21) and ranks high in comparison with other medical specialties (32-72%). The studies were of high quality/content with negligible duplication validating the rigorous peer-review selection process. Only a third of free-papers were not followed by publication as FTA. Changes to the study cohort/design, authors or/& conclusion was common (seen in two-thirds of all published FTA).

Significance: The SRS presentations (esp. posters) should be interpreted with caution until their subsequent publication as a FTA. However acceptance of an abstract for presentation at the SRS annual meeting (esp. podium) is a benchmark of quality.

Paper #51

Comparing Financial Disclosure Reporting at Annual Spine Conferences

Brian L. Ju, BS (Yale University School of Medicine); Christopher P. Miller; Peter G. Whang, MD; Jonathan N. Grauer, MD; Level of Evidence: N/A

Introduction: Recently, increasing attention has been given to determining how financial conflicts of interest affect the integrity of medical science. In response, various financial disclosure policies have been adopted to increase transparency. However, there is still confusion regarding what type of industry relationships must be disclosed, and there is currently sparse data evaluating the consistency of such reporting among spine surgeons. The purpose of this study was to determine the variability in self-reported disclosures at three spine conferences in 2008.

Methods: We compiled author disclosures from the North American Spine Society (NASS), Cervical Spine Research Society (CSRS), and Scoliosis Research Society (SRS) conferences in 2008. We evaluated disclosure policies for each society and compared disclosures of authors who presented at more than one meeting.

Results: Disclosure data was listed for a total of 2,049 authors; of these individuals, 334 authors presented at more than one conference. CSRS and NASS required all disclosures. SRS required disclosures pertinent to the paper. 153 authors presented at NASS and CSRS, and 52% had discrepancies in their disclosures; of these, 46% reported "no disclosures" at one meeting yet declared at least one item at the other. SRS disclosures were also compared, understanding that project specific disclosures at SRS should have been reflected in the global disclosures requested by the other meetings.

Conclusion: These results emphasize the variability in disclosures at three conferences within the past year. While individuals' disclosures change periodically, such broad differences would not be expected over a short time period. Rather than through intentional duplicity, we believe that the variability is likely due to confusion regarding what to disclose in different circumstances and the lack of uniform disclosure policies among associations. Revisiting these policies, as many organizations are currently doing, is warranted.

Significance: There are considerable inconsistencies among disclosure information provided to these meetings. Explicit and standardized guidelines are needed to help facilitate the accurate disclosure of financial relationships and to characterize their effects on scientific research.

Paper #52

Musculoskeletal Injuries Among Spine Surgeons: Results of a Survey of the SRS Membership

Joshua D. Auerbach, MD; Zachary D. Weidner, BA; Andrew H. Milby, BS; Mohammad Diab, MD; Baron S. Lonner, MD (NYU Hospital for Joint Diseases); Level of Evidence: IV

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Introduction: Spinal deformity surgery is characterized by long duration and repetitive, forceful tasks. The purpose of this study is to describe the type and prevalence of musculoskeletal injuries (MSI) among spine surgeons.

Methods: A modified version of the Physical Discomfort Survey was sent to surgeon members of the Scoliosis Research Society (SRS) via standard mail and e-mail. A total of three attempts were made to contact potential respondents. Sixty-two percent (561/904) responded. Mean respondent age was 54 years. Mean annual total case volume was 147, of which 62 were spinal deformity. Eighty-four percent of respondents had an active surgical practice.

Results: The most common self-reported diagnoses included neck pain/strain/spasm (38%, 215/561), lumbar disc herniation/radiculopathy (31%, 172/561), cervical disc herniation/radiculopathy (28%, 155/561), rotator cuff disease (24%, 134/561), varicose veins or peripheral edema (20%, 112/561), and lateral epicondylitis (18%, 99/561). 7.1% (40/561) of spine surgeons underwent surgery for lumbar disc disease, and 4.6% (26/561) for cervical disc disease (Table). Among active spine surgeons, multiple linear regression analysis revealed that total case volume correlated with neck pain ($p=0.01$) and lower extremity edema ($p=0.03$), while the volume of deformity cases correlated with wrist pain ($p=0.003$) and hand pain ($p=0.03$). Age was correlated with shoulder pain ($p=0.03$), elbow pain ($p=0.04$), and hand pain ($p=0.02$). Number of years in practice did not correlate with MSI.

Conclusion: Compared with disease estimates in the general population, spine surgeons have a higher prevalence of MSI, most notably lumbar and cervical radiculopathy, rotator cuff disease, varicose veins or peripheral edema, and lateral epicondylitis. In our cohort, spine surgeons underwent surgical intervention for lumbar disc disease (7.1%) and cervical disc disease (4.6%) at rates that far exceed disease estimates in the general population.

Significance: Increased awareness of common MSI among spine surgeons will hopefully lead to earlier treatment and, ultimately, enhanced preventive measures.

Table: Treatment Received for Most Common Self-Reported Diagnoses

Diagnosis	Immobilization, brace, rest, or traction	Physical therapy and/or exercise	NSAIDs, analgesics, muscle relaxants	Oral steroids	Injection	Surgery	Time off from work
Cervical disc herniation	26.2%	20.5%	33.6%	8.2%	2.8%	10.7%	18.9%
Rotator cuff pathology	10.8%	27.0%	37.8%		6.8%	14.9%	20.8%
Lateral epicondylitis	23.9%	21.7%	22.8%		37.0%	5.4%	8.7%
Carpal tunnel syndrome	25.0%	2.1%	14.6%			39.6%	39.6%
CMC/basal thumb arthritis	20.3%	1.4%	23.0%		9.5%	6.8%	9.5%
Lumbar disc herniation	25.0%	16.4%	25.0%	3.9%	13.3%	23.4%	40.6%
Varicose veins/edema	63.4%*					5.4%	3.6%

*Jelly stockings

(Percentages reported are the percentage of patients with the particular diagnosis that underwent treatment)

Paper #53

Neuromuscular Scoliosis in Children with SCI as a Function of Age, Time Since Injury, Neurological Level, Motor Level, and Injury Severity

Louis N. Hunter, PT, MS; Amer F. Samdani, MD (Shriners Hospital for Children, Philadelphia); Randal R. Betz, MD; Lawrence C. Vogel, MD; Ross S. Chafetz, PT, DPT, MPH; John Gaughan, PhD; Mary Jane Mulcahey, PhD;

Level of Evidence: IV

Introduction: The objectives of the study were to investigate the determinants of neuromuscular scoliosis as a function of current age, time since spinal cord injury (SCI), neurological level (NL), motor level (ML) and injury severity as defined by the International Standards for Neurological Classification of SCI (ISNCSCI).

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Methods: 186 children with spine radiographs and ISCSCI exams. Relationship between ISCSCI motor score (MS) sensory score (SS) and neurological level (NL), ASIA Impairment Scale (AIS), age at and time since injury, and progression of scoliosis (Cobb angle) was evaluated using stepwise regression. Odds ratio was calculated to evaluate age at injury as a risk factor for requiring spine fusion.

Results: Age at injury ($p < 0.050$), AIS classification ($p < 0.01$), and MS ($p < 0.01$) were predictive of worse Cobb angle. Age at injury ($p < 0.031$) and years since injury ($p < 0.0001$) were predictors of progression to spine fusion. Of the subjects > 14 years of age at the time of evaluation who were injured < 12 years of age ($n = 32$), 50% required a spine fusion compared to 12% injured > 12 years ($n = 5$). Those injured < 12 years of age were 7.4 times more likely to require a spinal fusion as compared to those > 12 (95% CI = 2.31, 23.7).

Conclusion: ISCSCI motor score, length of time since injury, and injury severity (AIS classification) were found to be determinants of neuromuscular scoliosis in children with SCI.

Support: Shriners Hospitals for Children Grant#8956.

Paper #54

Scoliosis Surgery in Duchennes Muscular Dystrophy, Peri-Operative Medical and Surgical Considerations

Rolando Roberto, MD (University of California- Davis); Braden Boice, BS; Anto T. Fritz, MD; Hosun Hwang, MD; Andrew Skalsky, MD; Yolanda Hagar, MS; Laurel Beckett; Craig McDonald, MD; Munish Gupta, MD; Level of Evidence: IV

Introduction: Spine fusion has been advised in DMD once scoliosis exceeds 35° with occasional reports that fusion diminishes the rate of pulmonary function loss. We investigated changes in Cobb angle, pelvic obliquity (PO), forced vital capacity (FVC) and left ventricular fractional shortening (LVFS) in relation to surgical intervention.

Methods: After IRB approval, we reviewed charts and x-rays of DMD patients at our institutions. We recorded LVFS, FVC, Cobb angle, PO, EBL, operative time, length of time intubated, steroid exposure (yes/no), survival after surgery, and the effects of surgical intervention and steroid use on those parameters. Data was entered into Microsoft Excel and analyzed with SAS and R.

Results: 174 patients with DMD were identified. Cobb angle, pelvic obliquity, LVFS and FVC were available on 80, 78, 105 and 109 patients respectively. Mean Cobb angle at clinic referral was 18° with a 25% increase per year. 42 underwent spinal fusion (mean age 11.7, SD 2.6) at a mean pre-op curve of 48° (SD 22, range 10-92) corrected to a mean post-op curve of 25° (SD 18, range 7 to 82). The mean PO at clinic referral was 5° , with a mean increase of 14%/year. Pre-op PO averaged 13° (SD 11.4, range 0-48) and post-op PO averaged 7.6° (SD 9, range 0-40). Mean FVC at clinic referral was 110% predicted. Prior to operation FVC %predicted decreased 5% points/year such that mean Pre-op FVC was 55% predicted (SD 21, range 11-95), post-op FVC averaged 44% (SD 14, range 15-72). Pre-op LVFS averaged 31.6 (SD 5.2, range 19.1 to 47.4) and post-op LVFS averaged 30.1 (SD 5.9, range 12.7 to 39.4). Subjects receiving oral steroids did not have significantly different measures for FVC, LVFS or PO when compared to non-steroid treated patients. Average time intubated was 1.5 days; average ICU stay was 5.2 days (SD 5.3, range 1-21). Overall 1-year survival was 100% and 5-year

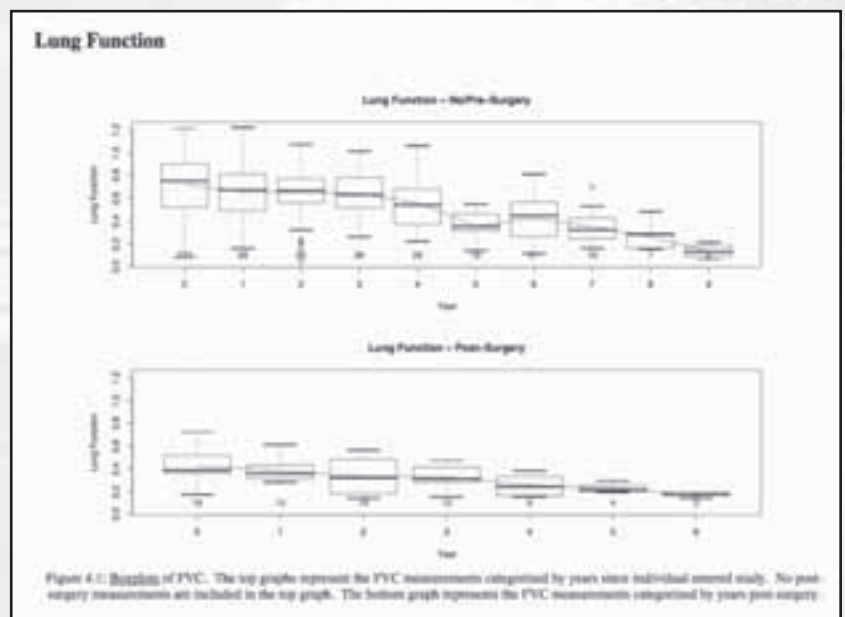


Figure 4.1: Boxplots of FVC. The top graph represents the FVC measurements categorized by years since individual referral study. No post-surgery measurements are included in the top graph. The bottom graph represents the FVC measurements categorized by years post surgery.

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survival was 87% based upon social security death records.

Conclusion: Spinal fusion for scoliosis in DMD was safely performed in selected patients at mean Cobb angle of 48°. The long-term rate of pulmonary function loss was unaffected by surgery.

Significance: Surgery may be offered to prevent deformity progression at Cobb angles >35 but will not affect rate of pulmonary function loss.

Paper #55

Long Term Results of the Galveston Technique for Pelvic Fixation in Neuromuscular Scoliosis

Amr Abdelgawad, MD; Douglas G. Armstrong, MD, FRCSC; Connie Poe-Kochert, CNP; Jochen P. Son-Hing, MD, FRCSC; **George H. Thompson, MD (Rainbow Babies and Children's Hospital); Level of Evidence: IV**

Introduction: There are a variety of procedures to correct spinal deformity and to achieve spino-pelvic stabilization in patients with neuromuscular scoliosis. Very few studies have specifically studied the results and complications associated with the Galveston technique.

Methods: Our computerized Pediatric Orthopaedic Spine Database identified 107 patients who underwent a PSF and LRI, including Galveston technique who had a minimum of 2 years postoperative follow-up. There were 55 females and 52 males with a mean age at surgery of 13.5 ± 3.5 years (range, 3 to 24 years). Forty-one patients had a same-day or staged anterior fusion. The mean follow-up was $7.8 \pm$ years (range, 2.1 to 16.3 years). We analyzed the major curves and pelvic obliquity preoperatively and postoperatively and any complications.

Results: The mean preoperative major curve was 76 ± 21 degrees (range, 26 to 140 degrees). At last follow-up this was improved to 33 ± 16 degrees (range, 0 to 83 degrees). The mean preoperative pelvic obliquity was 17 ± 10 degrees (range, 5 to 18 degrees). At last follow-up it measured 7 ± 6 degrees (range, 1 to 26 degrees). Seven patients (6.5%) had complications: 3 rod fractures, 3 distal migrations of the implants and one patient with both a rod fracture and distal migration. These occurred late and only one patient required revision surgery. There were no lumbosacral pseudoarthrosis.

Conclusion: LRI with Galveston technique is an excellent procedure for patients with neuromuscular scoliosis. It provides a solid distal foundation with minimal complications.

Significance: LRI with Galveston technique provides excellent correction of spinal deformity and pelvic obliquity in patients with neuromuscular scoliosis

Paper #56

**RUSSELL A. HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

Quantification of Intradiscal Pressures Below Thoracolumbar Spinal Fusion Constructs: Is There Evidence To Support "Saving A Level?"

Joshua D. Auerbach, MD; Baron S. Lonner, MD; Thomas J. Errico, MD; **Andrew L. Freeman, MS (Excelsior Research Center); Derek Goerke, BME; Brian P. Beaubien, MS; Level of Evidence: N/A**

Introduction: "Saving levels" in spinal deformity surgery is a common goal. Constructs with end-instrumented vertebra (EIV) in the lumbar spine may alter the biomechanical environment of the remaining unfused lumbar intervertebral discs, leading to accelerated disc degeneration and back pain. No study to date has quantified the relative pressure changes that occur in the unfused caudal discs with progressively longer fusions into the lumbar spine.

Methods: We used a validated in vitro cadaveric model to assess intradiscal pressures (IDP) below simulated thoracolumbar fusions. Five fresh frozen T8-S1 specimens were instrumented with 4.35-6.0mm pedicle screws, and 6.35mm SS rods from T8-L5. A 400N axial load with a follower-type loading system and 7.5Nm moments were applied in flexion and extension. A needle mounted pressure transducer was drawn through the mid-

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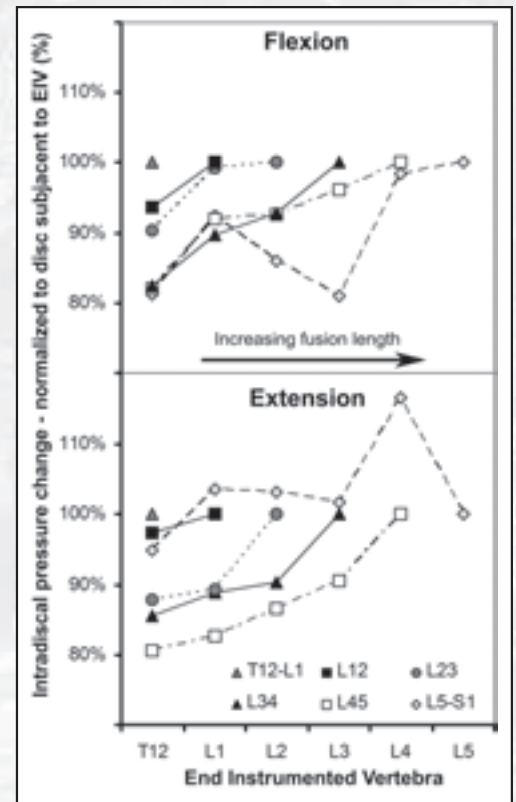
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sagittal plane of each disc to obtain AP IDP profiles. After acquiring IDP measurements at a given construct length, the rod was cut one level higher until EIV=T12. IDP data from the middle 25% of each unfused disc were averaged and normalized to the mean value of the disc immediately subjacent to the EIV.

Results: In both flexion and extension the mean normalized IDP of the unfused discs below the EIV increased with increasing fusion length (Fig). The IDP increases from the shortest to longest constructs were significant in the L2/3, L3/4 and L4/5 discs in either flexion or extension ($p \leq 0.002-0.032$). Each 1-level increase in construct length increased IDP by a mean $4 \pm 7\%$ for each unfused disc. The discs closest in proximity to the EIV experienced the highest IDPs.

Conclusion: Under the loading conditions applied in this model, unfused caudal lumbar discs experienced increased IDPs with increasing length of instrumented spinal construct, most notably at the subjacent discs closest to EIV. For each level saved in long fusion constructs, the intradiscal pressures below may be reduced by approximately 4%, thereby reducing the relative risk for the development of subjacent disc degeneration and the need for revision surgery.

Significance: This is the first study to quantify the relative biomechanical protection resulting from "saving a level" in long spinal fusion constructs.



Paper #57

**RUSSELL A. HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

Influence of GDF-5 on Osteogenic Differentiation of Adipose-Derived Stromal Cells in a Three-Dimensional Microsphere Matrix (PLAGA)

Qing Zeng, MD; Gary Balian, PhD; Francis H. Shen, MD (University of Virginia); Level of Evidence: I

Introduction: Using the copolymer poly (lactide-co-glycolide) [PLAGA], a sintering technique based on microsphere technology was used to fabricate three-dimensional porous scaffolds for bone regeneration. Adipose-derived stromal (ADS) cells were seeded onto an 85:15 PLAGA scaffold. We characterized the effects of GDF-5 on cell proliferation, cell differentiation, matrix mineralization and gene expression for selected bone marker proteins by rat ADS cells cultured on mixed scaffolds of PLAGA (85:15) in vitro.

Methods: rat ADS cells were maintained in DMEM medium containing Vitamin D to induce osteogenic lineage. These cultures were maintained at 37°C in a humidified atmosphere of 95% air and 5% CO₂ until they were ready to be seeded on the SMM. The media and GDF-5 were changed every other

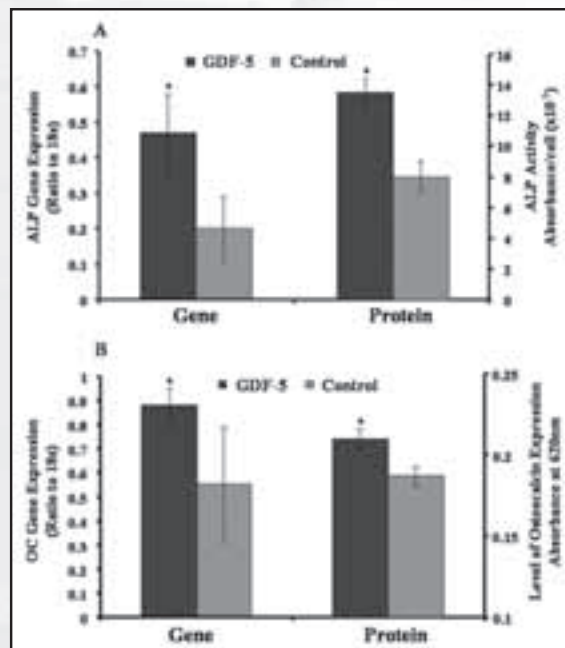


Figure 1. (A) In GDF-5 treated groups, the ALP protein and gene expression were significantly higher when compared to the control groups at 14 days. (B) Osteocalcin gene expression and protein were also increased when treated with GDF-5 at 28 days (* $p < 0.05$ vs. control group).

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day. At days 7, 14 and 28, scaffolds were removed and characterized for cell proliferation, differentiation, matrix mineralization, biochemical assay, gene expression and morphological analysis (SEM).

Results: Alizarin Red staining, indicated that calcium deposition increased with time, and was significantly greater ($p < 0.05$) at 14 and 28 days in the scaffolds that had been treated with GDF-5 compared with the control group. Gene expression for Cbfa1, ALP and OC was higher in the cultures treated with GDF-5 compared with the control group without GDF-5 at all the time points. Analysis for both ALP and OC gene expression demonstrated significant increases at day 14 and 28 and the transcription data agreed well with the temporal pattern obtained at the protein expression level of ALP and OC (Figure 1). Alkaline phosphatase activity (ALP) suggested that the osteogenic phenotype of ADS cells was stimulated upon treatment with GDF-5. In addition, SEM results at day 14 demonstrated similar cell distribution both on the surface and interior of the scaffold; there were more abundant cellular connections on day 14 than on day 7.

Conclusion: The results of this study confirm that adipose-derived stromal cells, when treated with GDF-5, are not only capable of adhering to the bioengineered scaffold, but also remain viable and demonstrated the ability to migrate, proliferate, and subsequently undergo osteogenic differentiation under the conditions described.

Paper #58

**RUSSELL A. HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

Conditional Deletion of Fibronectin Results in a Scoliosis-Like Phenotype

Qian Chen, MD (University of Missouri); Hong Zhao; Jie Zhao; Donna M. Pacicca, MD; Prof. Reinhard Fässler; Sarah L. Dallas, MD; Level of Evidence: N/A

Introduction: Fibronectin (FN) is an extracellular matrix (ECM) glycoprotein important for multiple cell functions. Although FN has not been viewed as a candidate gene for congenital scoliosis, studies from our laboratory suggest that misregulation of FN results in a scoliosis-like phenotype. Since conventional gene knockout of FN is early embryonic lethal, conditional FN knockout (FNcKO) mice were generated.

Methods: FNcKO mice were generated by crossing mice carrying a floxed FN gene with mice expressing Cre-recombinase driven by a 3.6kb Col1a1 promoter. The mice were analyzed by X-ray, histology and MicroCT. Expression of ECM proteins was examined by immunostaining. BMP signaling was evaluated by phospho-Smad1/5/8 staining.

Results: FNcKO mice showed severe vertebral deformities resembling scoliosis, including; kinky tail (involving one or multiple tail vertebrae), lateral spine curvatures and kyphosis. Various deformities included; vertebral fusions, hemivertebrae, asymmetric vertebrae and/or abnormal segmentation. The spinal curvatures became more pronounced as the animals aged. These mice showed reduced bone mineral density and reduced amounts of type I collagen, decorin and biglycan in their bones, suggesting a role for FN in assembly of these matrix components. Deletion of FN was also associated with reduced BMP signaling in osteoblasts. In vitro gene deletion of FN in osteoblast cultures confirmed impaired ECM assembly, which was rescued by supplementation with FN. In the embryo, FN is localized at somite boundaries and disruption of FN in avian embryos impairs somite formation. By examining developing FNcKO embryos, it was found that the caudal defect appeared as early as E11.5, suggesting a defect in somitogenesis and/or re-segregation.

Conclusion: Misregulation of FN may play a role in scoliosis by regulating assembly of ECM proteins and/or growth factor pathways (such as BMP signaling) that are important for axial skeleton patterning and bone growth and development.

Significance: This study provides new evidence that misregulation of FN can lead to abnormal vertebral development. These studies provide the foundation for future research to explore the potential of the FN gene or genes that regulate its assembly as candidate genes associated with scoliosis.

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Paper #59

**RUSSELL A. HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

Disc Health Preservation after Six Months of Spinal Growth Modulation: Expanding the Treatment Options for Fusionless Scoliosis Correction

Vidhadhar V. Upasani, MD; Christine L. Farnsworth, MS; Reid C. Chambers; Tracey P. Bastrom, MA; Gregory M. Williams, MS; Robert L. Sah, MD, ScD; Peter O. Newton, MD (Rady Childrens Hospital); Level of Evidence: N/A

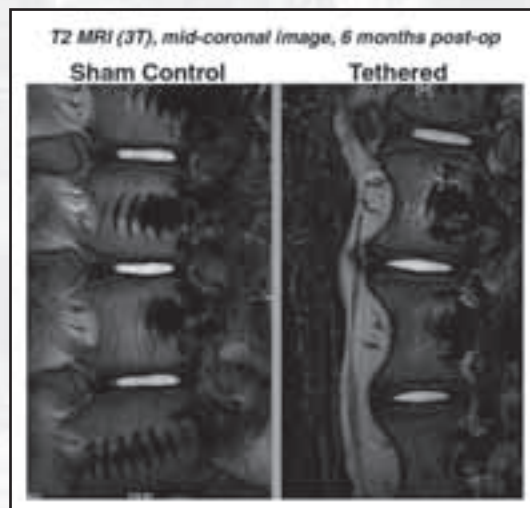
Introduction: Growth modulation with an anterolateral polyethylene tether has been proposed as a non-fusion treatment strategy for idiopathic scoliosis. Its effect on intervertebral disc health is unknown. The purpose of this study was to assess 3D spinal deformity creation over 6 months of growth modulation and to compare intervertebral disc physiology between tethered and sham surgical control animals.

Methods: Six immature mini-pigs were instrumented with anterior vertebral body screws connected to a polyethylene tether over 4 vertebrae (T8-T11). Another 6 animals underwent sham surgery: screw placement without a tether. Radiographs, CT and MR studies were used to evaluate deformity creation over 6 months. Intervertebral disc health was evaluated based on gross morphology, MR grading, histologic grading and biochemical analyses. ANOVA ($p < 0.05$) was used to compare 6-month post-op data between the tethered and control animals.

Results: Radiographs and CT images demonstrated significant coronal deformity creation ($17.5 \pm 4.0^\circ$ vs $1.8 \pm 0.5^\circ$; $p < 0.001$), increased thoracic kyphosis (change from pre-op: $5.3 \pm 0.9^\circ$ vs $2.4 \pm 1.6^\circ$; $p = 0.002$), and significant axial plane deformity (T9 vertebral rotation: $4.5 \pm 1.3^\circ$ vs $1.0 \pm 0.8^\circ$; $p = 0.004$) in tethered animals compared to sham controls, retrospectively. Macroscopic, MR and histologic evaluation revealed no signs of degeneration. Biochemical analysis demonstrated no significant difference in average water content ($85 \pm 4\%$ vs $86 \pm 3\%$; $p = 0.2$), proteoglycan content ($7.7 \pm 1.8\%$ vs $7.3 \pm 2.3\%$; $p = 0.4$) or cell density (380 ± 110 vs 350 ± 100 ; $p = 0.4$) in the nuclei of tethered and control discs. Only average water content ($60 \pm 7\%$ vs $68 \pm 5\%$; $p < 0.001$) of the annulus fibrosus was found to be statistically lower with the tether.

Conclusion: Six months of spinal growth modulation created significant 3 plane deformity compared to controls. Although disc health was qualitatively maintained, quantitative changes in annulus water content and disc height were observed. These changes likely represent the disc metabolic response to compressive loads generated by the tether.

Significance: In the short term, dynamic compression created by a flexible tether was able to consistently modulate endochondral vertebral ossification without detrimentally affecting intervertebral disc health.



Paper #60

**RUSSELL A. HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

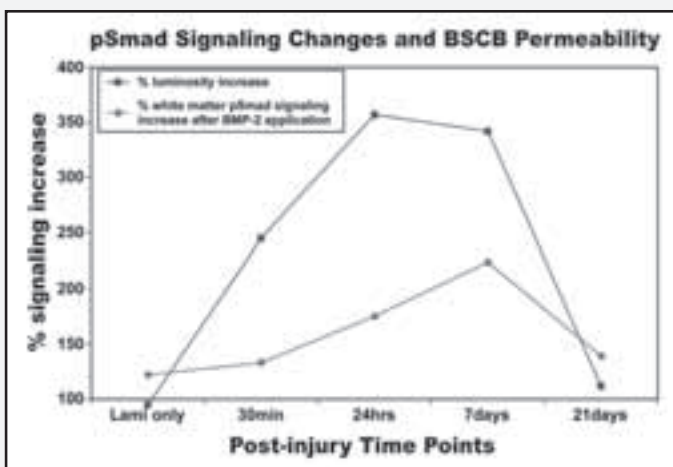
BMP-2 Use in the Presence of Spinal Cord Injury Elicits a Robust Intrathecal Signaling Cascade Which May be Detrimental to Neurologic Recovery

Anton E. Dmitriev, MSc, PhD(c) (Walter Reed Army Medical Center); Suzanne Farhang, BSc; Ronald A. Lehman, MD; Geoffrey Ling, MD, PhD; Aviva J. Symes, MD; Level of Evidence: N/A

Introduction: The use of bone morphogenetic protein (BMP-2) and its indications for spinal fusion continue to be expanded with recent reports citing spinal trauma application. However, there are no data establishing the effects of BMP-2 on the injured spinal cord. Our objectives were to evaluate the extent of BMP-specific intrathecal signaling following application to the spine at various time-points after a SCI.

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Methods: Part I: Forty (40) female Sprague-Dawley rats underwent either a T10 dorsal hemisection SCI (n=32) or laminectomy-only (n=8). SCI animals were further subdivided into 4 follow-up groups (n=8/group): 30min, 24hrs, 7days and 21days, at which time a 2nd procedure was performed and either 86ug of BMP-2 or sterile water control was placed over T9-11 on a collagen sponge (ACS). Animals were perfused 24hrs after and spinal cords immunohistochemically analyzed. Sections of the lesion were stained with BMP-specific pSmad 1, 5, 8 antibody and co-stained with CNS cell-specific markers. pSmad positive cells were then counted around the lesion. Part II: Additional 25 rats were randomized to the same groups as in Part I, except in the 2nd procedure luciferase (blood spinal cord barrier permeability marker) was injected iv and analyzed within the cord.



Results: After injury, a significant increase in the number of pSmad positive cells was observed when BMP-2 was implanted at the 30min, 24hrs and 7 day time-points ($p < 0.05$). Co-staining revealed BMP-specific signaling activation in neurons, glial cells, macrophages and fibroblasts. Spinal cord permeability to luciferase was significantly increased at 30min, 24hrs and 7 days post-lesion ($p < 0.05$). A significant linear regression was established between the extent of BSCB permeability and pSmad signaling ($r^2 = 0.66$, $p = 0.000$). (Figure 1)

Conclusion: Our results indicate that BMP-2 use around a spinal cord lesion elicits a robust signaling response within the spinal cord parenchyma. All CNS cell types and the invading fibroblasts are activated to the extent dependent on the integrity of the meningeal and BSCB barriers.

Significance: In the presence of a spinal cord injury and/or dural tear, BMP-2 diffuses intrathecally and activates a signaling cascade in all major CNS cell types, which may impact neurologic recovery.

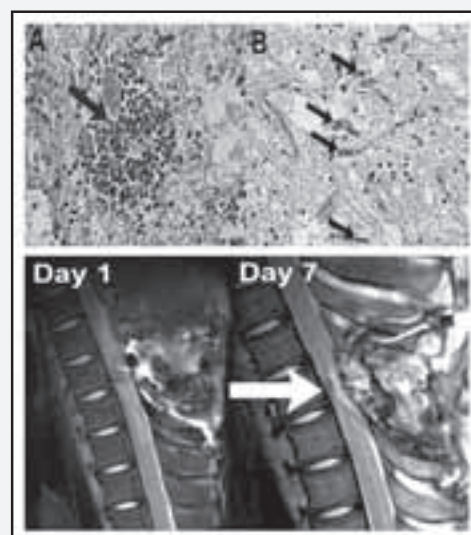
Paper #61

A New Model of Pediatric Spinal Cord Injury in Infant Piglets: Functional Outcome, MR Imaging, and Histopathology

Amer F. Samdani, MD (Shriners Hospital for Children, Philadelphia); W. Dalton Dietrich, PhD; Randal R. Betz, MD; Manuel Gonzalez-Brito, DO; John Kuluz, MD; Level of Evidence: N/A

Introduction: Currently, there is no model for pediatric SCI. The need for such a model is emphasized by the vastly different injury patterns observed in pediatric versus adult patients. Thus, we sought to develop a pediatric large animal model of complete spinal cord injury characterized by functional outcome, MRI, and histopathology.

Methods: Female infant piglets ages 2-3 weeks (N=8) were utilized for these experiments. The piglets were anesthetized, intubated, and monitored via an arterial line, central line, and pulse oximeter throughout the procedure. A posterior laminectomy was performed at T7-8 and a SCI rendered using a controlled cortical impactor (CCI). With the CCI, the severity of the injury can be varied by altering the depth (mm) and force (psi) of the impactor. Outcome measures included (1) clinical assessment of motor, sensory, and bowel/bladder function, (2) serial MRIs, and (3) histopathology. Two piglets were survived for 7 days, three for 14 days, and three for 28 days.



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Results: We were able to produce complete SCI in all animals using 70 psi of force at a depth of 5mm. This was characterized by loss of motor, sensory, and bowel/bladder (no rectal tone with neurogenic bladder) below the level of injury. MRI revealed a well-defined hemorrhagic contusion on T2 weighted images with evolution over time (Figure 1). At sacrifice, histopathology demonstrated an expected marked inflammatory infiltrate with a small number of caspase-3 positive cells (apoptotic marker) at the periphery of the injury (Figure 1). Notably, the histopathological changes closely mirrored the MRI.

Conclusion: We present our initial results characterizing a large animal model for pediatric complete SCI. This model will be utilized to (1) characterize pathophysiological differences between adult and pediatric SCI, and (2) serve as a model to evaluate laboratory advances for SCI.

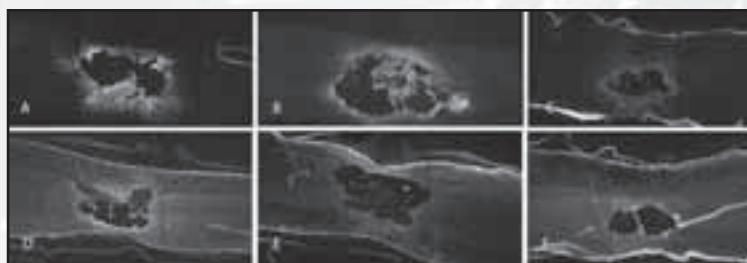
Significance: We have characterized clinically, radiographically, and histopathologically a new model for pediatric complete SCI. This model will be utilized to evaluate various therapeutic modalities prior to initiating clinical trials.

Paper #62

Early Surgical Decompression With Duraplasty in Acute Spinal Cord Injury Improves Functional Recovery in an Animal Model

Jeremy S. Smith, MD; Ryan Anderson; Thu Pham; Nitin Bhatia, MD (University of California- Irvine); Oswald Steward, PhD; Ranjan Gupta, MD; **Level of Evidence: N/A**

Introduction: The role of decompressing the subarachnoid space through a durotomy as a treatment option for acute traumatic spinal cord injury (SCI) in the cervical spinal cord has not been explored. We sought to determine the role of durotomy and duraplasty in acute cervical SCI and its effects on inflammation, scar formation and functional recovery.



Methods: Seventy-two adult female

Sprague-Dawley rats were assigned to 3 groups: contusion injury alone, contusion injury with durotomy and decompression, and contusion injury with durotomy followed by placement of a dural allograft. A moderate contusive injury was delivered to the exposed spinal cord at C5 using a force directed impactor. The injured segment was re-exposed 4 hours after injury and a durotomy with decompression was performed. Dural allografts were affixed to the surrounding intact dura using a fibrin sealant. The Grip Strength Meter (GSM) was used to assess forelimb function. Animals were sacrificed at 2 and 4 weeks and immunohistochemistry was performed to assess scar formation, inflammatory cell infiltration, and lesional volume.

Results: Animals receiving dural allograft had significantly improved GSM scores in the recovery period relative to other groups. ($p < 0.05$). Immunohistochemical analysis revealed increased scar formation, cavitation and inflammatory response in the animals treated only with a decompressive durotomy. Relative to the group receiving a contusion injury alone, animals receiving a durotomy followed by dural allograft displayed decreased cavitation and scar formation. Lesional volume measurements showed significantly increased ($p < 0.05$) cavitation size at 4 weeks in both the contusion only and durotomy only groups relative to those animals that received dural allograft following durotomy.

Conclusion: Functional recovery after acute cervical SCI was improved with decompression of the subarachnoid space and placement of a dural allograft. This behavior data correlated with the histologic evidence of decreased spinal cord cavitation and scar formation. The results support the rationale of acutely decompressing the subarachnoid space following a compressive spinal cord injury.

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Paper #63

Spinal Shock in Spinal Cord Injuries - Is Duration of Shock Related to Neurological Level?

Rajeshwar N. Srivastava, MS (Ortho) (KG Medical College, CSM Medical University); Level of Evidence: II

Introduction: A study was done to determine the duration of spinal shock in spinal cord injury (SCI), the first reflex to return while recovering from spinal shock & the factors influencing duration of spinal shock.

Methods: 116 patients in spinal shock following SCI were included. A detailed neurological examination of sensory, motor and reflex activity was done everyday till the patients were out of spinal shock. The duration of spinal shock by appearance of any reflex, the first reflex to return & the influence of variable factors on duration of spinal shock were studied

Results: In 76 patients (85.4%) anal wink (AW) was the first reflex to return either alone or simultaneous with BC / DPR. In 7 patients cremasteric reflex, in 3 pathological reflexes & in 2 deep tendon reflexes (ankle) were the first to return. Mean duration of spinal shock (MD of SS) was shorter in children, shorter in malnourished, shorter in untrained/laborers, shorter in patients admitted early and shorter in patients without any complications. 'MD of SS' was not influenced by sex of patient, associated injuries and by different modalities of treatment.

Conclusion: On statistical analysis of duration of spinal shock with neurological level as a variable 'MD of SS' was 1.7 days in cervical cord lesions, 8.2 days in upper thoracic, 15 days in lower thoracic and 17 days in lumbar cord lesions. Such an arithmetical progression was also found at each segmental level i.e. the duration of spinal shock progressively increased at every segmental level. 'MD of SS' was 1.36 days at C4, 1.60 at C5, 1.72 at C6, 8.1 at T6, 12.4 at T8, 13.1 at T10, 15.3 at T12 & 21.6 at L2.

Significance: An arithmetical relationship exist between the duration of spinal shock and the segmental level of spinal cord injury - the duration of spinal shock was directly proportional to level of injury We do not have the answer of this important observation of arithmetical progression of spinal shock duration in relation to level of injury. Higher or proximal the lesion, shorter is the duration. Does the duration of spinal shock dependant on the cord length/ neuronal mass involved?

Paper #64

Predictors of Complications Following Spinal Stabilization of Thoracolumbar Spine Injuries

John R. Dimar, MD (Kenton D. Leatherman Spine Center); Charles Fisher, MD; Alexander R. Vaccaro, MD; David O. Okonkwo, MD, PhD; Marcel Dvorak, MD, FRCSC; Michael Fehlings, MD, PhD; Raja Rampersaud, MD, FRCS; Leah Y. Carreon, MD, MSc; Level of Evidence: IV

Introduction: The management of complications following major traumatic spinal injury and surgical stabilization is a challenge for spine specialists. The purpose of this study is to report on the incidence of complications following surgical stabilization of thoracolumbar spine injuries and to identify factors predictive of occurrence of a major complication.

Methods: A retrospective review of subjects enrolled in a multicenter database for spine trauma (EPOST) was done. Standard demographic data, Glasgow Coma Scores (GCS), Injury Severity Score (ISS), ASIA score, Charlson CoMorbidity Index (CCI), mechanism of injury, administration of methylprednisolone (NASCIS II, III), time from injury to surgery, and surgical approach were evaluated. All postoperative and perioperative

Complication	Number	Percentage (%)
Pulmonary	12	5.04
Construct Failure	8	3.36
DVT	6	2.52
Pulmonary Embolism	5	2.10
Wound infection (Deep)	13	5.46
Wound infection (Superficial)	2	0.84
Wound hematoma	2	0.84
Neurologic deterioration	5	2.10
UTI	27	11.34
Wound dehiscence	4	1.68
CSF Leak	0	0.00
Dural Tear	2	0.84
Vascular injury	1	0.42
Visceral injury	0	0.00
Other	78	32.77

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complications within six months of surgery were recorded. Multivariate regression analysis was done to identify factors predictive of the occurrence of a major complication after surgical stabilization of a thoracolumbar injury.

Results: There were 230 patients (57 females, 173 males), 35% were smokers. The mean age at injury was 41.8±17.8 years and the mean body mass index was 25.7±4.2 kg/m². The most common injury mechanism was a fall (52%) followed by MVA (36%) and sports injury (10%). The mean admission ISS was 9.2±7.8, mean CCI was 0.2±0.7, mean GCS was 14.6±1.6. NASCIS II & III was instituted in 15.5% & 4.2% of patients respectively; mean time from injury to surgery was 8.9±59 days; surgical approach was anterior only in 30 (13%), posterior only in 154 (65%), and anteroposterior in 52 (22%) patients. The total incidence of complications was 79% (minor 30%, major 49%). The different complications are summarized in Table 1. The complications listed as "other" are singular incidents of a specific complication. Factors predictive of the occurrence of a major complication were administration of high dose steroids (NASCIS II) (Odds Ratio:2.3; CI: 1.1-4.8, p=0.030) ASIA score (OR:0.7; CI:0.6-0.8, p=0.000) and CCI (OR:1.9; CI:1.2-3.0, p=0.001).

Conclusion: The severity of neurologic injury, number of comorbidities and use of the high dose steroids independently increase the risk of having a major complication following surgical stabilization of thoracolumbar spine fractures.

Variable	Number	Percentage (%)
Gender		
Female	57	24.78
Male	173	75.22
Smoker		
Yes	79	35.91
No	141	64.09
Mode of Injury		
MVA	83	34.87
Pedstrian Accident	2	0.84
Sports	25	10.50
Fall	102	42.86
Blunt assault	2	0.84
Other	24	10.08
ASIA Score		
A	42	18.50
B	18	7.93
C	9	3.96
D	41	18.06
E	117	51.54
Medical Management		
NASCIS II	37	15.55
NASCIS III	10	4.20
Other	2	0.84
Surgical Approach		
Anterior Only	30	12.71
Posterior Only	154	65.25
Anterior-Posterior	52	22.03

Paper #65

Classification of Spinopelvic Resections: Oncologic and Reconstructive Implications

Michael J. Yaszemski, MD, PhD (Mayo Clinic); Peter S. Rose, MD; Bradford L. Currier, MD; Mark B. Dekutoski, MD; Paul M. Huddleston, MD; Ahmad Nassr, MD; Mark A. Pichelman, MD; Franklin H. Sim, MD; Level of Evidence: IV

Introduction: Curative treatment of malignancies in the sacrum and lower lumbar spine frequently requires en bloc spinopelvic resection. There is no standard classification of these procedures. We present outcomes and a classification scheme with oncologic and reconstructive guidelines for spinopelvic tumors based on an analysis of 30 cases.

Methods: We reviewed oncologic staging, surgical resections, and reconstructions of 30 patients presenting with malignant tumors undergoing spinopelvic resection with curative intent. Mean follow-up of surviving patients was 38 months.

Results: Tumors included osteosarcoma (n=9), chondrosarcoma (n=6), chordoma (n=5), other sarcomas (n=5), neurogenic tumors (n=4), and local extension of carcinoma (n=1). We classify resections into 4 types. Type 1 resections included a total sacrectomy with lower lumbar spine and bilateral medial iliac resections. Type 2 resections included hemisacrectomy, partial lumbar spine excision, and iliac wing resection. Type 3 resections encompassed external hemipelvectomy with hemisacrectomy and partial excision of one or more lumbar vertebrae. Type 4 resections encompassed external hemipelvectomy, total sacrectomy, with

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or without lumbar vertebrectomies, and with or without partial iliac resection on the remaining side. For each resection type, we have developed staged surgical approaches to allow resection with wide margins and reconstruction of spinopelvic continuity. Tumor free margins were achieved in all cases. Perioperative mortality was 3/30. Ten additional patients have died of disease, 2 died of other causes, 2 are alive with disease, and 16 have no evidence of disease. 13/18 surviving patients are independent in their activities of daily living.

Conclusion: En bloc excision and reconstruction of spinopelvic neoplasms may be classified into four types. For each type, we have devised surgical treatment guidelines to allow for wide resection and reconstruction of spinopelvic continuity. Long term survival and independent function can be achieved in this challenging patient population.

Significance: This represents the first standardized classification of oncologic spinopelvic resections and reconstructions.

Resection Type	Spinal Resection	Pelvic Resection	Reconstruction
1 (n=12)	Total sacrectomy +/- lumbar spine	Bilateral iliac wings	PSF L-spine to pelvis; fibular struts L-spine to pelvis
2 (n=6)	Hemisacrectomy +/- lumbar hemivertebrectomy	Unilateral medial ilium	PSF L-spine to pelvis with unilateral strut L-spine to pelvis
3 (n=9)	Hemisacrectomy +/- lumbar hemivertebrectomy	External hemipelvectomy	None vs PSF remaining L spine to remaining hemipelvis
4 (n=3)	Total sacrectomy +/- lumbar spine	External hemipelvectomy +/- medial ilium on retained side	Femur of amputated leg used to connect L spine to remaining hemipelvis

Paper #66

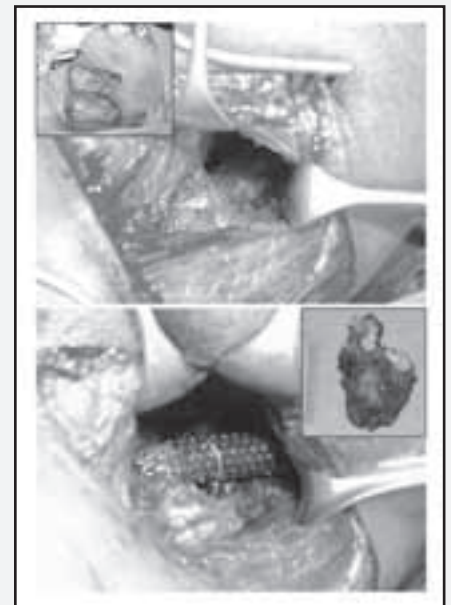
En-bloc Excision of Chordomas in the Cervical Spine: Review of Five Consecutive Cases with over Four-Year Follow-Up

Patrick C. Hsieh, MD (University of Southern California); Gary Galia, MD, PhD; Daniel Sciubba, MD; Jean-Paul Wolinsky, MD; Ziya Gokaslan, MD; Level of Evidence: N/A

Introduction: Studies have demonstrated that en bloc surgical excision of chordoma with negative margins results in improved local disease control and survival compared to intralesional resections. Chordomas arising from the cervical spine are rare and they present unique challenges for en bloc tumor excision. To date, only a few case reports of en bloc excision of chordoma in the cervical spine are reported in literature.

Methods: A retrospective review of an institutional spine tumor database was performed. Five consecutive patients that underwent en bloc tumor excision for cervical spine chordoma from 2000-2007 were identified. Retrospective review of their medical charts was performed to analyze their surgical margins, peri-operative complications, tumor recurrence rate, and survival.

Results: The most common presenting symptom in this cohort was dysphagia (80%). All patients underwent biopsy for tissue diagnosis prior to surgery. The mean age of diagnosis in this cohort was 61.2 years-old and our mean follow-up for this study is 4.2 years. All five patients required multi-stage procedures to achieve en bloc tumor excision, and they required peri-operative tracheostomy and gastrostomy tubes. 30-day peri-operative complication was significant for one wound infection. In addition, long-term



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complications included two instrumentation failure requiring revisions, but there were no neurological or cerebrovascular complications. Independent analysis of the surgical margins by the pathologists revealed that marginal en bloc excisions were achieved in all five patients. At the time of analysis, the mean disease-free survival is 4.2 years for the group and only one patient had tumor recurrence that required repeat surgical excision.

Conclusion: En bloc excisions of chordoma in the cervical spine are complex procedures with technical challenges and significant complication rate. Nevertheless, improved disease-free survival can be achieved in patients with cervical chordomas by en bloc tumor excision with acceptable complication rate.

Significance: Despite technical challenges and significant potential for surgical complication, en bloc tumor excision of chordoma in the cervical spine can be performed to improve local disease control and survival.

Paper #67

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Posterior Vertebral Column Resection in Severe Spinal Deformities: A Total of 102 Cases

Cagatay Ozturk, MD (Istanbul Spine Center); Mehmet Aydogan, MD; Mehmet Tezer, MD; Mercan Sarier, MD; Selhan Karadereliler, MD; Azmi Hamzaoglu, MD; Level of Evidence: IV

Introduction: Vertebral column resection is the only procedure providing both coronal and sagittal plane correction at the same time. In this study; we have presented the surgical strategy, correction rates and complications of posterior vertebral column resection (PVCR) in patients with spinal deformities due to various etiologies.

Methods: Between 1996-2007; 102 patients were treated by PVCR. There were 80 female and 22 male patients with a mean age of 37.6 years. Diagnoses were severe deformity in 56 patients, osteoporotic fractures in 25 patients, postinfectious severe angular kyphosis in 12 patients and posttraumatic deformity in 9 patients. The critical points in the surgical technique are wide laminectomy (one level above and one level below the resected level to prevent neural impingement after correction), bilateral sequential compression for kyphosis, repeated gradual compression on convex side in kyphoscoliosis, start of correction from concave site on either side of osteotomy immediately proximal and distal to osteotomy site, then going up and down alternatively in lordoscoliosis, final evaluation of spinal canal, anterior fusion across the resection gap by titanium mesh cages, placement of H-shaped strut allograft between intact spinous processes to prevent compression of dura by hematoma in the laminectomy area.

Results: The minimum follow-up was 2 years, average of 9.3 years. The average correction ratios was 72% in coronal and 71% in sagittal plane. The mean (SD) values of pelvic incidence, sacral slope and pelvic tilt changed from 42 ± 140 , 31 ± 90 and 11 ± 50 preoperatively to 52 ± 160 , 39 ± 120 and 13 ± 60 respectively at the last control visit. No patient has required revision surgery for any neurological, instrumentation or fusion complication.

Conclusion: PVCR is beneficial for the patients who have decreased pulmonary functions due to the nature of deformity and due to related co-morbidities. This technique prevents the patients from adverse effects of anterior surgery. It is a technically demanding procedure. So, it should be performed by highly experienced surgical team.

Significance: Posterior vertebral column resection is an effective technique since it is a spinal column shortening procedure and it allows to do correction in same session.

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Paper #68

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Major Complications of Three-Column Osteotomies in 240 Consecutive Spinal Deformity Patients

Joshua D. Auerbach, MD (Washington University School of Medicine); Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jennifer K. Sehn, BS; Andrew H. Milby, BS; David Bumpass, MD; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Lukas P. Zebala, MD; Brenda Sides, MA; **Level of Evidence: III**

Introduction: Three-column spinal osteotomies (pedicle subtraction osteotomy (PSO), vertebral column resection (VCR)) are common techniques to correct rigid spinal deformities. This study sought to: 1) characterize the risk factors for the development of major complications in PSO and VCR procedures, and 2) determine if the presence of a major complication affects ultimate clinical outcome.

Methods: A retrospective review was performed on 240 consecutive PSOs (n=156) and VCRs (n=84) at a single institution between 1995-2008. Using established criteria, we stratified complications as major or minor. Risk factors for complications and their effect on SRS clinical outcomes at baseline and at ≥2yrs were assessed.

Results: 240 consecutive patients met inclusion criteria. Major medical and surgical complications occurred in 34% of PSOs (53/156) and 21% of VCRs (18/84). Overall, 20.4% (49/240) experienced major surgical complications (7 permanent), and 17.1% (41/240) experienced major medical complications (4 permanent). PSOs were older (52 vs 22yr, p<0.001), had fewer levels fused (9.9 vs 11.6, p=0.003), greater EBL (1,992 vs 1201cc, p<0.001), shorter operative times (475 vs 519min, p=0.02), and less segmental kyphosis correction (35.1° vs 44.8°, p=0.05). Risk factors for major complications included age>60yrs (p=0.003), ≥3 comorbidities (p=0.009), EBL>2L (p=0.01), and fusion to sacrum (p=0.05). Patients with and without major complications had equivalent baseline SRS subscores (2.63 vs 2.67, p=0.98), experienced significant improvement, and had equivalent final subscores at ≥2yrs follow-up (3.66 vs 3.59, p=0.43). While both improved significantly in SRS subscores, PSOs started off worse and improved more than VCRs (+0.9 vs +0.6, p<0.001) with no differences in final satisfaction (4.1 vs 4.5, p=0.11) (Table).

Conclusion: Major complications occurred in 34% of PSO and 21% of VCR procedures. Risk factors for developing a major complication included age>60yrs, ≥3 comorbidities, EBL>2Liters, and fusion to sacrum. The occurrence of a major complication did not have a negative impact on the ultimate clinical outcome. While both improved significantly, PSOs started off worse and improved more than VCRs with no differences in final satisfaction.

Table. Comparative Data: PSO and VCR

	PSO (n=156)	VCR (n=84)	p-value
Age	52.0±15.9	21.9±16.7	P<0.001
No (%) Revision Procedures	130 (83)	44 (52)	P<0.0001
Body Mass Index (kg/m²)	28.0±6.0	22.0±5.5	P<0.0001
#medical comorbidities	2.7±2.1	2.2±2.1	NS
#Levels fused	9.9±4.0	11.6±4.2	P=0.003
EBL (cc)	1,992±1,111	1,201±910	P<0.0001
Operative Times (min)	475±109	519±115	P=0.02
Segmental kyphosis correction (degrees)	35.1±10.9	44.8±18.5	P=0.05
No. (%) Major Complications	53 (34)	18 (21)	NS
No. (%) Minor Complications	79 (51)	31 (37)	P=0.04
Pre-op SRS Subscore	2.5±0.8	3.4±0.3	P<0.001
Ultimate (≥2yrs) SRS Subscore	3.4±0.8	4.0±0.4	P=0.001
Pre-op to ≥2yrs post-op SRS Subscore	+0.9±0.5	+0.6±0.2	P<0.001
Ultimate (≥2yrs) SRS Satisfaction	4.1±0.5	4.5±0.7	P=0.11

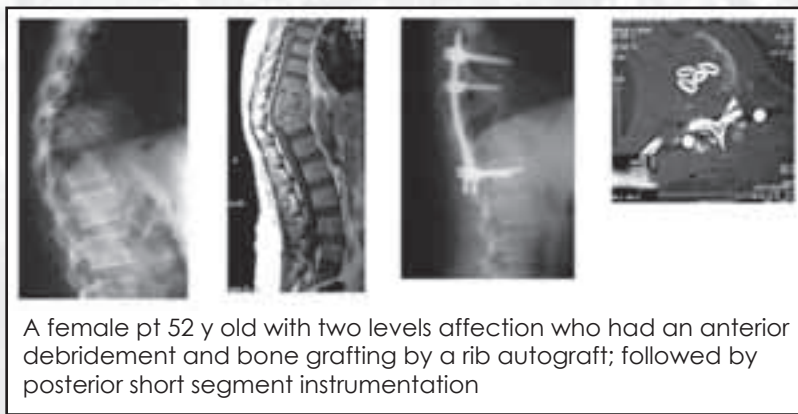
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Paper #69

Sagittal Alignment Following Anterior Debridement and Posterior Instrumentation for Multiple Levels Tuberculous Spondylodiscitis

Wael Koptan, MD; Yasser ElMiligui, MD (Cairo University Hospital); Motaz SalahEIDin, MD; Wael Hammad, MD; **Level of Evidence: III**

Introduction: The incidence of tuberculosis is increasing rapidly in the last decade. Anterior reconstruction using iliac crest or rib autografts was associated with many complications especially in multiple level affections. Additional posterior instrumentation may reduce postoperative kyphosis and subsequent loss of correction. The aim of this work is to compare the results of iliac crest and rib grafts regarding fusion rates, sagittal plane alignment, the incidence of complications and to assess the role of short segment instrumentation.



Methods: The results of 38 patients with multiple level resistant tuberculous spondylodiscitis surgically treated between 1998 and 2005 were retrospectively reviewed. Thirty-six patients were followed-up for a minimum of 3 years; an average of 5y (range 3 - 8y). The average age was 49 years (ranged from 31 to 68 y) and twenty patients had an associated neurologic deficit. All patients were investigated by standard labs, plain radiographs and an MRI. The disease affected two levels (26 patients) and three levels (10 patients). All had an anterior debridement and bone grafting by iliac crest autograft in 15 patients (Group 1) and rib autograft in 21 patients (Group 2); followed simultaneously by posterior short segment instrumentation.

Results: The kyphotic deformity was corrected from an average of 37 degrees to an average of 5 degrees (Group 1) and from an average of 46 degrees to an average of 7 degrees (Group 2) postoperatively. At the last follow up, both groups had a similar fusion rate and loss of correction. Group 1 patients had 5 donor site complications (33%). All patients except one had an improvement in their neurologic status.

Conclusion: Additional posterior instrumentation in spondylodiscitis affecting multiple levels with associated kyphosis applies immediate stability; allows adequate graft uptake and long term correction of the kyphotic deformities. Both iliac crest and rib grafts have shown a similar radiological outcome, however, iliac crest grafting had a high incidence of donor site morbidity.

Paper #70

Incidence of Surgical Site Infection Following Adult Spinal Surgery: An Analysis and Prevalence Of Risk Factors

Albert Pull ter Gunne, MD; David B. Cohen, MD (Johns Hopkins Hospital); **Level of Evidence: III**

Introduction: SSI is a common complication after spinal surgery. It occurs between 0.7 and 12% of patients and leads to higher morbidity, mortality and healthcare costs. We performed a large cohort study to identify risk factors for SSI and the absolute rates of SSI.

Methods: Retrospectively, we abstracted records of all 3174 adult patients who underwent orthopaedic spinal surgery at our institution between June 1996 and December 2005. Cases of SSI were compared to the rest of the cohort. Sub-group analysis of deep and superficial SSI was performed.

Results: 132 (4.2%) patients developed a SSI with 84 having deep infection. Estimated blood loss >1 liter ($p=0.017$), previous SSI ($p=0.012$) and diabetes ($p=0.050$) were found to be independent risk factors for SSI. Obesity ($p=0.009$) increased the risk of superficial infection, while anterior spinal approach decreased the risk ($p=0.010$). Diabetes ($p=0.033$), obesity ($p=0.047$), previous SSI ($p=0.009$) and longer surgeries (2-5 hours ($p=0.023$)) and 5 or more hours ($p=0.009$)) were independent significant risk factors for deep SSI.

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Conclusion: SSI is commonly seen after spinal surgery. A prior SSI, diabetes and obesity all increased the risk of SSI. Higher EBL and longer operative times also increase risk of different types of SSI while anterior approaches to the spine were associated with the lowest risk of SSI. Preoperative management of obesity and diabetes should be considered. Peri-operative strategies to minimize blood loss and operative time while utilizing an anterior approach should be considered to decrease the risk for postoperative wound infection.

Significance: This is the largest case-control cohort analysis of SSI in adult spinal surgeries. This allowed us to determine absolute SSI rates and evaluate previously identified risk factors for SSI to determine those that are true independent risk factors.

Paper #71

Rates of Infection Following Spine Surgery Based on 108,419 Procedures: A Report from the Scoliosis Research Society Morbidity and Mortality Committee

Justin S. Smith, MD, PhD (University of Virginia); Christopher I. Shaffrey, MD; Charles A. Sansur, MD; Sigurd Berven, MD; Theodore J. Choma, MD; Michael J. Goytan, MD; Hilali Noordeen, FRCSD; D. Raymond Knapp, MD; Robert A. Hart, MD; Reinhard Zeller, MD; William F. Donaldson, MD; David W. Polly, MD; Joseph H. Perra, MD; Oheneba Boachie-Adjei, MD; Level of Evidence: III

Introduction: CMS created a list of “never events” and has proposed denial of hospital payment for their treatment. While some are preventable, surgical infection is multifactorial and occurs despite meticulous efforts. The Scoliosis Research Society (SRS) prospectively collects morbidity and mortality (MM) data from its members. We used these data to assess infection rates following spine surgery.

Methods: The SRS MM database was queried for cases from 2004-2007. Cases were stratified based on adult (≥ 21) vs pediatric (< 21), primary vs revision, use of implants and diagnosis. Superficial and deep infection rates were calculated.

Results: 108,419 cases were identified, with an infection rate of 2.2% (superficial=0.8%, deep=1.3%). Revision cases (16,503) had a 65% higher rate of infection (3.3%) compared with primary cases (91,916; 2.0%). Pediatric cases (25,432) had a 35% higher rate of infection (2.7%), compared with adult cases (82,082; 2.0%). The infection rate for cases with implants (74,114) was 28% higher than the rate for cases without implants (34,305), 2.3% vs 1.8%, respectively. Rates of infection were calculated based on diagnosis, and a subset of these rates is shown in the table.

Conclusion: Our data suggest that post-surgical infection, even among skilled spine surgeons, is an inherent potential complication. These data provide general benchmarks of infection rates as a basis for on-going efforts to improve safety of care and argue against their classification as “never events”.

	n	Superficial Infection Rate (%)	Deep Infection Rate (%)	Total Infection Rate (%)
Adult				
Kyphosis	2012	1.4	2.8	4.2
Degenerative scoliosis	2577	1.2	2.9	4.1
Lumbar stenosis	12270	0.9	1.2	2.1
Spondylolisthesis	10529	0.9	1.2	2.1
Posterior cervical fusion	1136	0.7	1.3	2.0
Lumbar discectomy	12694	0.5	0.4	0.9
Anterior cervical fusion	8538	0.1	0.2	0.3
Pediatric				
Neuromuscular kyphosis	308	3.2	9.1	12.3
Neuromuscular scoliosis	5191	1.8	3.9	5.7
Scheuermann's kyphosis	871	1.7	2.6	4.3
Scoliosis	20424	1.0	1.7	2.7
Spondylolisthesis	827	1.1	1.5	2.6

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Paper #72

Analysis of Risk Factors Associated with Post-Operative Acute Myocardial Infarction [AMI] in Spine Surgery

Andrew V. Slucky, MD; (Kaiser Permanente Medical Center) Ravinder Bains, MD; Timothy Huang, MD; Level of Evidence: III

Introduction: Risk analysis of patients incurring post-op AMI after spine surgery was performed to identify pre-op risk factors.

Methods: Retrospective chart review was performed with risk analysis for post-op AMI association with pre-op factors (prior cardiac disease [CD], hypertension [HTN], hyperlipidemia [HLD], obesity, asthma/COPD, diabetes [DM], renal disease [RD], smoking [SM]) and peri-op factors (spine region, procedure duration, blood loss, pre-op B-blockade).

Results: Review identified 2049 consecutive procedures in 1900 patients. Post-op AMI incidence was 0.89% [17/1900]. Summative pre-op risk factors for AMI vs. non-AMI patients was 0-risk factors: 0%[AMI] vs. 24%[non-AMI], 1-factor: 0%[AMI] vs. 23%[non-AMI], 2-factors: 12%[AMI] vs. 22%[non-AMI], and 3-factors: 88%[AMI] vs. 31%[non-AMI]. Pre-op risk factor prevalence was prior CD: 88%[AMI] vs. 29%[non-AMI], HTN: 82%[AMI] vs. 48%[non-AMI], HLD: 53%[AMI] vs. 17%[non-AMI], obesity: 53%[AMI] vs. 24%[non-AMI], asthma/COPD: 41%[AMI] vs. 21%[non-AMI], DM: 47%[AMI] vs. 16%[non-AMI], RD: 35%[AMI] vs. 5%[non-AMI], SM: 47%[AMI] vs. 29%[non-AMI]. The calculated AMI relative-risk, specific to pre-op factor was as follows: prior CD - 17.3, HTN - 4.9, HLD - 5.3, obesity - 3.5, asthma/COPD - 2.6, DM - 4.5, RD - 9.4, SM - 2.1. In patients incurring post-op AMI, 59% were on pre-op B-blockade. There was no proportionate trend relative to procedure duration or blood loss. Post-op AMI was higher in thoracolumbar procedures vs. cervical procedures [81% vs. 19%] as compared to the regional distribution in non-AMI patient procedures [59% vs. 41%].

Conclusion: Patients with a history of prior cardiac disease in combination with two notable risk factors [HTN, HLD, DM, RD] or with 3 such factors regardless of prior cardiac disease history are at marked increased post-op AMI risk versus patients with two or less risk factors. Post-op AMI was more incident with thoracolumbar procedures. Peri-op factors of procedure duration, blood loss, or lack of pre-op B-blockade do not appear to be predictive factors for post-op AMI.

Significance: Determination of factors for post-operative AMI in spinal surgery allows for identification of patients at risk and maximization of hospital resource management.

Paper #73

Are Postoperative Dressing Changes Necessary?

Ravinder S. Bains, MD (Kaiser Permanente Medical Center); Cary Idler, MD; Andrew V. Slucky, MD; Timothy Huang, MD; Kurt Van Peteghem; Josef Gorek, MD; Level of Evidence: III

Introduction: There is no scientific evidence for postoperative dressing changes. There is no consensus on when dressing changes should be performed. We offer a protocol when dressing changes should be performed.

Methods: The infection control database from January 1999 to December 2007 was retrospectively reviewed. In January 2005 we implemented our protocol of no dressing change for 5 days. Overall infection rates for instrumented and uninstrumented spine surgery cases for 2 time periods were determined. Infection rates for cervical, thoracic and lumbar cases were also evaluated and Fischer's exact test was performed to evaluate statistical significance.

Results: 6809 spine surgeries were performed by 5 spine surgeons at one institution during the 8 yr period. Overall, SSI rate for uninstrumented cases was reduced from 1.2% (14/1175) to 0.4% (4/1032) [p=0.06]. SSI rate for instrumented cases were reduced from 3.9% (100/2559) to 0.9% (18/2042) [p<0.0001] The reduction in SSI rates were most significant in instrumented posterior cervical and lumbar surgeries: Posterior cervical SSI rate was reduced from 3.2% (6/186) to 0.4% (1/224) [p<0.05]. Posterior lumbar instrumented fusion SSI rates were reduced from 5.5% (65/1179) to 0.8% (8/950) [p<0.001]. Finally, SSI rates for uninstrumented lumbar

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decompression surgeries were also reduced from 1.2% (14/1159) to 0.3% (3/1009) [p=0.03]

Conclusion: Dressing changes in the immediate postoperative period are not necessary. Our results show no increased infection risk. A sterile dressing applied in the operating room may serve as barrier to the noscomial pathogens in the hospitals, and suggests that this may lead to reduced infection risk.

Significance: Postoperative dressing changes are not necessary. The time and cost savings associated with this practice can be substantial.

Paper #74

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Validity and Reliability of Intraoperative Monitoring in Pediatric Spinal Deformity Surgery: A 23 Year Experience of 3,436 Surgical Cases

Earl D. Thuet, BS (BJC Healthcare); Jacquelyn C. Winscher, BS; Anne M. Padberg, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Matthew B. Dobbs, MD; Mario Schootman, PhD; Scott J. Luhmann, MD; Level of Evidence: II

Introduction: This study sought to demonstrate the effectiveness of intraoperative monitoring in reducing iatrogenic neurologic injury for pediatric spinal surgery patients.

Methods: 3436 monitored pediatric spinal procedures at a single institution from 1/1985 through 9/2008 were reviewed. Monitoring included Somatosensory & Descending Neurogenic Evoked Potentials and various nerve root monitoring techniques. Patients were divided into 10 diagnostic categories. True positive and false negative monitoring outcomes were analyzed for each category. Neurologic deficits were classified as spinal cord, nerve root or peripheral.

Results: 7 diagnostic groups demonstrated true positive findings resulting in surgical intervention. In 75 true positive events, 59 patients had immediate recovery of data and normal post-op exams, 11 had short term deficits and 5 had long term neurologic deficits. 5 of the 6 permanent deficits were detected with intraoperative monitoring. The undetected deficit was nerve root in origin.

Conclusion: Intraoperative data were sensitive to 5 of 6 permanent deficits. Spinal cord monitoring data correctly detected neurologic status in 97.9% of patients. The ratio of intraoperative events to total monitored cases was 1 event every 42 surgical cases and 1 permanent motor deficit every 573 cases. The incidence of permanent neurologic injury in this series was 0.2%

Significance: Intraoperative monitoring effectively reduces the incidence of iatrogenic neurologic injury in pediatric spinal surgery patients.

Diagnosis	True Positive	Immediate Post-Op Deficit	Permanent Deficit	False Negative	Immediate Post-Op Deficit	Permanent Deficit
Kyphosis/Kyphoscoliosis (n=226)	21 (9.3%)	2	1 cord (motor)	1 (0.4%)	1	0
Syndrome (n=143)	6 (4.2%)	0	0	0	0	0
Revision (n=329)	10 (3.0%)	4	1 root (motor)	1 (0.3%)	1	1 root (motor)
Neuromuscular Scoliosis (n=626)	17 (2.7%)	3	1 cord (motor)	0	0	0
Congenital (n=234)	6 (2.6%)	1	1 cord (motor)	1 (0.4%)	1	0
Spondylolisthesis (n=154)	3 (1.9%)	2	0	4 (2.6%)	4	0
Idiopathic Scoliosis (n=1618)	12 (0.7%)	4	1 cord (sensory)	0	0	0
Fracture/ Trauma (n=47)	0	0	0	0	0	0
Pathologic (n=31)	0	0	0	0	0	0
Degenerative (n=28)	0	0	0	0	0	0
Totals (n=3436)	75 (2.2%)	16 (0.47%)	5 (0.15%)	7 (0.2%)	7 (0.2%)	1 (0.03%)

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Paper #75

Blindness and Visual Evoked Potentials: A Novel Application of an Established Technique to Monitor Intra-Operative Visual Pathways

Gregory M. Mundis, MD (San Diego Center for Spinal Disorders); Siavash S. Haghighi, MD; Jason E. Billingham, MD; Behrooz A. Akbarnia, MD; Level of Evidence: IV

Introduction: Post-operative blindness (POB) complicating long prone spine surgery (PSS) has an incidence of 1/1000 (0.1%). Despite its rare occurrence, the morbidity that ensues makes this complication one of the most feared. VEPs are a means of monitoring the visual pathway in real time during PSS. VEPs have been used in neurosurgery to monitor visual pathways during intracranial surgery. Its application in deformity surgery is less invasive using topical probes. Tracings are comparable to those obtained with SSEPs.

Methods: VEPs were traced in 13 consecutive patients undergoing PSS. Monitoring was performed only in cases with PSS at least 6 hours long. VEPs were recorded using mid-occipital to mid-frontal montage. VEPs were elicited using strobe light emitting goggles. Tracings were recorded every hour along with blood pressure and vital signs (VS). Patient demographic data, intra-operative blood loss(ebl), length of surgery(los), procedure, pre-operative diagnosis, and type of anesthesia were recorded.

Results: 0/13 patients developed POB. There were 10 females and 3 males, average age 62 (25-84) yrs, and most frequent diagnosis of adult idiopathic scoliosis. EBL avg 1186 cc (500-2200 cc). LOS was 466 min (360-780 min) with avg 9 levels fused (2-15). All received sevoflurane (0.8-2.4%), propofol and narcotic infusion anesthesia. VEPs did not show any changes in mean peak latency compared to baseline, however there was significant variability of tracings within individual patient recordings. No patients experienced prolonged hypotension. No correlation was found between intra-operative VS and variability of VEPs.

Conclusion: VEPs are a promising technology in long PSS to detect disruption in the visual pathway of any etiology. We believe the variability in tracings is not the primary objective of VEPs but rather a disruption in the tracings that would indicate a similar disruption in the visual pathway. Like any developing technology, research and refinement in technique will lead to a more predictable and reliable screening tool to detect intra-operative visual disruption.

Significance: Blindness resulting from lengthy prone spine surgery is a feared complication. VEP has promise as a screening tool for early detection and possible intervention.

Paper #76

Neurophysiological Changes in Deformity Correction of Adolescence Idiopathic Scoliosis with Intraoperative Skull Femoral Traction

Randolph Gray, MBBS, FRACS; Laura Holmes, BSCh CNIM; Samuel Stranzas; Christian Zaarour, MD; Stephen Lewis, MD, FRCSC, MSc (Hospital for Sick Children); Level of Evidence: IV

Introduction: Intra-operative skeletal traction is used to facilitate coronal plane deformity correction. Its use can be associated with spinal cord stretching and ischemia with resultant electrophysiological changes. The prevalence of such changes, its clinical significance and safety is unknown.

Methods: Radiographs and charts were reviewed of 38 consecutive scoliosis patients treated with intra-operative skull-femoral traction between 2005 and 2008. All patients had SSEP and MEP monitoring.

Results: After exclusion of two patients with non-traction related changes, 37 consecutive procedures in 36 patients with a mean age of 15.4 (11.4-17.9) years were reviewed. The mean skull traction was 8.6kg(6.8-11.3) and femoral traction was 22.3 kg (13.6-31.7). Intra-operative MEP changes occurred in 18/37(48%) and SEP changes in 1(2.7%) procedure. The 18 cases with MEP changes had a mean Cobb of 86°, curve flexibility index of 0.14, and 41% correction with traction compared to 70°, 0.27, and 50% in the 19 cases without MEP changes (p<0.05). Intra-operative interventions were performed in response to the changes in MEP resulting in complete recovery in 10/18(55%), complete unilateral recovery with partial contralateral recovery in 6(33%) and incomplete bilateral recovery in 2(11%) patients. There were no patients with unrecordable MEP or SSEP amplitudes at wound closure. There were no post-operative neurological deficit

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Conclusion: Intra-operative traction is associated with frequent abnormalities in MEP monitoring. The thoracic location of the major curve, mean Cobb angle of 86°, and increased rigidity are risk factors for changes in MEP monitoring with traction. The presence of any MEP recordings at closure was associated with normal neurological function. SSEP should not be used as the sole means of scoliosis monitoring.

Significance: The presence of any MEP recordings at closure was associated with normal neurological function. SSEP alone is insufficient in accurately monitoring scoliosis correction.

Paper #77

Is the Cost of Neuromonitoring with Motor Evoked Potentials for Deformity Surgery Justified?

Timothy R. Kuklo, MD, JD (Washington University School of Medicine); David W. Polly, MD; Mohammad Diab, MD; Level of Evidence: II

Introduction: To analyze societal costs of routine neuromonitoring in deformity surgery versus the potential societal costs of spinal cord injury from an adverse surgical event in terms of malpractice settlements and lifetime patient care needs.

Methods: A national database of personal injury verdicts/awards (Westlaw) was searched to determine the average settlement after an adverse outcome following spinal surgery in the past 10 yrs, regardless of fault. Lifetime patient care needs were also determined, based on age at injury/life expectancy. 4,000 spinal deformity cases/yr in the US at a neural injury rate of .03% were assumed for analysis. The cost of neuromonitoring was determined to be \$190/hr based on review of 2 separate hospital contract rates (mean \$950/case). Search terms included spine surgery, scoliosis, paraplegia and neurologic injury yielded 110 potential cases, of which there were 43 defense verdicts, 22 cases determined to be n/a, and 27 injuries determined not to be related to surgery.

Results: The database yielded 18 cases of neural injury in spine surgery, of which 6 were deformity operations (ave. age 16.6 yrs) having an average verdict of \$11.9 million (range \$2.9-25.0 mil). The other 12 cases (ave \$754,000 payout) did not involve spinal deformity. This also did not include an evaluation of settlements prior to trial, where payout of a typical structured settlement may be 1.5-5 times the final settlement. The estimated cost of neuromonitoring was \$950/case X 4000, or \$3.8 million/yr. Assuming a false negative rate of MEPs at ~0.25% and an inability to monitor 10% of cases, potentially 3 cases/yr of paraplegia would be avoided with complete neuromonitoring (SSEP, MEP, EMG).

Conclusion: Assuming 12 cases of neurologic injury/yr (.03% of 4000 cases) not including other non-paraplegic neurologic injuries and pre-trial settlements, and with monitoring at \$950/case (\$3.8 mil/yr), a conservative estimate of societal savings would be over \$30-40 mil/yr of direct costs - hence insurance reimbursement of neuromonitoring services should be mandatory.

Paper #78

Study Testing Association of Genetic Markers Of Melatonin Signaling and Biosynthesis to Predict Adolescent Idiopathic Scoliosis (AIS) or Curve Severity

Lesla M. Nelson, BS (Axial Biotech); Kenneth Ward, MD, James W. Ogilvie, MD; Level of Evidence: II

Introduction: Melatonin has been linked to development of AIS in previous studies. This study sought to determine, as part of a genome-wide association study (GWAS), whether gene polymorphisms related to melatonin signaling or biosynthesis are associated with AIS.

Methods: A total of 589 AIS patients were recruited with complete medical records describing the progression of their scoliosis as well as 1533 ethnically matched controls with no history of IAS. To assure diagnostic accuracy, each AIS patient's medical records and spinal radiographs were reviewed by a spine surgeon (J.W.O.) to confirm the diagnosis of AIS; all patients were required to have a final Cobb angle of at least 40°. A total of 6 genes involved in melatonin signaling or biosynthesis were analyzed. Signaling genes

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include the melatonin receptors 1A and 1B and the protein kinase C delta. Biosynthesis pathway genes included: tryptophan 5-hydroxylase 1, serotonin N-acetyltransferase, and hydroxyindoleo-methyltransferase. Genotypes were determined using an Affymetrix 6.0 genechip and accompanying software.

Results: A total of 33 single nucleotide polymorphisms in the 6 melatonin related genes were analyzed as part of the GWAS. No significant differences were observed

Conclusion: Despite published reports, genetic polymorphisms associated with the genes of either melatonin synthesis or signaling pathways are not predictors of AIS or curve progression in our population.

Significance: Genetic markers from melatonin related pathway genes are unlikely to be either diagnostic for AIS or prognostic for curve progression in Adolescent Idiopathic Scoliosis patients.

Paper #79

High Circulating Levels of Osteopontin Are Associated with Idiopathic Scoliosis Onset and Spinal Deformity Progression

Alain Moreau, PhD (Université de Montréal); Anita Franco, MSc; Bouziane Azeddine, MSc; Pierre H. Rompré, MSc; Marie-Hélène Roy-Gagnon, PhD; Keith M. Bagnall, B.Ed; MSc, PhD; Benoît Poitras, MD; Hubert Labelle, MD; Charles H. Rivard, MD; Guy Grimard, MD; Jean Ouellet, MD; Stefan Parent, MD, PhD;

Level of Evidence: II

Introduction: We hypothesized that scoliosis development in patients with idiopathic scoliosis (IS) and different melatonin-deficient animal models could be induced by a similar mechanism involving a common downstream effector regulated by melatonin. Indeed, the study of the molecular changes occurring in pinealectomized chickens revealed an increased production of OPN, at the mRNA and protein levels, in paraspinal muscles of scoliotic chickens. Therefore, we investigated the involvement of OPN, a multifunctional cytokine, in IS pathomechanism.

Methods: A group of 320 consecutive patients with IS were compared with 120 healthy control subjects and 82 asymptomatic offspring, born from at least one scoliotic parent, who are considered at-risk of developing this disorder. Plasma OPN and soluble CD44 receptor (sCD44) levels were measured by enzyme-linked immunosorbent assays. Contributions of OPN and CD44 receptors to idiopathic scoliosis were validated using C57Bl/6j mice, a well known scoliosis animal model.

Results: Mean plasma OPN levels were significantly increased in IS patients and correlated with disease severity, with average values of 743 ± 326 ng/ml and 975 ± 389 ng/ml for moderate (10-44 degree) and severe (≥ 45 degree) spinal deformities, respectively, when compared to the healthy control group (568 ± 216 ng/ml). Elevated plasma OPN levels were also found in the asymptomatic at-risk group (871 ± 387 ng/ml), suggesting that these changes precede scoliosis onset. Mean plasma sCD44 levels were significantly lower only in IS patients with Cobb angle ≥ 45 degree compared to healthy control subjects. All transgenic C57Bl/6j mice devoid of OPN or CD44 receptor were protected against scoliosis, contrasting with wild-type ones.

Conclusion: Our clinical data and experiments on animals demonstrate that OPN is essential to induce scoliosis formation and curve progression through interactions with CD44 receptors, thus offering a first molecular concept to explain the pathomechanism leading to the asymmetrical growth of the spine in idiopathic scoliosis.

Significance: Plasma OPN and sCD44 values could be useful markers for diagnosis of IS and prognosis of curve progression.

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Paper #80

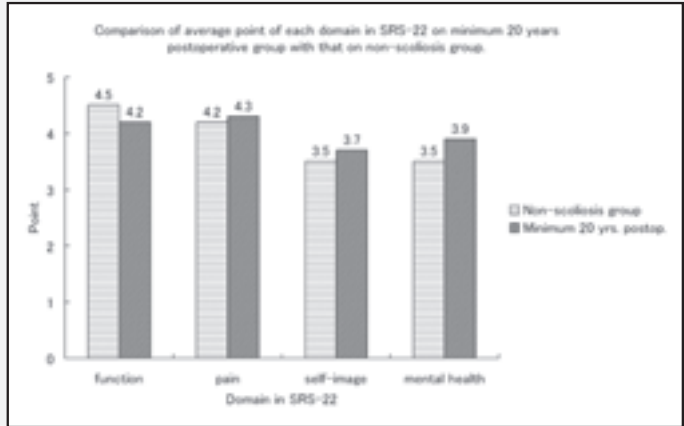
** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Results of the SRS-22 Patient Questionnaire: in Non-Scoliosis Group vs. Minimum 20 years Clinical Outcome after Scoliosis Surgery

Takahiro Iida, MD (Dokkyo Medical University Koshigaya Hospital); Nobumasa Suzuki, MD, PhD; Yasumasa Ohyama, MD; Jyunya Imura, MD; Akihisa Ato, MD; Satoru Ozeki, MD; Yutaka Nohara, MD;

Level of Evidence: III

Introduction: Previous study on minimum 20 years clinical outcome in patients who underwent 3-dimensionally oriented correction surgery for scoliosis has shown satisfactory clinical result with very low incidence of low back pain (annual meeting of SRS, 2007). However, SRS-22 health-related quality-of-life questionnaire has revealed that assessment of self-image (3.7) and mental health (3.9) tended to be lower than that of function and pain (4.2 and 4.3 respectively). Without control of SRS-22 in our country, it remained unsettled whether this tendency was really worse than general people in our population. The purpose of the study was to investigate SRS-22 questionnaire of non-scoliosis group to compare with that of long-term follow-up group.



Methods: 771 employees in two institutes where authors are engaged were sent SRS-22 questionnaire with additional question about age, gender, and past history including scoliosis. In 763 responders, 36 employees who had been pointed out scoliosis were excluded and 727 were included in this study. There were 718 female, 5 male (4 unknown), with average age of 29 years (20-64 years). The average of function, pain, self-image, and mental health (except satisfaction) was calculated. Cronbach's alpha was calculated to evaluate internal consistency of each domain.

Results: The average of each domain of SRS-22 was 4.5 (function), 4.3 (pain), 3.5 (self-image), and 3.5 (mental health). Cronbach's alpha was 0.405, 0.719, 0.752, and 0.719 respectively. No significant difference was found between non-scoliosis group and minimum 20 years postoperative group in the assessment of pain. However, assessment of function was significantly higher, and that of self-image and mental health were significantly lower in non-scoliosis group than in postoperative group.

Conclusion: Big sample size of non-scoliosis group resulted in these statistical difference. This study revealed that quality-of-life in patients who underwent instrumentation surgery for scoliosis and followed minimum 20 years was as same as that in non-scoliosis group, even on self-image and mental health of SRS-22.

Significance: As results of each domain of SRS-22 may differ according to populations, control group is necessary to evaluate long-term postoperative results.

Paper #81

The Nature History of Scoliosis Secondary to Chiari I Malformation and Syringomyelia after Suboccipital Decompression in Young Patients

Li Wei-guo, MD; Prof. Qiu Yong, (Nanjing University Medical School); Wang Bin, MD; Level of Evidence: III

Introduction: To assess the outcomes of scoliosis associated with CM&S after suboccipital decompression and to determine factors predicting the progression of scoliosis.

Methods: This study consisted of 72 males and 49 females of scoliosis associated with CM&S, with a mean age of 12.2 years (range, 4-18 years), who underwent suboccipital foraminotomy. Pre-op Cobb angle average 41° (range, 12-96°). Patients were divided into 2 groups: progressed > 5° after suboccipital

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decompression (progressors) and those whose curves stabilized or decreased (nonprogressors), as compared to pre-op Cobb angle. Neurological impairment, syrinx size and severity of scoliosis were assessed during the follow-up.

Results: At the mean follow-up of 33 months (range, 15~110 months), 72 cases (mean age, 14.2 years) and 49 cases (mean age, 9.3 years) were included in the progressors and the nonprogressors group, respectively. Of patients < 10 years, 17 progressors had the mean pre-op Cobb angle of 67°, versus the other 18 nonprogressors with a mean curve of 28° (p<0.01). Of patients ≥ 10 years, 55 progressors had a mean Cobb angle of 43°, while the other 33 nonprogressors with a mean curve of 31° (p<0.05). Multiple factors analysis showed that scoliosis progression were associated with patients age, curve severity, trunk tilt degree, double curve and the improvement of the syrinx.

Conclusion: The results show that progression of scoliosis after suboccipital decompression of CM&S was associated with age, curve severity, trunk tilt degree, double curve and the improvement of the syrinx.

Significance: Patient's age, curve severity, trunk tilt degree, double curve and the improvement of the syrinx might influence the progression of scoliosis secondary to CM&S.

Paper #82

** RUSSELL A. HIBBS AWARD NOMINEE FOR BEST CLINICAL PRESENTATION

Two Decade Results in Surgical Management of Congenital Scoliosis (CS)

Nanjundappa S. Harshavardhana, MS(Ortho), Dip, SICOT (Queen's Medical Centre); Ujjwal K. Debnath, FRCS, MS/Orth; Michael P. Grevitt, FRCS (Orth); Hossein S. Mehdian, MD, FRCS(Ed); James Hegarty, RGN; John K. Webb, FRCS; Level of Evidence: III

Introduction: We report long term results of CS and predict the age of definitive fusion analysing the indications for revision surgery.

Methods: 52 patients with CS (18M;34F) who had primary growth arrest with fusion & subsequently followed-up for 20.5 y(r10.5-52.5y) formed the study cohort. The etiology were HV(22), unilateral unsegmented bar(15), unsegmented bar with contralateral HV(4), Wedged vertebra(5), hemimetameric shift(2) and unclassifiable(4). Intraspinous anomalies were seen in 10 and associated syndromes in 11 cases. The curve was located at cervico-thoracic(3), thoracic(33), thoraco-lumbar(9), lumbar(5) and lumbo-sacral(2) respectively. Three groups of index surgeries were identified. Group 1: Posterior in-situ fusion(16), Group 2: Combined anterior/posterior correction and fusion(32) and Group 3: Anterior HV excision & fusion(4).

Parameters	Group I	Group II	Group III
Number of patients	16	32	4
Sex	Male	12	2
	Female	12	2
Age @ 1 st Sx	4.8y (1.1-11y)	8.7y (6.5-14y)	2.3y (1.5-4.1y)
Cobb angle @ 1 st Sx	63.2°	67.5°	38.5°
Post-op Cobb angle	39.5°	37.5°	14.5°
Cobb @ final fu	45°	42°	21°
Revision Sx	9/16	15/32	1/4
Average no. of Sx	1.68(1-3)	1.72(1-4)	1.25(1-4)

Patient demographics

Results: 25 patients had revision surgery & key indications were spinal imbalance, crankshaft phenomenon, implant failure, junctional kyphosis or pseudoarthrosis. Group I: Mean age at primary surgery was 4.8 y(r 1.1-11y) when the Cobb measured 63.2 which corrected to 39.5 post-op & 45 at final follow-up. 9/16 patients required re-surgery at mean age of 12 y(r 10-16y). Group II: Mean age at initial surgery was 8.7 y(r 6.5-14y). The mean Cobb at initial surgery was 67.5, 37.5 post-op & 42 at final follow-up. 15/32 patients required revision surgery at a mean age of 13.2 y(r 10.5-33y). Group III: Mean age at index surgery was 2.3 y(r 1.5-4.1y). The mean Cobb angle measured 38.5 which corrected to 14.5 post-op & was 210 at final f/u. One patient required reoperation at 23 yrs.

Conclusion: Growth arrest & fusion performed at early age can deteriorate over time esp. if a stand-alone posterior in-situ fusion is performed. The timing of definitive fusion was influenced by the type, number & location of HV and presence of unsegmented bar. Early excision and fusion is recommended for junctional

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HV to prevent long-term rigid deformities.

Significance: This paper reports long-term surgical results of CS and discusses problems encountered prior to definitive fusion in optimising outcomes as there is paucity of literature in this field.

Paper #83

The Efficacy and Complications of Posterior Hemivertebra Resection

Jianguo Zhang, MD (Peking Union Medical College); Guixing Qiu, MD; BinYu, MD; Level of Evidence: IV

Introduction: Posterior hemivertebra resection was popular in the last 5 years, larger series analysis and reports of its complications is rare.

Methods: We reviewed patients who had such a procedure between Jul. 1, 2002 and Oct. 1, 2006. Radiographs were reviewed to determine: the hemivertebra type and location; the coronal curve magnitude and sagittal alignment preoperatively, postoperatively and at the final follow-up; and the presence of interbody fusion. Operative reports and charts were reviewed to record any complications.

Results: We defined 56 patients underwent the procedure. The age at surgery was 9.9(1.5-17)years. A total of 58 hemivertebrae were resected in 56 patients. The location of the hemivertebra was as follows: 15 thoracic, 34 thoracolumbar, 8 lumbar, and 1 lumbosacral. 11 had coexisting contralateral bar or fused ribs. The average follow-up was 32.9 (24-58) months. The mean fusion level was 5.0 (2-11) segments. The largest coronal curve was 42.4° (13°-100°) preoperatively and 11.5° (0-44°) postoperatively with a correction rate of 72.9%. Regional kyphosis was 42.0° (10°-110°) preoperatively and 12.6° (-15°-50°) postoperatively with a correction rate of 70.0%. There was a maximal 1.9° correction loss at the final follow-up. Complications included one delayed wound healing, 2 pedicle cutting needed revision, and one rod breakage with no migration, one proximal junction kyphosis. There was no neurological complications. Uncontinuous trabeculae was found in the residual space after resection on the lateral view in 5 cases without any sign of implant failure and correction loss.

Conclusion: Posterior hemivertebra resection with transpedicular instrumentation can achieve excellent correction and short fusion with no neurologic complication. Pedicle cutting remains a challenge in younger child with 2 segmental fixation and possible unfusion in the residual space needs further investigation.

Significance: This study further clarified the safety and excellent correction ability of posterior hemivertebra resection, found the phenomenon of possible nonfusion in the residual space after resection, and higher pedicle cutting rate in younger child with 2 segmental fixation.

Paper #84

Combined Anterior-Posterior Approach vs. Single Posterior Approach in Corrective Surgery with Osteotomy for Congenital Scoliosis

Noriaki Kawakami, MD (Meijo Hospital); Taichi Tsuji, MD; Kazuyoshi Miyasaka, MD; Tetsuya Ohara, MD; Ayato Nohara, MD; Michiyoshi Sato, MD; Kenyu Ito, MD; Chest Wall & Spinal Deformity Study Group; Level of Evidence: III

Introduction: The purpose of this study was to identify ideal indications of combined ant. and post. surgery (AP-Ap) with vertebrectomy in CS, even when it has become possible to resect anomalous vertebrae to correct scoliosis via a single post. approach (P-Ap).

Methods: This was a retrospective comparative study. Of 164 patients with CS we had operated, 29 were matched with inclusion criteria such as: operation with vertebrectomy, scoliosis angle between 35° and 60°, and a minimum 2-year follow-up. We excluded mild (<35°) and severe (>60°) scoliosis, vertebral anomalies (CVA) in the high thoracic area, lumbosacral hemivertebrae, severe lordosis, and complex medical conditions that might contraindicate an anterior approach from this study. The cohort consisted of 13 males and 16 females. In all, 14 of these were via a P-Ap (P-group) and 15 were by an AP-Ap (AP-group). CVAs

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were evaluated according to the 3D classification system reported by Kawakami, classifying them into solitary simple (SS), multiple simple (MS), multiple complex (MC), and segmentation failure (SF).

Results: Age and sex were not significantly different in both groups. In the P-group, preop. Cobb angle was $44.2 \pm 6.3^\circ$; all CVAs were located in thoracolumbar-lumbar regions; 6 of 14 were solitary; and 12 of 14 patients (85.7%) belonged to the simple type. In the AP-group, preop. Cobb angle was $48.0 \pm 6.6^\circ$; 9 of 15 CVAs were located in thoracic-thoracolumbar regions; 13 of 15 were multiple and 8 of 15 (53.3%) belonged to MC or SF. Scoliosis in the P-group and AP-group had correction rates of $70.1 \pm 19.3\%$ and $64.2 \pm 18.8\%$, respectively ($p=0.414$). The AP-Ap was taken when multiple CVAs within the curvature that needed release in multiple segments were present in 13 (86.7%), and the procedure was a reoperation in one. Postop. neurological complications occurred in 4 of the P-group and one in the AP-group although they were all transient.

Conclusion: Not only should a post. approach, but also an ant. approach, might be indicated for CS correction if CVAs are multiple, belong to the complex type, and/or exist in mid-thoracic spine.

Significance: Combined ant. and post. approach might be indicated for the CVAs with complex type of multiple vertebral anomalies and/or those located in the thoracic region.

Paper #85

***Pediatric Cervical Spine Fixation: A Comparison of Complication Rates Associated With Screw/Rod Constructs vs. Non-Screw/Rod Constructs**

Jonathan J. Carmouche, MD (Roanoke Orthopaedic Center); John E. Lonstein, MD; Robert B. Winter, MD; James D. Schwender, MD; Joseph H. Perra, MD; Level of Evidence: III

Introduction: Pediatric cervical spine instrumentation with screw and rod constructs is less common than in adults due to the relative rarity of indications, size mismatch, and perceived risk of neurologic or vascular injury. Rigid internal fixation may improve fusion rates and decrease the need for external immobilization.

Methods: 83 procedures performed in 76 skeletally immature patients met inclusion criteria including minimum 2-year follow-up. Surgical indications included trauma, pseudoarthrosis, os odontoideum, kyphosis, tumor, congenital scoliosis and thoracic deformity extensions. Between 2001 and 2006, 19 patients, mean age $10 + 2$ (yrs + mo) (range $2 + 3$ to $17 + 10$) underwent 20 posterior cervical procedures using screw and rod constructs. Between 1990 and 2004, 57 patients, mean age $9 + 4$ (range $1 + 5$ to $16 + 5$) underwent 63 posterior procedures with non-screw/rod constructs, all by experienced spinal surgeons. Charts and radiographs were reviewed for comorbidities, complications and fusion rates.

Results: In the screw-rod group, there were two cases (10%) of delayed wound healing. There were no cases of ascending fusion, neurologic or vascular complications and no non-unions. Screw placement was aborted in two cases (10%) due to poor visibility in one and poor bone quality in a second. A halo was used in 4 cases (20%). In the non-screw-rod group, the total complication rate was 44%. A halo was used in 33 cases (52%). Halo associated complications occurred in 42% and included pin loosening, pin-tract infection and soft tissue breakdown from the halo cast. There were 10 pseudoarthroses (16%), 1 superficial wound infection (1.6%), 1 neurologic injury (1.6%) and 2 ascending levels of fusion (3.2%).

Conclusion: Fixation using screw and rod constructs was associated with lower complication rates. Most complications were halo associated but the pseudoarthrosis rate was also quite high in the non-screw/rod group. Screw/rod constructs afford more rigid fixation, higher fusion rates, lower complication rates and decreased reliance on halo immobilization.

Significance: Significance. Screw and rod constructs for pediatric cervical fixation improve fusion rates, decrease the need for external immobilization and decrease complication rates.

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Paper #86

Low Profile Pelvic Fixation Using S2 Alar Iliac (S2AI) Fixation in the Pediatric Population Improves Results at Two-Year Minimum Follow-Up

Paul D. Sponseller, MD (Johns Hopkins Hospital); Ryan Zimmerman; Phebe S. Ko, BS; Khaled M. Kebaish, MD; Albert Pull ter Gunne, MD; Ahmed S. Mohamed, MD; Tai-Li Chang, MD; Level of Evidence: III

Introduction: Anchor stability and prominence are problems with pelvic fixation in pediatric spinal deformity surgery. A new method of iliac fixation with a starting point in the S2 ala offers in-line anchors that are deep under the midline muscle flap. We report the clinical results of this technique.

Methods: 32 consecutive patients with the S2AI technique and >2y follow-up were studied. Diagnoses were 23 cerebral palsy, 2 myelomeningocele, and 7 syndromic. Fusion was 15.8 levels (SD 2.7, R 12-18). Clinical examinations, radiographs and CT scans were analyzed. Outcomes included sacropelvic pain, screw placement, implant prominence, radiographic lucency, need for revision and infection. S2AI patients were compared with 17 prior patients who had pelvic fixation using traditional sacral and iliac screws.

Results: Mean age at surgery was 14.3 y (SD 2.3, R 9.8-19.3). S2AI screws were 67 mm (R 45-85) in length and 7-9 mm in width (Fig 1). Pelvic obliquity was corrected $21.1 \pm 2.3^\circ$ (74%) using the S2AI technique and $11.4 \pm 2.5^\circ$ (52.9%) using traditional iliac screws. Cobb angle correction was $48.7 \pm 4.5^\circ$ (73%) using the S2AI technique and $51.1 \pm 3.1^\circ$ (63%) using traditional iliac screws. S2AI fixation had better pelvic obliquity correction ($p=0.01$) but there was no difference in Cobb correction. Three of 64 screws showed adjacent lucencies of 1.3 mm (R 1.0-2.0). CT scans of 23 patients showed no intrapelvic protrusion, but three screws protruded laterally (all <5mm). One early patient required revision to bilaterally longer iliac screws to relieve pain. There were 2 superficial infections in the S2AI group and 1 deep infection in the traditional group. No S2AI patient had implant prominence, skin breakdown or anchor migration versus 3 in the traditional group.

Conclusion: S2AI pelvic fixation produces satisfactory results with improved correction of pelvic obliquity and fewer clinical complications than prior techniques. Radiographic and clinical anchor stability is satisfactory at two year follow-up.

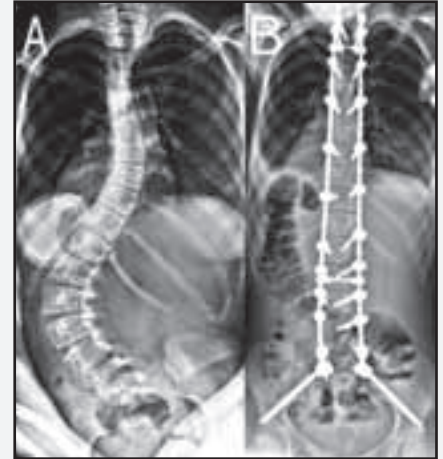


Figure 1. Pre- (A) and postoperative (B) AP radiographs showing S2AI pelvic fixation.

Paper #87

Anatomic Safe Zone for S2-Alar Screws

Timothy R. Kuklo, MD, JD (Washington University School of Medicine); Mark A. Pichelmann, MD; Level of Evidence: N/A

Introduction: As an alternative to iliac screws, S2-alar screws provide supplemental sacropelvic fixation, without violating the SI joint. The purpose of this study was to determine the anatomic safe zone, the proximity to vital structures, and the standard screw trajectory for this technique.

Methods: 10 cadaveric torsos (5M/5F) underwent bicortical S2-alar screw fixation in the prone position with a standard insertion technique (lateral and cephalad towards the arcuate line under fluoroscopic guidance) using 6.5 mm multi-axial pedicle screws (ave 50 mm). The pelvises were then dissected and anatomic structures and screw tip distances to critical neurovascular structures were measured with a fine caliper (mm). Measures included: transverse sacral width, S1 width, R/L lateral S1 foramen to lateral ala, superior S1 foramen to sacral promontory, R/L lateral common iliac artery and vein to lateral ala; and R/L screw to SI joint, L5 and S1 nerve roots, and iliac arteries and veins. Medial-lateral trajectory was measured relative to midline and cephalad trajectory relative to superior S1 endplate. A "safe trajectory arc" was calculated. (Table).

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Results: Neurovascular structures measured: left common iliac vein to S1 joint 24.8 mm (22-28) and right 22.3 (20-26), left common iliac artery to S1 joint 22.1 mm (19-26) and right 20.4 (18-23). Screws averaged 11.8 mm (range, 5-20) and 12.5 mm (range, 7-17) respectively from the right iliac artery and left iliac vein (the closest vascular structures). The L5 roots were closer to the screws than S1, 11.8±3.2 (7-17) and 12.5±2.4 (10-16) respectively. Screws averaged 8.8 mm (5-12) from the right S1 joint and 8.4 mm (3-13) from the left S1 joint. The trajectory averaged 29-45° in the sagittal plane and 25-40° in the coronal plane.

Conclusion: Bicortical S2-alar screw placement is reliable and safe. Specifically, there is a 15 x 25 mm "safe zone" on the lateral sacral ala which projects at a 25-40° lateral arc projected onto the arcuate line of the ala. The average screw trajectory for the right screw was medial to lateral 31.9°±4.8 (25-40) and caudad to cephalad 36.9°±5.2 (29-45). For the left screw, the average screw trajectory was medial to lateral 32.9°±3.2 (27-37) and caudad to cephalad 37.2°±3.8 (33-43).

Anatomic Measurements (mm)						
Specimen	Age	Transverse Sacral Width at S1	S1 width	Lateral S1 Foramen to Right Lat Ala	Lateral S1 Foramen to Left Lat Ala	Superior S1 Foramen to Promontory
Mean	65	102.1	41.9	25.6	25.8	10.6
St Dev	10.42	7.44	2.99	3.13	2.78	0.85
Range	36-81	92-112	37-48	18-29	19-30	9.0-12
Trajectory and Safe Zone						
	Right Lateral Screw trajectory	Left Lateral Screw trajectory	Right superior screw trajectory	Left superior screw trajectory	Right Safe Zone (Arc)	Left Safe Zone (Arc)
Degrees	31.9	32.9	36.9	37.2	35°	35°
St Dev	4.75	3.21	5.17	3.77	± 2.2/±3.0	±1.9/±3.3
Range	25-40	27-37	29-45	33-43	24-40°	26-42°

Paper #88

Multicenter Study of Posterior Vertebral Column Resection for Pediatric Deformity

Harry L. Shufflebarger, MD; Seth K. Williams, MD (University of Miami) Peter O. Newton, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Paul D. Sponseller, MD; **Level of Evidence: III**

Introduction: Vertebral column resection (VCR), consisting of posterior vertebral body excision along with the adjacent disks, is used for correction of severe pediatric deformity. This is the first multicenter study to examine the underlying condition necessitating surgery, immediate correction rates, operative time, blood loss, and neurological complications, to standardize indications and inform surgeons of perioperative neurological morbidities.

Methods: A retrospective chart review of patients who underwent a VCR for pediatric deformity between 2003 and 2008 was performed. Patients were divided into 5 deformity categories: 1) neuromuscular/paralytic (N/P); 2) complex congenital (CC); 3) adolescent idiopathic (AIS); 4) kyphosis (K); and 5) congenital hemivertebra (CH). Radiographic outcomes and intraoperative data are reported.

Results: Data was available for 31 of 33 consecutive patients. Major curve correction averaged 63° (56%) in the N/P group, 36° (46%) in the CC group, 44° (60%) in the AIS group, 44° (57%) in the K group, and 25° (55%) in the CH group. Operative time averaged 439 minutes in groups 1-4 (N/P, CC, AIS, K) and 249 minutes in group 5 (CH). Blood loss averaged 1870 cc in groups 1-4 and 760 cc in group 5 (CH). Groups 1-4 demonstrated intraoperative spinal cord MEP and/or SSEP monitoring changes in 8 of 18 (44%) patients; 3 postoperative lower extremity (LE) partial motor deficits resulted (1 resolved and 2 with ongoing recovery). Group 5 demonstrated monitoring changes in 2 of 13 (15%) patients; 1 postoperative unilateral LE deficit fully resolved.

Conclusion: VCR is a valuable deformity surgery technique with potential neurological complications that can be minimized by the use of spinal cord monitoring to guide intraoperative decisions. VCR risks appear

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less when performed for hemivertebra excision. Intraoperative neuromonitoring changes are common and the surgeon should be prepared to make adjustments accordingly.

	Neuromuscular/paralytic	Complex Congenital	AIS	Kyphosis	Congenital Hemivertebrae
N	4	8	4	2	13
Pre-op major curve Cobb angle (range)	103° (64-138°)	73° (38-127°)	76° (50-93°)	75° (65-84°)	46° (18-81°)
Curve correction	63°	37°	44°	44°	25°
% Curve correction	56%	46%	60%	57%	55%

Paper #89

***Safety and Accuracy of Pedicle Screws Placed in Infantile and Juvenile Patients**

Katsumi Harimaya, MD, PhD (Washington University School of Medicine); Jochen P. Son-Hing, MD, FRCSC; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Richard M. Schwend, MD; Scott J. Luhmann, MD; Timothy R. Kuklo, MD, JD; Linda A. Koester; Brenda Sides, MA; Level of Evidence: IV

Introduction: Our purpose was to determine the safety of pedicle screws placed in infantile and juvenile patients less than age 10, and to evaluate the accuracy of pedicle screw placement as well as the incidence of short and long-term (>2 years follow-up) complications.

Methods: A retrospective review of 88 patients treated with 948 pedicle screws placed for a variety of pediatric spinal deformities was performed at a single institution with 2 children's hospitals. To evaluate the accuracy of pedicle screw placement, AP and lateral radiographs were reviewed by 2 spinal surgeons not involved in the surgical treatment by means of the methods reported by Kim YJ et al (Spine 2005).

Results: The average age at surgery was 6.8 years (range, 0 to 9+11). The distribution of thoracic (n=594) and lumbar (n=354) pedicle screws is shown in the table. Of 948 pedicle screws placed, 3 screws (0.3%) violated the lateral wall of the pedicle, 2 screws (0.2%) the inferior wall; and 3 screws (0.3%) were suspected of medial violation wall for a total of 8 screws (0.84%) malpositioned. Although short-term complication occurred in 9 patients (10.2%) (4-wound infection, 2-foot drop, 2-respiratory problems, 1-6th cranial nerve palsy), there were no insertion or short-term complications specifically related to the use of pedicle screws. Long-term complications occurred in 9 patients (10.2%) (3 deformity progression, 4 growing/Shilla rod breakage), while 2 patients required revision surgery due to the prominence of a proximal thoracic pedicle screws (n=4) placed in a growing rod/Shilla constructs (2/88=2.3% of patients, 4/948=0.4% of screws).

Conclusion: There were no intraoperative or short-term pedicle screw insertion related complications and a very low long-term complication rate (2.3% of patients, 0.4% of screws) specifically related to the use of pedicle screws in infantile and juvenile spinal deformity patients. Over 99% of screws were deemed in accurate position by a detailed, independent radiographic assessment.

The distribution of pedicle screws (88 patients)

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	L1	L2	L3	L4	L5	S1	Total
Left	6	24	44	45	29	21	22	24	21	23	30	28	39	33	39	30	20	18	496
Right	5	22	36	37	24	26	17	21	19	23	20	27	34	33	39	32	21	16	452
Total	11	46	80	82	53	47	39	45	40	46	50	55	73	66	78	62	41	34	948

Paper #90

A More Distal Fusion is Associated with Increased Motion at L4/L5: A Set Up for Degeneration?

Michelle C. Marks, PT, MA (Harms Study Group Foundation); Peter O. Newton, MD; Maty Petcharaporn, BS; Tracey Bastrom, MA; Suken A. Shah, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Firoz Miyanji, MD, FRCSC; Level of Evidence: III

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Introduction: The implications of hyper or hypo-mobility in the un-fused segments of the spine following instrumentation are poorly understood. The purpose of this study was to assess inter-vertebral segmental and cumulative motion in the distal un-fused segments of the spine in patients with AIS following instrumentation as a function of the lowest instrumented level.

Methods: Patients were offered inclusion into this IRB approved prospective study at their routine 2, 3, 4 or 5 year post-operative visit at one of 5 participating centers. Motion was assessed by standardized radiographs acquired in maximum right, left and forwarding bending positions. The intervertebral angles were measured via digital radiographic measuring software at each level from T12 to S1. The relationship of the vertebral segmental motion for each interspace to the lowest instrumented vertebrae was evaluated with an ANOVA ($p < 0.05$). The relationship between the cumulative preserved motion and each domain of the SRS questionnaire were evaluated using a Pearson's correlation coefficient ($p < 0.05$).

Results: The data for 57 patients are included. The lowest instrumented vertebrae ranged from T12 to L4. In lateral bending, as the lowest instrumented vertebrae progressed distally, there was significantly greater L4-L5 segment motion ($p = 0.001$). A similar trend was appreciated at L5-S1 level. In addition, the summed motion from L3 to S1 also increased with a more distal fusion ($p = 0.02$). Similar results were not found in forward bending. None of the domains of the SRS questionnaire correlated with the preserved L3-S1 motion.

Conclusion: In a group of post-operative adolescent idiopathic scoliosis patients, evaluation of the distal unfused intervertebral motion showed that preservation of vertebral motion segments allowed greater distribution of functional motion across more levels. The relationship between the increased lateral L4-5 motion and subsequent disc degeneration with a more distal fusion is unknown, but suspected.

Disc Level	Lowest Instrumented Vertebra					p
	T12	L1	L2	L3	L4	
12/1	5 ± 3					
1/2	7 ± 2	7 ± 2				0.64
2/3	9 ± 3	10 ± 3	12 ± 4			0.13
3/4	10 ± 4	10 ± 3	11 ± 6	12 ± 3		0.42
4/5	4 ± 3	7 ± 4	10 ± 5	11 ± 6	12 ± 4	0.001
5/1	3 ± 2	4 ± 3	3 ± 2	4 ± 3	9 ± 13	0.09
Measured L3-S1	23 ± 8	24 ± 5	31 ± 12	33 ± 10	N/A	0.02

Table 1. Lateral bending intervertebral motion in relation to the lowest instrumented vertebrae (degrees).

Paper #91

Relation of Sacral Tilt with Idiopathic Scoliosis and its Postoperative Clinical Importance

Azmi Hamzaoglu, MD; Cagatay Ozturk, MD; Haluk Berk, MD (Istanbul Spine Center); Fatih M. Korkmaz, MD; Meric Enercan, MD; Kursat A. Ganiyusufoglu, MD; **Level of Evidence: IV**

Introduction: The aim of this study is to determine the possible role of sacral tilt, limb length inequality and associated pelvic girdle anomalies in the etiology of idiopathic scoliosis and secondly to determine the effect of sacral tilt on adjacent disc wedging below LEV in certain idiopathic curves like thoracolumbar/lumbar (TL/L), double major (DM) curves postoperatively.

Methods: Between 2006-2008, 159 patients with idiopathic scoliosis from outpatient clinics were reviewed. In all patients, standing PA and lateral spinal column and Ferguson graphies were routinely taken. Curve type, sacral tilt, L5 tilt, iliac asymmetry and limb-length differences were measured. Then, as a second step of study, surgically treated 87 patients with DM or TL/L curves were examined retrospectively in terms of adjacent subjacent disc wedging below LEV and sacral tilt.

Results: In the first part of the study, the mean age of patients was 14.21 (2-25) years and all but 14 were female. Sacral tilt towards to convex side of TL/L curve was present in 117 (74%) patients. L5 tilt towards to convex side of TL/L curve and limb length inequality being shorter (<5 mm) lower extremity on the convex side of TL/L curve were more prevalent in sacral tilt positive patients (57%) ($p = 0.021$). It was found that there was a correlation between L5 tilt and sacral tilt ($p = 0.048$) and between sacral tilt and hemipelvis volume ($p = 0.024$). There was no correlation between sacral tilt and pelvic asymmetry, age, sex, curve type or amount

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of limb length inequality. At the second step of study, disc wedging adjacent to LEV was present in 75 of 87 patients and sacral tilt was present in 96% of them (72 of 75 patients) (p: 0.008).

Conclusion: Being independent from age in the current study suggested that it may have a primary role in the etiology. We believe in that lumbosacral hemicurve due to sacral tilt behaves like hemivertebra and causes disc wedging below LEV. The postoperative trunk decompensation is seen more in relation with presence of sacral tilt and limb length inequality. Determination of sacral tilt with Ferguson graphy and limb length inequality with digital CT examination is mandatory in preoperative evaluation.

Paper #92

Loss in Spinal Motion from Inclusion of a Single Mid-Lumbar Level in Posterior Fusion for Adolescent Idiopathic Scoliosis

Mark C. Lee, MD (Connecticut Childrens Medical Center); Brian G. Smith, MD; Jeffrey Thomson, MD; Sylvia Ounpuu, MSc; Matthew J. Solomito, BSBE; Level of Evidence: III

Introduction: Current discussion on fusion levels for adolescent idiopathic scoliosis focuses on the theoretical loss of spinal motion with inclusion of more distal lumbar segments. Intense debate centers on the impact of a single additional lumbar fusion level on overall spinal motion. It is argued that preservation of a single additional level will allow significantly improved spinal motion and possibly slow disc deterioration and lumbar facet arthrosis. However, no objective data is available to describe the impact on spinal motion in multiple planes of adding a single lumbar segment to a fusion construct.

Methods: 23 patients with adolescent idiopathic scoliosis (age = 15+/- 2 years; mean maximum pre-op Cobb = 59 +/-12 degrees) undergoing spinal fusion to either the distal level of L1/L2 (n=11) or L3 (n=12) were evaluated preoperatively and one year post-operatively with radiographic and three dimensional positional analysis. Kinematic and kinetic data for the trunk and both lower extremities were collected using a VICON 512 system (VICON Motion Systems, Lake Forest, CA) during standing and during maximal sagittal bending, coronal bending and rotational motions.

Results: (Table 1) The L1/L2 group had negligible loss of motion in the sagittal and coronal planes at 1 year post-op, but rotational motion was decreased significantly by 37 +/- 34 degrees. The L3 group had a loss of motion of 25 +/-63 degrees in the sagittal plane and 36 +/- 28 degrees in the coronal plane, but only the coronal plane motion loss was significant. The L3 group also had a significant loss in rotational motion from pre-op. Comparison of the two groups demonstrated no significant difference in loss of motion in the sagittal and rotational planes. However, coronal plane bending was significantly different, with the L3 group demonstrating a decreased maximal bending of 18 +/- 10 degrees (p=0.002) when compared to the L1/L2 group.

Conclusion: Extension of the posterior spinal fusion level to L3 in adolescent idiopathic scoliosis significantly decreases the coronal bending range of motion of the spine.

Significance: The data supports the idea that preservation of a single lumbar level improves spinal motion in at least one plane and may be critical to the long term health of the spine.

Table 1. Difference in Pre and Post-Op Spine ROM

Plane	L1/L2	L3	ANOVA p-Value
Coronal	4 ± 15	22 ± 13	0.002
Sagittal	7 ± 24	25 ± 63	0.343
Rotational	37 ± 34	36 ± 28	0.928

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Paper #93

The Minimum Clinically Important Difference in SRS-22 Appearance, Activity and Pain Domains After Surgical Correction of Adolescent Idiopathic Scoliosis

Leah Y. Carreon, MD, MSc (Kenton D. Leatherman Spine Center); James O. Sanders, MD; Mohammad Diab, MD; Peter F. Sturm, Steven D. Glassman, MD; Daniel J. Sucato, MD; Spinal Deformity Study Group; Level of Evidence: III

Introduction: The Minimum Clinically Important Difference (MCID), a threshold of improvement that is clinically relevant to the individual patient, is increasingly used to evaluate treatment effectiveness. The purpose of this study is to determine the MCID of the SRS-22 Appearance, Activity and Pain domains in patients with adolescent idiopathic scoliosis (AIS) undergoing surgical correction of their spinal deformity.

Methods: 887 patients with AIS who underwent surgical correction and had completed SRS-22 pre-op and the SRS-30 at one-year post-op were included. Patients who had prior spine surgery, who were younger than 8 years old were excluded. Paired sample t-tests were used to compare pre-op and one-year post-op scores. Spearman correlations were used to evaluate associations between domain scores and summed responses to anchors for Appearance, Activity and Pain. MCID values for the SRS-22 domains were determined using Receiver-Operating-Characteristic Curve Analysis with summed responses to anchor questions 23-30 of the SRS-30.

Results: There were 735 females and 152 males with a mean age of 14.3 years and a mean Cobb angle of 53 degrees. There was a statistically significant difference between paired pre-op and one-year SRS domain scores. Although Spearman correlations between the domain scores and the anchors were moderate, analysis of variance showed a statistically significant difference between the summed responses to the anchors. The MCID for the Pain domain is 0.20 (AUC=0.723), 0.06 for Activity (AUC=0.620) and 0.98 for Appearance (AUC=0.629). The MCID for Activity is less than the Standard Error of Measurement.

Conclusion: The MCID for the Pain domain is 0.20 and 0.98 for Appearance. As these patients are generally in good health, a minimal though significant change in Activity was seen, such that the calculated MCID was within measurement error. As expected, the largest and more important change was in the Appearance domain. Future studies are needed to determine the MCID for the mental domain and the total SRS score and to further validate the MCID values in this study.

Table 1. Paired comparison of pre-operative and one-year post-operative scores.

Domain	Pre-Operative Scores, Mean (SD)	One Year Post-operative scores, Mean (SD)	p-value
Appearance	3.29 (0.64)	4.29 (0.58)	<0.0001
Activity	4.15 (0.55)	4.23 (0.46)	0.001
Pain	4.10 (0.71)	4.35 (0.61)	<0.0001
Mental	3.96 (0.69)	4.22 (0.64)	<0.0001
Satisfaction	NA	4.48 (0.68)	<0.0001
Total	3.86 (0.46)	4.30 (0.41)	<0.0001

Paper #94

Can We Predict Postoperative SRS Outcomes Scores in Adolescent Idiopathic Scoliosis?

James O. Sanders, MD (University of Rochester); Leah Y. Carreon, MD, MSc; Daniel J. Sucato, MD, MS; Peter F. Sturm, MD; Mohammad Diab, MD; Level of Evidence: III

Introduction: The SRS instrument is the current standard for measuring outcomes in AIS. It is unclear which factors contribute to postoperative scores, and understanding them is crucial to maximize outcomes.

Methods: Prospectively collected 2yr postoperative SRS scores of AIS surgical patients were evaluated using stepwise linear regression analysis to determine factors predictive of 2yr domain and total scores. Poor postoperative score patients (> 2 s.e. below mean) were compared using t-tests to those with better results.

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Results: 477 patients were included. Patients with greater curve correction have improved SRS total, appearance, and pain scores. The main driver for score improvement was the appearance domain. Those with larger preoperative Cobb angles have statistically worse 2yr appearance scores, larger preoperative trunk shift worse mental and total scores, and larger BMI worse total, mental, and pain scores. Complications, postoperative curve magnitude, curve pattern did not significantly contribute to postoperative scores. There were no factors contributing to satisfaction. The SRS instrument exhibited a significant ceiling effect. Factors more common in those with poor results are shown in the table. Neither complications nor final Cobb differed between groups.

Conclusion: Postoperatively, the SRS instrument in AIS is strongly driven by the appearance domain. Larger preoperative Cobb and trunk shift result in poorer scores. Heavier patients have less improvement overall with more pain and poorer mental scores. Satisfaction is unrelated to any specific factors. Poor pain scores are more likely in those with larger preop trunk shifts and Lenke 3 curves, bracing and less main curve correction in those with worse appearance scores and ASF in those with worse mental scores.

Significance: While the SRS instrument is responsive to curve correction, poor postoperative scores are related to more than normal contour restoration and likely related to unaddressed factors. Control over curve correction and, subsequently, patient's perception of appearance are under some surgeon control, other factors such as BMI and more disfiguring preoperative curves are not. If satisfaction is under the surgeon's influence, it is not captured by the SRS instrument.

SRS Domain	Factors more likely in poor result patients
Pain	Larger preop trunk-shift and Lenke 3
Appearance	Prior bracing, less preop shoulder difference or coronal decompensation, less main Cobb correction (50% vs. 60%).
Mental	ASF rather than PSF
Activity	Lesser preop coronal decompensation, trunk shift, or scoliometer
Satisfaction	None
Total	Less 2yr coronal decompensation

Paper #95

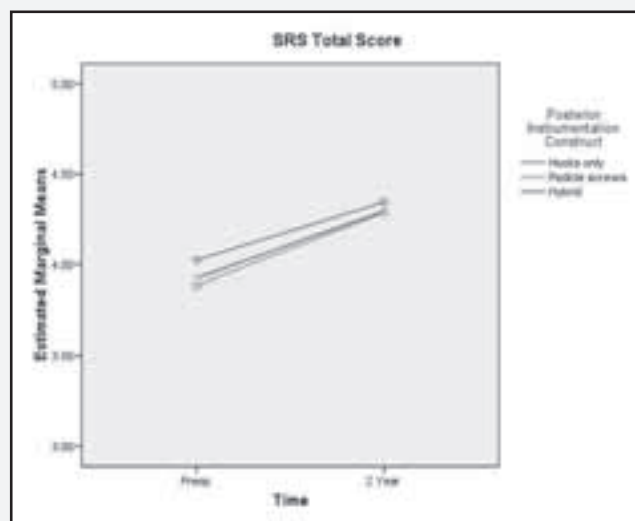
***Instrumentation Construct in Pediatric Patients Undergoing Deformity correction correlated with SRS Scores**

John P. Lubicky, MD (Indiana University School of Medicine); Jean Hanson, MD; Elizabeth H. Riley, MIS, MLS;
Level of Evidence: III

Introduction: Surgical treatment of scoliosis has evolved over time using implants and surgical techniques; however, quality of life indicators are not always collected in order to elucidate if surgery and instrumentation will improve quality of life in pediatric patients. Additionally, it is not often known whether or not the changes are predicated on type of instrumentation used.

Methods: A non-parametric test, Kruskal Wallis, was performed to determine if there were differences at baseline between instrumentation groups. A repeated-measures ANOVA was conducted with the preop and the two year SRS scores. One year was not included because inclusion reduced the sample size.

Results: Changes in the SRS Pain, Activity, Appearance,



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Mental, Satisfaction and SRS Total domains did not differ significantly among instrumentation groups for any time intervals. Yet, when a repeated measure analysis was used SRS Pain did show a significant change over time for all instrumentation patterns and a different analysis for instrumentation showed a significant change for the hybrid and pedicle screw groups. Significant changes over time were seen in the repeated measure analysis of SRS Activity, SRS Appearance, and SRS Satisfaction by instrumentation type showed a significant change for all instrumentation. Analysis of SRS Mental based on instrumentation types showed no change over time and only the pedicle group's change was significant.

Conclusion: Based on data from 388 adolescent patients, there were no significant baseline differences between the three instrumentation construct groups based on mean scores for the six SRS domains. None of the SRS domains had differences among the instrumentation constructs in change scores. None of the SRS domains had significant differences among the instrumentation constructs in repeated measures ANOVA.

Significance: Scores for SRS indicators increased over time indicating that surgery with instrumentation improved six domains reflecting quality of life for all groups. Changes between quality of life indicators did not differ between instrumentation types for any of the time intervals.

Paper #96

Beta Tricalcium Phosphate as a Bone Graft Substitute for the Posterior Treatment of Adolescent Idiopathic Scoliosis: Results of a Prospective Clinical Study

Suken A. Shah, MD (Alfred I. duPont Hospital for Children); Petya Iorgova, MS; Mohamed H. Mohamed Ali, MD; Kenneth J. Rogers, PhDATC; Level of Evidence: IV

Introduction: Iliac crest bone autograft (ICBG) is thought to be the gold standard for posterior arthrodesis for spinal deformity applications and more recently, allograft bone has been reported to be sufficient in achieving spinal arthrodesis in the adolescents. However, theoretical risks of disease transmission, inconsistent quality and volume, immunologic reactions and infections are associated with the use of allograft bone. The purpose of this study was to evaluate the safety and efficacy of beta tricalcium phosphate (β -TCP) granules with bone marrow aspirate for the posterior treatment of adolescent idiopathic scoliosis (AIS).

Methods: A single surgeon's series of PSF for AIS was consecutively enrolled and prospectively followed for a minimum of 2 years. PSF was performed with segmental instrumentation, local autograft and β -TCP granules with iliac crest bone marrow aspirate. Clinical failure was determined by 1.) radiographically evident pseudarthrosis, 2.) loss of correction of greater than 10° from the first erect postoperative radiograph, or 3.) implant failure.

Results: Sixty patients (48 females and 12 males; mean age 13.9 years) had an average preop main curve magnitude of 59° (range 45 - 90°) which was corrected to mean 14° (76%) at the first erect radiograph and mean 16° (73%) at final follow up of 3.5 years (range 2-5). The most common curve type was Lenke 1 (75%) and the average fusion included 10.3 levels. There were no radiographically evident pseudarthroses or implant failures at final follow up. There were no deep wound infections in the study population. An average of 60 cc of β -TCP granules were mixed with 22 cc of bone marrow aspirate at the time of surgery. There were no reports of morbidity from the bone marrow aspiration or wound complications (seroma, etc) from the use of β -TCP.

Conclusion: β -TCP with bone marrow aspirate yields an excellent clinical outcome for arthrodesis in patients with AIS with no morbidity of ICBG harvest, and none of the risks or quality concerns associated with allograft bone.

Significance: β -TCP with bone marrow aspirate yields an excellent clinical outcome for arthrodesis in patients with AIS with no morbidity of ICBG harvest, and none of the risks or quality concerns associated with allograft bone.

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Paper #97

Three-Stage Correction of Severe Rigid Idiopathic Scoliosis Using Halo-Gravity Traction

Wael Koptan, MD; Yasser ElMiligui, MD (Cairo University Hospital); Motaz SalahElDin, MD; Wael Hammad, MD; **Level of Evidence: III**

Introduction: To our knowledge, few series reported the use of perioperative halo-gravity traction comparing its results to classic two staged correction without traction. The aim of this work is to review the clinical and radiographic results of perioperative halo-gravity traction in severe rigid curves analyzing its efficacy, advantages and possible complications.

Methods: The results of 50 patients with severe rigid idiopathic scoliosis treated between 1997 and 2005 were retrospectively reviewed. Forty-seven patients were followed-up for a minimum of 3 years; an average of 6y (range 3 - 8y). They included 21 patients who had a three staged correction by an anterior release, 2w of halo-gravity traction then posterior instrumentation (Group 1) and 26 who had anterior release followed by correction using a posterior construct (Group 2). The average age was 18y+1m and 16y+2m respectively. The average preoperative dorsal and lumbar scoliosis in Group 1 were 106.5° (range 92 - 142°) and 87° (range 77 - 103°) respectively and at Group 2 were 102° (range 90 - 115°) and 81° (range 75 - 100°) respectively. There was no significant difference in curve flexibility or sagittal plane alignment in both groups.

Results: A significantly better correction was achieved in Group 1 (an average of 59%) compared to Group 2 (an average of 47%). At final follow-up, the loss of correction averaged 8° for Group 1 and 11° for Group 2. A shorter hospital stay was found in Group 2; a shorter operative time was found in Group 1 and there was no significant difference in blood loss, early or delayed complications.

Conclusion: Treatment of severe rigid scoliosis is very demanding and despite the advantages of recent instrumentation techniques, halo-gravity traction is an efficient, safe modality. The application of gradual traction over a period of 2w led to better correction, shorter operative time with no significant complications.

Paper #98

Correlation of Preop Curve Severity with Pulmonary Function Tests (PFTs) in AIS

Charles E. Johnston, MD (Texas Scottish Rite Hospital); B. Stephens Richards, MD; Daniel J. Sucato, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD; Spinal Deformity Study Group; **Level of Evidence: III**

Introduction: Potential pulmonary function impairment is traditionally invoked as an indication for surgical correction of scoliosis. We analyzed the relationship between impaired pulmonary function and curve severity.

Methods: PFTs (FEV1, FVC) were correlated with preop deformity magnitudes (coronal, sagittal, axial planes) in 866 AIS patients, all Lenke 1-4 curves. PFTs < 65% pred were considered impaired, ≥65% normal. MT curves were stratified as <70 vs ≥70o, T5-12 kyphosis as <10 vs ≥10o, Nash-Moe rotation (NM) as <3 vs ≥3. Additional combination severities of MT & sagittal plane were also analyzed.

Results: MT curve averaged 69.3o in the impaired group (n=167) compared to 58.3o in 699 "normals" (p<.0001). T5-12 sagittal averaged 21.0o impaired, 23.6o normal (p=.025). NM averaged 1.88 impaired, 1.66 normal (p=.002). Results were similar for both FEV1 and FVC. In patients with MT≥70 (n=161), absolute and pred FEV1 & FVC preop were less than patients with MT<70 (n=705, p<.0001). Further stratification (<60, 60-79, ≥80) showed %FEV1 differences (82.4, 75.4, 63.2 respectively, p<.0001). For sagittal plane, FEV1 & FVC were less (p<.0001) in patients with T5-12<10o (n=146, mean 69.1%) compared to those with ≥10 (n=720, mean 80.2%). There was no difference in PFT between those with T5-12=10-19o vs. ≥20. No PFT differences were found between NM<3 and ≥3. Combinations of coronal+sagittal deformity: SEE TABLE

Conclusion: Preop PFT impairment is significantly correlated with coronal and sagittal deformities, with MT curves >70o (especially >80o) or T5-12 kyphosis <10o, alone or in combination, being more impaired. Axial

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deformity does not correlate with preop PFT impairment. This data suggests that specific surgical attention to coronal & sagittal deformity is indicated when preop PFTs are <65% pred values.

Significance: This data suggests that surgical attention to coronal & sagittal deformity is indicated when preop PFTs are <65% pred values, while axial plane correction is less critical for improving pulmonary function.

Group	MT°	>=80	>=80	60-79	60-79	<60	<60
	T5-12°	<10	>=10	<10	>=10	>=10	>=20
N		6	59	57	269	139	253
N <65% pred		5	33	23	47	13	21
% pts. <65% pred		83	56	40	17	9	8

Chi-square p<.0001

Paper #99

Correction of Thoracic Hypokyphosis in AIS by Simultaneous Translation on Two Rods. Sagittal and Coronal Correction of 72 Patients with Two Years of Follow-Up

Jean-Luc Clement, MD (Lenval Hospital); Edouard Chau, MD; Anne Geoffray, MD; Marie-José Vallade;

Level of Evidence: IV

Introduction: The long-term outcome of surgically treated scoliosis is dependent not only on the coronal correction but also on restoration of sagittal curves. Recent publications confirm the moderate correction of thoracic hypokyphosis by posterior instrumentation with hooks or pedicle screws.

Methods: Radiographic parameters were measured preoperatively at 6 weeks, 1 year and last follow-up (2-7.4 years) in a consecutive cohort of 72 patients treated by PSF. All operative procedures were performed by the same surgeon using stable anchorages such as screws or self-stabilizing claws. The screws and claws included a polyaxial threaded extension, which were fixed to the rod with connecting clamps. Reduction of the deformity was obtained by gradual and alternate tightening of the nuts at all threaded extensions on both rods, which allowed the vertebrae to gradually approach the rods while performing the translation maneuver.

Results: In coronal plane, the average main curve was reduced from 54° to 17° and maintained 70% of correction at last follow-up. There was no difference between the 56 patients of thoracic scoliosis (Lenke 1-4) and the 16 patients with thoracolumbar or lumbar scoliosis (Lenke 5 and 6). In sagittal plane, for patients with hypokyphosis (32 cases<20°), the average kyphosis angle was significantly improved by 9° to 30° and maintained during follow-up (31°) with a mean gain of 21° (p<0.000). Only one patient reported hypokyphosis (18°) at last follow-up. For patients with normal kyphosis, the average gain was 7°.

Conclusion: In a large consecutive cohort, reduction of scoliosis by ST2R is an effective method that allows restoration of normal thoracic kyphosis.

Paper #100

Are We Improving Postoperative Sagittal Contour with New Posterior Instrumentation Compared to 'Old School' Instrumentation?

David H. Clements, MD (Cooper Bone & Joint Institute); Randal R. Betz, MD; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Harms Study Group; **Level of Evidence: III**

Introduction: The purpose of this study was to compare the change in sagittal contour after surgical correction of thoracic adolescent idiopathic scoliosis (AIS) using anterior screw versus posterior hybrid versus posterior screw constructs. The study was performed using data entered in a multicenter AIS patient database.

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Methods: Patients with a diagnosis of Lenke 1 AIS who were eligible for surgery were enrolled in this IRB-approved study. Patients were divided into three groups; anterior screw (Group 1), posterior hybrid (Group 2) or posterior screw (Group 3) constructs in the structural thoracic curve. The mean preoperative and minimum 2-year postoperative correction of the sagittal curve measurement was recorded for the levels T2-T5, T2-T12, T5-T12, T10-L2, lumbar lordosis and lateral C7 plumb to the sacrum. Correlation was then made between these measurements for the 3 groups comparing pre-op to 2-year post-op, and comparing pre-op and 2-year post-op curve means between the three groups. 166 patients were available for review in the anterior screw Group 1, 66 in the hybrid anchor Group 2 and 90 in the screw anchor Group 3.

Results: At 2-year follow-up, the anterior Group 1 increased kyphosis significantly from T2-T12 and T5-T12 and increased lumbar lordosis. The posterior screw Group 3 saw a significant decrease in kyphosis at T5-T12 and decreased lumbar lordosis, while T2-T5 kyphosis increased. The posterior hybrid Group 2 saw no significant change at T2-T5, T2-T12, and T5-T12 or in lumbar lordosis. T10-L2 did not change significantly in any group. The posterior screw Group 3 was the only group to have a statistically significant, but clinically insignificant, change in C7 plumb to the sacrum.

Conclusion: Using “new” posterior screw instrumentation on Lenke 1 curves has had a negative effect on postoperative sagittal contour. The mid thoracic kyphosis and lumbar lordosis decreases in an already flat sagittal deformity, and proximal thoracic kyphosis is increased. “Old” posterior hybrid instrumentation is not as bad, and tends toward minimal change of the sagittal contour. “Older” anterior instrumentation recreates the best sagittal contour. Clearly, the attachment of the anchor in relation to the vertebral axis of rotation has a large effect.

Table 1: Preoperative averages and average change (+/-SD) in sagittal values (positive number indicates increase, negative indicates a decrease from pre- to 2-year postoperative)

	Anterior screw and rod instrumentation (Group 1)	Posterior hybrid (Group 2)	Posterior screw (Group 3)	p value
T2-T5	8 minus 0.5 ± 7	8 plus 2 ± 7	8 plus 3 ± 8	≤0.001
T2-T12	28 plus 7 ± 10	31 minus 0.3 ± 11	31 minus 2 ± 12	≤0.001
T5-T12	20 plus 8 ± 11	24 minus 2 ± 11	23 minus 5 ± 13	≤0.001
T10-L2	0.9 plus 0.6 ± 10	-0.8 plus 3 ± 13	0.2 minus 0.6 ± 11	0.13
Lumbar lordosis	-59 plus 4 ± 9	-63 minus 3 ± 12	-60 minus 4 ± 11	≤0.001
C7-Sacrum	-1 plus 0.2 ± 5	-2 minus 0.8 ± 5	-2 plus 1.5 ± 5	0.006

Paper #101

Comparative Analysis of Sagittal Plane Measures following Three Different Posterior Segmental Spinal Instrumented Fusion of AIS

Yongjung Kim, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Oheneba Boachie-Adjei, MD; Paul D. Kim, MD (Columbia University); Youngbae B. Kim, MD; **Level of Evidence: III**

Introduction: To compare the various sagittal parameters in adolescent idiopathic scoliosis (AIS) following 3 different posterior segmental spinal instrumented fusion with a minimum 2-year follow-up.

Methods: Radiographic measurements of 352 AIS patients (average age 14.6 years) who underwent posterior only segmental spinal instrumentation (PSSI: Hook only n=164, hybrid with sublaminar wiring (hooks above, screws below, and sublaminar wiring in the middle) n=75, pedicle screw (PS) instrumentation n=113) and fusion at 3 institutions with a minimum 2 years postoperative follow up were analyzed.

Results: The sagittal thoracic kyphosis angle (T5-T12) demonstrated significant difference at 8 weeks post operation (5 degree(D) decrease in hooks, 1 degree decrease in hybrid sublaminar wiring, and 12 D decrease in PS, p<0.0001) and at the ultimate follow-up (0 D decrease in hooks, 1 D decrease in hybrid sublaminar wiring, and 11 D decrease in PS compared to preoperation, p<0.0001). The lumbar lordosis angle at the ultimate follow-up did not demonstrate a significant differences (0 D change in hooks only and hybrid sublaminar instrumentation vs. 2 D decrease in PS, p=0.19). Average proximal junctional angle changes

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at the ultimate follow-up demonstrated smallest increase in hybrid sublaminar wiring instrumentation (2 D increase, 6 D increase in hooks only, and 8 D increase in PS instrumentation; $p < 0.0001$). However, there was no differences in sagittal vertical axis (distance between C7 plumb and posterior superior end plate of S1) change (9mm decrease in PS instrumentation, 4mm decrease in hooks only, and no change in hybrid sublaminar instrumentation, $p = 0.41$).

Conclusion: Thoracic kyphosis change during operative procedure made an significant impact on the proximal junctional angle change, but not on the lumbar lordosis and C7 plumb line at the ultimate follow-up among the 3 groups using hooks only vs. Hybrid with Sublaminar wiring vs. thoracic pedicle screw instrumentation.

Significance: This is the first study to compare 3 different instrumentation techniques for adolescent idiopathic scoliosis. Sagittal balance is also important for adolescent idiopathic scoliosis.

Paper #102

Restoration of Thoracic Kyphosis in Thoracic Adolescent Idiopathic Scoliosis using Pedicle Screw and Stiff Rod Instrumentation

Prof. Se-Il Suk, MD, PhD; Jin-Hyok Kim, MD; Sung-Soo Kim, MD (Seoul Spine Institute); Dong-Ju Lim, MD; Tae-Hyung Kim, MD; Jung-Il Han, MD; Level of Evidence: IV

Introduction: AIS is characterized by thoracic hypokyphosis. It has been reported that posterior segmental instrumentation tends to restore thoracic kyphosis insufficiently and induce proximal junctional kyphosis (PJK). The purpose of this study is to evaluate the thoracic sagittal curve and proximal junctional change in AIS after pedicle screw instrumentation with stiff rods.

Methods: A total of 107 thoracic AIS patients treated with pedicle screw instrumentation and stiff rods (7mm stainless steel) and fusion not extending above T3 were retrospectively analyzed with a minimum follow up 2 years (2 ~ 10 years). Standing long-cassette radiographic measurements were analyzed including various sagittal/coronal parameters for preoperative, early postoperative and last follow-up exams. The proximal junctional sagittal Cobb angle was measured between the lower end plate of the uppermost instrumented vertebra and the upper end plate of second vertebrae above. Abnormal PJK was defined as a proximal junctional sagittal angle of 10° greater than the preoperative measurement.

Results: The preoperative T5-12 thoracic kyphosis of $18^\circ \pm 9.4^\circ$ was significantly restored to $23.9^\circ \pm 7^\circ$ ($P < 0.0001$) in immediate postoperation and well maintained as $26.2^\circ \pm 11^\circ$ ($P < 0.0001$) at last follow-up. The preoperative proximal junctional sagittal angle of $6.9^\circ \pm 5^\circ$ was changed to $8.0^\circ \pm 5.5^\circ$. There was no PJK after rigid instrumentation with stiff rods except for 1 patient who had a preoperative thoracic kyphosis of 44° .

Conclusion: In thoracic AIS patients, pedicle screw instrumentation with stiff rods in the treatment of thoracic AIS restored and maintained thoracic kyphosis and PJK was avoided.

Significance: In the treatment of thoracic AIS, pedicle screw instrumentation and stiff rods restores thoracic kyphosis and avoids PJK

Paper #103

The Effect of VEPTR Treatment of Thoracic Insufficiency Syndrome on Sagittal Plane Alignment

Peter F. Sturm, MD (Shriners Hospital for Children, Chicago); Sahar Hassani, MS; Kristen Zaharski; Mary Riordan; Chest Wall and Spinal Deformity Study Group; Level of Evidence: IV

Introduction: VEPTR has been shown to control curve progression while allowing for spine and thoracic growth and lung maturation in thoracic insufficiency syndrome (TIS). Repeated spinal distraction forces associated with correction in growing rod constructs have been shown to be kyphogenic. No study to date has examined the effect of VEPTR on sagittal plane alignment.

Methods: A retrospective x ray and data base review was performed on those patients entered in to the

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initial FDA/IDE prospective VEPTTR study between September 1996 and February 2003. Patients underwent initial VEPTTR insertion and then expansion every 6 months. Thoracic kyphosis was measured on standing x rays preoperatively, at first follow up visit and at final follow up.

Results: The indication for surgery was primary or secondary thoracic insufficiency syndrome. Most patients had congenital scoliosis and chest wall abnormalities. Adequate X ray follow up of more than 2 years was available for 91/142 patients. Those patients make up the cohort in this study. Average age at surgery was 5 years 4 months. The average follow up was 42 months. The upper fixation point was at the third rib or above in 72 patients, below in 19. A rib to spine construct was used in 73 patients, a rib to pelvis in 8, and a rib to rib alone in 10. Kyphosis, preoperatively averaged 39 degrees (-10 to 110), and 39 degrees (5 to 110) postoperatively. Final kyphosis was 50 degrees (20 to 102). Nineteen patients had an initial kyphosis greater than 55 degrees. In this latter group, the preop kyphosis averaged 70 degrees (55-110), post op 59 (31-100) and final kyphosis 75 degrees (42-102).

Conclusion: In the overall patient group initial VEPTTR insertion did not affect kyphosis while in the hyperkyphotic patients kyphosis initially decreased. In both groups the kyphosis increased with subsequent lengthenings. Distraction forces associated with VEPTTR lengthening produced kyphosis but for the most part this was not clinically significant.

Significance: Kyphosis increased during subsequent VEPTTR lengthenings in children with congenital scoliosis and chest wall abnormalities. However, this was not found to be clinically significant.

Paper #104

Pedicle Subtraction Eggshell Osteotomy at the Spinal Level for Fixed Sagittal Imbalance

Gregory P. Graziano, MD; Karl F. Bowman, MD; Frances A. Farley, MD (University of Michigan); Level of Evidence: IV

Introduction: The purpose of this study is to evaluate thoracic pedicle subtraction osteotomy for the management of thoracic kyphosis.

Methods: This is a retrospective case review of all spinal cord level osteotomies with a minimum of two year follow-up. IRB approval was obtained. All etiologies were included. Medical records and radiographs were reviewed. Outcomes were recorded as intra-operative, early, and late post-operative complications and correction of pre-operative thoracic kyphosis and sagittal imbalance and the C7-S1 axis utilizing standard radiographic measurement techniques.

Results: The patient sample consisted of seven patients who underwent nine osteotomies. The osteotomies were performed at T5 (2), T6, T7, T8, T9, T10, T11 (2). Thoracic kyphosis pre-operatively averaged 94.2 degrees (range, 71 to 126 deg) and improved to 55.4 degrees (range 24 to 77 degrees). Lumbar lordosis prior to surgery averaged 50.7 degrees (range, 3 to 83 degrees) and improved to 48.8 degrees (range, 28 to 62 degrees). The sagittal vertical axis measured from C7-S1 demonstrated a preoperative sagittal decompensation averaging 2.3 cm (range, 1.5 to 3.8 cm) with correction to -2.35 cm (1.4 to -5.5cm). Coronal balance did not change significantly. Intra-operative complication included one dural tear and a pressure wound from patient positioning. Early post-operative complications include two periods of prolonged intubation for ventilator dependent respiratory failure. Late complication was a single deep infection requiring serial irrigation and debridement. One patient sustained a shear injury to the spinal cord during closure of the osteotomy site with no detectable intraoperative somatosensory evoked potential (SSEP) change and no demonstration of neurologic deficit in the post-operative period.

Conclusion: Pedicle subtraction osteotomy procedures are a highly effective method for the correction of kyphosis when performed at the site of the deformity. This allows restoration of sagittal balance with improvement in both the kyphosis and the C7-S1 plumb line. Careful surgical techniques are required with controlled closure of the osteotomy site.

*The FDA has not cleared a drug and/or medical device described in this presentation (i.e., the drug or medical device is being discussed in an off-label use). For full information see page 6.

Paper #105

Body Mass Index in Scheuermann's Kyphosis (SK): Does BMI Differ in Patients with SK vs. Adolescent Idiopathic Scoliosis (AIS)?

Baron S. Lonner, MD (NYU Hospital for Joint Diseases); Kristin E. Kean; Paul D. Sponseller, MD; Harry L. Shufflebarger, MD; Suken A. Shah, MD; Alvin H. Crawford, MD; Randal R. Betz, MD; Peter O. Newton, MD;
Level of Evidence: III

Introduction: Body Mass Index (BMI) in patients with SK has not been previously reported although clinical observation suggests that it is greater in patients with SK than in the general population and in those with AIS. Increased BMI may impact clinical detection of deformity, self-image reporting, and operative morbidity. The purpose of this study was to assess BMI in SK patients in comparison to AIS patients.

Methods: 36 patients (16 females, 20 males, average age 16.7 years) from a prospective multicenter study on SK were compared to 241 patients (204 females, 37 males, average age 14.3 years) from a prospectively collected database of AIS. ANOVA was used to detect differences in BMI and SRS-22 scores between the two groups. NIH BMI categories were used to define underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (>=30).

Results: The mean BMI in the SK group (24.5 +/- 5.5, range: 15.5-38.5) was significantly higher than in the AIS group (20.7 +/- 3.7, range: 14-37, p=0.001). There were no differences in BMI by gender in either group. The SK group had significantly lower (worse) SRS-22 scores in the pain (3.51 vs. 3.86, p=0.004), self image (2.97 vs. 3.80, p=0.001) domains as well as a significantly lower overall score (3.65 vs. 3.98, p=0.001). There were no significant differences in the function and activity domains.

Conclusion: BMI is higher in patients with SK versus those with AIS. SRS-22 outcome scores are more negatively impacted in the pain, self-image, and overall scores in the SK group than in the AIS group.

Significance: Higher BMI associated with SK may impact detection of the deformity, clinical effect on the patient, and operative morbidity.

*	SK	AIS
Underweight (BMI<18.5)	5.6% (2/36)	31.1% (75/241)
Healthy (BMI=18.5-24.9)	52.8% (19/36)	58.1% (140/241)
Overweight (BMI=25-29.9)	27.8% (10/36)	7.9% (19/241)
Obese (BMI>=30)	13.9% (5/36)	2.9% (7/241)
Total	36	241

Paper #106

Should Symptomatic Iliac Screws be Electively Removed in Postoperative Adult Spinal Deformity Patients Fused to the Sacrum?

Brian A. O'Shaughnessy, MD (Washington University School of Medicine); Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Timothy R. Kuklo, MD, JD; Woojin Cho, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Linda A. Koester; Level of Evidence: IV

Introduction: Iliac screws (IS) are an effective method to counter cantilever forces imparted on sacral fixation. Pain or implant prominence can lead to elective IS removal. Our purpose was to determine: (1) the prevalence of elective IS removal in adult spinal deformity; (2) if symptoms improved after IS removal; (3) complications of IS removal.

Methods: 395 consecutive ambulatory adult deformity patients fused to the sacrum with IS at a single institution were studied. All patients had min 2-year f/u. Clinical-radiographic data was analyzed. An 8-question IS removal questionnaire was specially designed and utilized.

Results: 24/395 (6.1%) patients (2M/22F) with mean age 50.5±10.8 years underwent elective IS removal 2.6±1.3 years from the index operation. Mean follow-up from initial surgery was 6.3±4.0 years. Hip/buttock pain was present in all 24 patients; 5 patients (20.8%) also reported IS prominence. Removal was bilateral

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in 18 (79.2%) and unilateral in 5 patients (20.8%). Using a (0-10) NRS pain scale, hip/buttock pain improved following IS removal: preop 6.9 ± 1.8 , postop 2.0 ± 2.7 ($p < 0.05$). Patients reported hip/buttock symptoms post-IS removal as: "much improved" (78.3%), "somewhat improved" (8.7%), and "unchanged" (13.0%). 2/24 (8.3%) patients sustained complications from IS removal (wound infection $n=1$; coronal/sagittal imbalance $n=1$). Presented with the same set of circumstances, 22/24 (91.7%) of patients would have their IS removed again, including one of the patients who had a complication.

Conclusion: In the adult spinal deformity population, the prevalence of elective IS removal was 6.1% at an average of 2.6 ± 1.3 -yrs postop. IS removal was associated with a low rate of complications, a high rate of hip/buttock pain relief (86.0% of patients were improved), and 91.7% overall satisfaction in well selected adult spinal deformity patients.

Significance: Elective iliac screw removal due to pain or prominence is uncommon following surgery for adult spinal deformity. In carefully selected patients, elective removal of iliac screws results in a significant improvement in hip/buttock pain and high overall satisfaction, with a low risk of complications.

Paper #107

Does a Consensus Algorithm for Treating Adult Thoracolumbar and Lumbar Major Spinal Deformity Help Guide Optimal Treatment?

Frank J. Schwab, MD (NYU Hospital for Joint Diseases); Virginie Lafage, PhD; Keith H. Bridwell, MD; Steven D. Glassman, MD; Christopher I. Shaffrey, MD; Jean-Pierre C. Farcy, MD; Level of Evidence: II

Introduction: Benefits of surgical care for adult spinal deformity has been shown but few guidelines exist to direct patient care. The Classification of adult spinal deformity ("Classification") provides a clinical framework but validation of treatment algorithms have not been reported. This study aims to evaluate outcomes following surgery for adult thoracolumbar/lumbar spinal deformity based upon a consensus algorithm developed by the Spinal Deformity Study Group.

Methods: Multi-center analysis of consecutive adult patients classified as Type IV, V curves (thoracolumbar, lumbar major) with sagittal malalignment (modifiers B/C, P/VP) were selected: 274 patients, 144 with 1yr, 69 with 2yr follow up (radiographs, health related quality of life (HRQOL) data and operative details). The treatment algorithm calls for fusion to the sacrum and osteotomies for these cases. Statistical comparison of outcomes was made between groups dependant upon adherence with the algorithm.

Results: Of 274 patients, 192 (70.1%) had fusions that extended to S1, 130 patients (47.4%), had osteotomies. By SRS measures (total, appearance, mental), patients treated according to the algorithm had greater improvement than those whose fusions stopped short of the sacrum ($p < 0.05$). In terms of SRS Appearance MCID at One Year - 75% of fusions at the guideline level met the threshold, compared to 43% of those with fusions higher than the guideline ($p = .001$, chi square test). By osteotomy guidelines, greater improvement was found for those having osteotomies: one-year and two year SRS Appearance ($p = .01$), SRS Mental ($p = .003$) and SRS Total Score ($p = .005$).

Conclusion: A Classification of adult deformity has been established and efforts are directed at validating an algorithm for optimal surgical approach. In this study combining Classification and treatment algorithm lead to improved outcome following surgery. The need for osteotomies and extension to the sacrum for Type IV/V sagittally imbalanced patients is established.

Significance: The Classification of adult spinal deformity can be combined with a treatment algorithm. In the setting of thoracolumbar/lumbar major curves with sagittal plane malalignment the algorithm effectively guides ideal treatment for best outcome based upon HRQOL measures.

Paper #108

***Extension of Prior Idiopathic Scoliosis Fusions to the Sacrum: a Matched Cohort Analysis of 65 Patients with Minimum Two-Year Follow-Up. Can BMP Improve Outcomes?**

Charles H. Crawford, MD (Washington University School of Medicine); Keith H. Bridwell, MD; Woojin Cho, MD; Jacob M. Buchowski, MD, MS; Brian A. O'Shaughnessy, MD; Michael S. Chang, MD; Joshua D. Auerbach, MD; Level of Evidence: III

Introduction: Extension of a prior idiopathic scoliosis fusion to the sacrum is a challenging operation that has been associated with a 37% rate of pseudoarthrosis. (Islam et al, Spine 2002). We hypothesized that rhBMP-2 could be successfully used as a substitute for distant autograft. To our knowledge, this is the first study to evaluate the use of BMP in this population.

Methods: Consecutive patients who had undergone a long idiopathic scoliosis fusion as a teen or young adult and later presented with distal degeneration requiring extension of the fusion to the sacrum were identified from a single institution prospective database. Group 1 (rhBMP-2 without distant autograft, 2002-2006) included 36/39 patients with min 2yr f/u while Group 2 (distant iliac or rib autograft without rhBMP-2, 1998-2002) included 24/25 patients with min 2yr f/u. Radiographs were measured using SRS criteria. Fusions were evaluated by independent observers using a published 4-point scale. Clinical outcomes were evaluated using SRS and ODI questionnaires.

Results: (Table 1) Groups were well matched with respect to demographic, radiographic, and surgical data with the following exceptions: In Group 1, the avg dose of rhBMP-2 was 11.6mg/level anterior and 17.2mg/level posterior. Group 2 (no BMP) was younger (43.5 vs 49.8 yrs, p=0.04), had more anterior levels fused (3.3 vs 1.7, p=0.01), more thoracoabdominal approaches (25% vs 2.7%, p=0.01), and greater EBL (1938ml vs. 1221ml, p=0.01). There was one wound complication (deep infection) in each group. Rates of radiographic pseudoarthrosis (11.1% vs. 20.8%) and revision for pseudoarthrosis (5.6% vs. 12.5%) were lower in the rhBMP-2 group, although this did not reach statistical significance. Pre-op, post-op, and improvements in SRS and ODI scores were similar between groups. We did not observe any increase in adverse events with the use of rhBMP-2.

Conclusion: The rhBMP-2 group had a lower, although not statistically significant, rate of pseudoarthrosis without any increase in complications. Patient reported outcome measures (ODI and SRS) showed similar improvements in both groups.

Significance: BMP-2 is a safe and effective alternative to iliac or rib harvesting when extending a prior long scoliosis fusion to the sacrum.

	BMP Group (n=36)	Autogenous Group (n=24)	p-value
Age at Surgery (years)	49.8	43.5	0.038
Female:Male	33:3	23:1	0.643
Previous Levels Fused	9.9	10.2	0.873
New Levels Fused	2.6	2.6	0.884
Final Number of Instrumented Levels	13.4	14.1	0.264
Estimated Blood Loss (mL)	1221.4	1938.1	0.007
Length of Surgery (hours)	10.8	11.3	0.565
Spinal Osteotomy	14	12	0.395
Posterior Fusion Only	4	0	0.121
Radiographic Pseudoarthrosis	4 (10%)	5 (20.8%)	0.462
Reoperation for Pseudoarthrosis	2 (5.4%)	3 (12.5%)	0.380
Patient Reported Outcomes			
Pre-op ODI	38.5	44.8	0.194
Post-op ODI	20.1	21.5	0.864
SRS Post-op Satisfaction	4.2	4.0	0.217
SRS Self Image Improvement	1.1	0.8	0.327
SRS Pain Improvement	1.0	1.2	0.518
SRS Function Improvement	0.6	0.9	0.221

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Paper #109

Sagittal Decomposition Following Pedicle Subtraction Osteotomy for Adult Patients with Sagittal Imbalance: Incidence, Risk Factors, and SRS Outcomes Score

Yongjung Kim, MD (Columbia University); Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Christopher L. Hamill, MD; Samuel Cho, MD; Youngbae B. Kim, MD; Level of Evidence: III

Introduction: To determine postoperative sagittal decompenation (SD) following pedicle subtraction osteotomy (PSO) for adult patients with sagittal imbalance with a minimum 2 year follow-up.

Methods: A radiographic and clinical assessment of 141 adult patients (average 54.7 years) with sagittal imbalance who underwent PSO with a minimum 2-year follow-up (average 4.3 years, range 2-12 years) was performed. SD was defined as the sagittal vertical axis (SVA) > 8 cm.

Results: The incidence was 29% (41/141), of which 16% (23) had early onset (at 8 weeks postoperatively) and 15% had late onset SD. Comparing between SD and non-SD groups, age at surgery, co-morbidities, postoperative thoracic kyphosis (TK) Cobb angle (T5-T12), postoperative lumbar lordosis (LL) Cobb angle (T12-S1), the change in LL Cobb angle following PSO, and the sum of TK and LL Cobb angles were statistically different (p<0.05) between them (See Table 1). Associated risk factors were: immediate postoperative SVA > 8 cm, the sum of TK, LL, and pelvic incidence Cobb angles > 45o, the sum of TK and LL Cobb angles < -25 o, T12 horizontal angle > -15 o, LL Cobb angle increase >/= 40 o, associated co-morbidities, age at surgery > 55 years, uppermost instrumented vertebra below T8, and preoperative SVA > 15 cm. The total SRS outcomes scores were 3.22 and 3.59 for SD and non-SD groups, respectively (p=0.025). The self-image subscale scores were 3.20 (for SD) and 3.72 (for non-SD) (p=0.006).

Conclusion: The prevalence of SD following PSO for adult patients with sagittal imbalance was 29%. Multiple factors should be considered to achieve optimal correction while minimizing the risk of developing SD. Patients' self-image seems to be affected the most with SD.

Significance: Prevention of sagittal decompenation is very important to get better radiographic and clinical outcome.

Table 1. Comparison between SD and non-SD groups

	SD Group (n=41)	Non-SD Group (n=100)	p-value
Age at surgery	59.2 ± 12.9	52.9 ± 13.2	0.011
Follow-up	4.8 ± 2.79	4.1 ± 2.00	0.16
Number of fused vertebrae	10.1 ± 4.25	11.4 ± 3.76	0.08
Associated co-morbidity	83%	55%	0.002
TK (T5-T12 angle)			
Preop.	30 ± 21.6°	25 ± 19.0°	0.19
8 weeks PO	40 ± 17.0°	32 ± 14.4°	0.011
Ultimate FU	44 ± 18.5°	33 ± 15.8°	0.002
Ultimate FU - Preop.	14 ± 13.2°	8 ± 15.5°	0.09
LL (T12-S1 angle)			
Preop.	-12 ± 17.0°	-16 ± 21.7°	0.24
8 weeks PO	-47 ± 14.8°	-53 ± 14.6°	0.042
Ultimate FU	-40 ± 17.9°	-52 ± 14.6°	0.001
Ultimate FU - Preop.	-28 ± 17.1°	-36 ± 17.1°	0.026
TK+LL angle			
Preop.	18 ± 20.9°	8 ± 21.9°	0.029
8 weeks PO	-7 ± 15.3°	-21 ± 17.4°	<0.0001
Ultimate FU	4 ± 17.0°	-18 ± 18.3°	<0.0001
Sacral slope			
Preop.	23 ± 14.0°	24 ± 16.7°	0.81
8 weeks PO	31 ± 10.9°	35 ± 10.8°	0.08
Ultimate FU	31 ± 11.8°	34 ± 11.3°	0.15
Sagittal vertical axis			
Preop.	17.2 ± 5.67cm	13.1 ± 6.27cm	<0.0001
8 weeks PO	7.7 ± 4.12cm	0.6 ± 4.00cm	<0.0001
Ultimate FU	12.9 ± 3.31cm	1.9 ± 3.43cm	<0.0001
Ultimate FU - Preop.	-4.4 ± 7.14cm	-11.2 ± 6.38cm	<0.0001

*Statistically significant difference if p < 0.05

SD = Sagittal decompenation if SVA > 8 cm, TK = Thoracic kyphosis, Preop. = Preoperative, PO = Postoperative, FU = Follow-up

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Paper #110

Pelvic Retroversion Determines A Reciprocal Relationship Between Pelvic Incidence and Sacral Slope in Advanced Degenerative Disease of the Spine

Sergio A. Mendoza-Lattes, MD (University of Iowa Hospitals & Clinics); Zachary Ries, BSc; Yubo Gao, PhD; Stuart Weinstein, MD; Level of Evidence: III

Introduction: Spinal degeneration leads to loss of lordosis and anterior displacement of the C7-plumbline (C7-P). Compensatory mechanisms include pelvic retroversion and reduction of the thoracic kyphosis (TK).

Methods: Retrospective cohort. Group-I: 20 asymptomatic, skeletally mature teenagers, Group-II: 55 consecutive adults with symptomatic degenerative lumbar deformity, Group-III asymptomatic adults (previous publications). Sagittal alignment parameters were measured. Sagittal alignment was expressed by the ratio C7-P/SFD.

Results: Sagittal balance of Group II was substantially more positive than Group I (C7-P/SFD= 1.54 ± 2.2 vs. -0.81 ± 1.6 ; $p < 0.001$) and Group-III (C7-P/SFD= -0.90 ± 1.0). PI of Group-I was significantly smaller than Group II (48.9 ± 13.1 vs. 57.8 ± 15.6 ; $p = 0.02$). SS of Group-I was significantly larger than that of Group-II (36.1 ± 9.2 vs. 30.6 ± 13.5 ; $p = 0.05$), but comparable to Group-III. Group-I also exhibited greater lumbar lordosis than Group II (-51.4 ± 11.5 vs. -31.4 ± 24.1 , $p < 0.001$) as well as greater thoracic kyphosis (38.2 ± 10.0 vs. 30.0 ± 15.7 , $p = 0.01$).

Conclusion: The degenerative process involves an overall straightening and anterior translation of the spine. Previous studies have shown a direct linear correlation between PI and SS in healthy individuals. This study indicates that a reciprocal relationship exists between PI and SS in advanced degenerative disease of the spine. A greater PI requires greater amount of compensation by pelvic retroversion. This compensatory mechanism facilitates the restoration of sagittal balance, but is limited by the anterior ileo-lumbar ligament (hip extension).

Significance: The results of this study suggest that restoration of the SS is essential in establishing normal alignment and balance of the lumbar spine.

Paper #111

Pedicle Subtraction Osteotomy in Older Patients with Degenerative Sagittal Imbalance

Kyu-Jung Cho, MD (Inha University Hospital); Ki-Tack Kim, MD, PhD; Prof. Whoan Jeang Kim; Sang-Hun Lee, MD; Jae-Hoon Jung; Hyung-Suk Kim, MD; Level of Evidence: IV

Introduction: Patients with degenerative sagittal imbalance are older than the patients with iatrogenic flatback deformity. It may cause insufficient correction of sagittal alignment, due to the loss of correction from poor bone quality and weak paraspinal muscles. The purpose of this study was to assess the correction of sagittal alignment by pedicle subtraction osteotomy (PSO) for severe degenerative sagittal imbalance.

Methods: Thirty-two patients who underwent fusion to the sacrum were analyzed with a minimum 2-year follow up. This study enrolled the patients with degenerative sagittal imbalance where C7 plumb was > 10 cm before surgery. The mean age was 65.5 years, ranged from 58 to 73. All of the PSO were performed at one segment, including at L3 (n=24), at L4 (n=4), at L2 (n=3), and at L1 (n=1). The average number of levels fused was 8.15 segments. Thirteen patients had structural interbody fusion at the lumbosacral junction. Fourteen patients had additional iliac screw fixation.

Results: The mean correction of osteotomy angle was 34.6o from 10.4o preoperatively to -24.2o at the last visit. The loss of correction after surgery was 2.8o. The lumbar lordosis was 3.6o before surgery, corrected to -38.7o after surgery, and changed to -28.5o at the last visit. The correction of lumbar lordosis was -32.1o, and loss of correction was -10.2o. The sagittal C7 plumb was 192.7mm before surgery, corrected to 39.7mm after surgery, and changed to 86.8mm at the last visit. The correction of sagittal C7 plumb was 105.9mm, and the loss of correction was 47.1mm. There was substantial loss of corrections. Complications related to the fixation were also common. Pseudarthrosis developed in 6 patients, of which 3 patients underwent revision surgery. There was loosening of proximal or distal screws in 8 patients.

Conclusion: Pedicle subtraction osteotomy in the older patients has a significant loss of correction.

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Therefore, addition of anterior column support and supplemental iliac fixation are required to maintain the correction and reduce the complications.

Paper #112

PSO Failures can be Predicted by High Pre-Op SVA and Pelvic Tilt

Virginie Lafage, PhD (NYU Hospital for Joint Diseases); Frank J. Schwab, MD; Justin S. Smith, MD, PhD; Jean-Pierre C. Farcy, MD; Oheneba Boachie-Adjei, MD; Alexis P. Shelokov, MD; Richard Hostin, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Michael F. O'Brien, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; International Spine Study Group; Level of Evidence: III

Introduction: Surgical outcome of Adult Spinal Deformity has been shown to be strongly affected by post-op global sagittal alignment. To achieve appropriate alignment numerous surgical maneuvers may be utilized including the Pedicle Subtraction Osteotomy (PSO) technique. The purpose of this study is to investigate radiographic parameters tied to successful and unsuccessful post-op alignment in the setting of PSO surgery.

Methods: Retrospective, consecutive, multi-center series of 105 patients who underwent a lumbar PSO for marked sagittal mal-alignment (mean pre-op SVA=143mm). Pre and post-op full length standing xrays were analyzed to identify changes in lumbar lordosis [LL], thoracic kyphosis [TK], global sagittal balance (SVA), and pelvic parameters (pelvic incidence [PI] and pelvic tilt [PT]). The cohort was divided into two groups according to the post-op SVA: 'successful realignment' (SVA<5cm, n=62), 'failed realignment' (SVA>10cm, n=20). Independent t-test analysis was used to identify differences in pre-op patient profiles and/or amount of deformity correction.

Results: Comparisons between the two groups demonstrated similar pre-op LL and TK. The 'failed realignment' group had larger pre-op SVA (21 vs. 10cm, p<0.001), larger pelvic incidence (64° vs. 54°, p=0.001) and larger pelvic tilt (37° vs. 31°, p=0.003). PSO application resulted in identical focal resection (23°) and lordosis change (+29°) for the two groups. In post-op, the 'failed realignment group' had greater SVA and PT. Multi-variate analysis revealed that pre-op SVA and PT, as well as the change in regional alignment was tied to global alignment outcome.

Conclusion: PSO technique can be used to obtain significant sagittal re-alignment, although sub-optimal results may still occur. This study demonstrates 2 subgroups of patients with similar PSO resections, changes in LL, TK, SVA and PT, although one group reached an acceptable post-op SVA and the other a large unacceptable one. As per the multi-variate analysis, 'unacceptable' post-op alignment could have been predicted pre-operatively, and would have required larger local resections and/or a larger regional. In patients with large pre-op SVA/ PT, the standard PSO technique alone may be insufficient to obtain proper sagittal realignment.

	Pre-op			Post-op			Change		
	successful	failed	p	successful	failed	p	successful	failed	p
Thoracic Kyphosis	-30	-33		-36	-44		-6	-10	
Lumbar Lordosis	23	17		52	45		29	28	
Pelvic Tilt	31	37	*	21	29	*	-9	-8	
Pelvic Incidence	54	64	*	54	64	*	-	-	
SVA	105	217	*	7	134	*	-98	-82	

Paper #113

Analysis of the Correlation between Adjacent Segment Degeneration and Spino-pelvic Alignment following Surgical Treatment in Adult Scoliosis

Kirkham B. Wood, MD (Massachusetts General Hospital/Harvard Medical School); Gang Li, MD; Peter G. Passias, MD; Michal Kozanek; Andrew J. Schoenfeld, MD; Richard S. Lee, MD; Weishi Li, MD; Shaobai Wang, SM; Qun Xia; Prof. Guoan Li; Level of Evidence: III

* The FDA has not cleared a drug and/or medical device described in this presentation (i.e., the drug or medical device is being discussed in an off-label use). For full information see page 6.

Scientific Program Abstracts

Introduction: This investigation sought to evaluate the correlation between adjacent-segment degeneration (ASD) and spino-pelvic geometric parameters in patients with adult scoliosis. A variety of factors have been postulated to influence ASD in adult scoliosis patients, with sagittal imbalance perceived to be one of the most important risks.

Methods: 76 patients (9 male and 67 female, average age 51.1 years) with adult scoliosis who underwent surgery at a single institution over the course of 15 years were studied. Spino-pelvic geometrics were determined for each patient through examination of full-length lateral radiographs obtained pre-operatively and during normal patient follow-up. The average follow-up for patients in this study was 3.2 years (range 2-15.8 years). The spino-pelvic geometrics investigated included lumbar lordosis, sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), and C7 plumb line length (C7PL). The presence of ASD was determined radiographically by the development of adjacent scoliotic progression, adjacent disc space collapse, the development of spondylolisthesis > 4 mm, or adjacent segment subluxation or translation. Clinically, ASD was defined as symptomatic spinal stenosis, or back and leg pain related to the degenerated level.

Results: Of the 76 patients included in this study, 14 (18%) developed ASD. Seven patients were found to demonstrate ASD by 2-year follow-up, while another 7 developed ASD by the time of final evaluation. There was a statistically significant difference identified for post-operative PI, PT and C7PL in patients developing ASD compared to those who did not ($P < 0.001$). Pre- and post-operative sagittal plane imbalance, SS, pre-operative PT, and pre-operative PI were not found to be predictive of ASD.

Conclusion: An important correlation exists between spino-pelvic geometrics and the development of ASD in a treated surgically for adult scoliosis. Post-operative PI, PT and C7PL appear to be predictive of the potential for subsequent ASD.

Significance: Certain spino-pelvic parameters can be utilized as predictors of the risk for ASD in adult scoliosis patients following surgery. Assessing spino-pelvic alignment in the pre-operative period, as well as during the procedure appears important.

Paper #114

Thoracic Pedicle Subtraction vs. Smith-Petersen Osteotomies for Correction of Sagittal Plane Deformity: A Case-Matched Series

Brian Hsu, MB BS, FRACS (Children's Hospital at Westmead); Amir A. Mehbod, MD; Ensor E. Transfeldt, MD; Timothy A. Garvey, MD; Joseph H. Perra, MD; James D. Schwender, MD; Manuel Pinto, MD; Daryll C. Dykes, MD, PhD; Francis Denis, MD; John E. Lonstein, MD; Robert B. Winter, MD; Level of Evidence: III

Introduction: Pedicle subtraction and Smith Peterson osteotomies are commonly used in the correction of sagittal plane deformity. In this study, we compared the complications and outcomes of these procedures in the thoracic spine

Methods: Between 1985 to 2005, 322 patients underwent spinal osteotomy procedures. Included were adults having a sagittal plane deformity, a previous spine fusion, and at least a 2-year follow-up with adequate radiographs. Inclusion criteria were met by 151 patients. Thirteen patients who underwent a thoracic PSO (TPSO) and were matched with 13 patients who had a thoracic SPO (TSPO). The clinical charts and radiographs were reviewed and all complications recorded.

Results: The TPSO group (mean age 56.6) each had a 1 level procedure. There was a pneumothorax in 1 patient, MEP loss in 1 patient during removal of implants, chylothorax repair (1 patient) and 1 dural tear. Long-term complications included 2 patients with pseudarthrosis. The mean length of stay was 10.2 days (5-22). The mean EBL was 1970mls (675-4740). Two patients in this group had a concomitant anterior procedure. In the TSPO group (mean age 50), the mean number of levels was 2.38 per patient. One patient had a respiratory failure requiring re-intubation. Long-term complications included 2 patients with pseudarthrosis and 1 patient with failure of hardware requiring revision. The mean length of stay was 6.9 days (4-12). The mean EBL was 1872mls (150-5520). Six patients had a concomitant anterior procedure. TPSO had a higher segmental kyphosis correction (29 vs 19 deg). TSPO had a greater improvement of global thoracic kyphosis

* The FDA has not cleared a drug and/or medical device described in this presentation (i.e., the drug or medical device is being discussed in an off-label use). For full information see page 6.

correction (17 vs 12 deg). The C7 plumbline improvement was 28mm in TPSO and -10mm in the TSPO. This was due to 3 TSPO patients developing loss of correction

Conclusion: TPSO had a higher complication rate (31 vs 8%) and a longer hospital stay. TPSO is effective in managing segmental kyphosis without an anterior procedure and gives greater segmental kyphosis correction but to a lesser degree than Lumbar PSOs. TSPO are more effective in improving global thoracic kyphosis when performed over 2 or more levels

Significance: TPSO has a higher complication rate but provides better segmental kyphosis correction

Paper #115

Efficacy of Prophylactic Placement of Inferior Vena Cava Filter in Patients Undergoing Spinal Surgery

Mehmet Aydogan, MD; **Cagatay Ozturk, MD (Istanbul Spine Center)**; Levent Onat, MD; Kursat A. Ganiyusufoglu, MD; Sinan Karaca, MD; Azmi Hamzaoglu, MD; **Level of Evidence: III**

Introduction: In this study; we have tried to determine the data regarding efficacy for prophylactic IVCF placement in patients at high risk for pulmonary embolism (PE) following major spinal reconstruction.

Methods: 129 high-risk patients undergoing complex spine surgery was studied prospectively to evaluate the role of prophylactic filters in the IVC between 2005-2008. A matched cohort of 193 patients was reviewed retrospectively for the presence of PE between 1999-2005 receiving no IVCF. Criteria for IVCF placement were history of thromboembolism, history of co-morbidities like diabetes and hypertension, active smoking, obesity, history of previous spinal surgery, contraindication to anticoagulation therapy, malignancy, bedridden >2 weeks prior to surgery, staged procedures or multiple levels, combined anterior/posterior approaches, expected need for significant ilioacaval manipulation during exposure, and single-stage anesthetic time >6 hr. Postoperatively, all patients were followed up by continuous oxygen saturation monitoring and the saturation value of less than 95% alarmed us for the presence of PE that lead to contrasted spiral thorax computed tomography examination.

Results: In the spine surgery population of 193 patients treated between 1999 and 2005, we identified 8 patients who had a symptomatic PE (4.2%), which included two one died of a massive PE (0.5%). In the study group of 129 patients, the mean age was 67.5 years (range 56-80 years), and there were 32 men and 97 women. The symptomatic PE was seen in only 2 patients (1.5%) in IVCF group who responded well to medical treatment.

Conclusion: Pulmonary embolism is one of the most frequent causes of mortality after complex spine surgery with an occurrence rate of up to 6% and mortality rate of 1-2%. Prophylactic IVCF can play a significant role to reduce pulmonary emboli rate in a selected subgroup of patients undergoing complex spinal surgery compared with unused ones

Significance: Prophylactic IVCF can play a significant role to reduce pulmonary emboli rate in a selected subgroup of patients undergoing complex spinal surgery compared with unused ones.



San Antonio
Texas

Traditional Program Abstracts

Poster #1

** JOHN H. MOE AWARD NOMINEE FOR BEST BASIC SCIENCE POSTER

Is the Intraoperative H-Reflex a Viable Substitute for Transcranial Electric Motor Evoked Potential (tceMEP) Monitoring in Detecting Emerging Spinal Cord Injury during Scoliosis Surgery?

Daniel Schwartz, PhD (Surgical Monitoring Associates); *Vidya M. Bhalodia; Anthony K. Sestokas, PhD; John M. Flynn, MD; Suken A. Shah, MD; Peter G. Gabos, MD; J. Andrew Bowe, MD; John P. Dormans, MD*

Introduction: The intraoperative H-reflex has been advocated as a viable alternative to monitoring tceMEPs during scoliosis surgery. The neurophysiological basis for this claim is that H-reflex amplitude suppression reflects alterations in descending spinal cord influences on alpha motor neuron excitability and should thus correlate highly with tceMEP changes. This study compared the efficacy of H-reflex monitoring to tceMEPs and SSEPs in detecting emerging spinal cord injury during scoliosis surgery.

Methods: tceMEP, SSEP and H-reflex monitoring was attempted in 92 pediatric patients (X age=12.9 yrs) undergoing corrective scoliosis surgery. Type of scoliosis was idiopathic in 47, congenital in 23 and neuromuscular in 22 patients.

Results: Table 1 summarizes the percent success rate for recording a reliable intraoperative baseline for each monitoring modality according to type of scoliosis. Baseline H-reflexes were unobtainable in a large segment of non-idiopathic patients, particularly when compared to tceMEPs. 22 patients showed significant neuromonitoring changes. H-reflex loss was noted in 6/79. The H-response failed to improve with intervention in 5/6, none of whom awoke with neurologic deficit. Conversely, tceMEP alerts occurred in 18 patients. In 17 of these, amplitudes returned to baseline following intervention, and none awoke with a deficit. The remaining patient showed sustained unilateral tceMEP loss, without H-reflex or SSEP changes, and emerged with post-operative hemiparesis. The only SSEP change which also was coincident with a tceMEP alert was in a neuromuscular child in whom H-reflexes were unobtainable.

Conclusion: This study does not support the H-reflex as a viable substitute for tceMEP monitoring during scoliosis surgery. The low sensitivity is essentially the same as for SSEPs, and significantly less than tceMEPs for detecting emerging spinal cord injury. The value of H-reflex monitoring is limited further by the large percentage of non-idiopathic scoliosis patients for whom a baseline response is unobtainable.

Modality	Type of Scoliosis		
	Idiopathic	Congenital	Neuromuscular
tceMEP	100%	100%	91%
H-Reflex	100%	87%	54%
SSEP	100%	91%	77%

Significance: H-reflex monitoring is not recommended for routine use during scoliosis surgery and should not be considered a viable alternative to tceMEPs.

Poster #2

Growth Modulation of the Thoracic Cage in a Fetal Ovine Model: A Feasibility Study

Stefan Parent, MD, PhD (Sainte-Justine University Hospital Center) *Sarah Bouchard, MD; Denise Carrier; Peter O. Newton, MD*

Introduction: Congenital scoliosis and fused ribs can create a three-dimensional deformity affecting the normal thoracic growth and function resulting in thoracic insufficiency syndrome. The objective of this study was to develop an animal model to evaluate the effect of chest deformity on pre- and post-natal lung development and volume. There is currently no pre-natal animal model of chest wall deformity mimicking the thoracic insufficiency syndrome seen in humans available to study the impact of an expansion thoracoplasty.

Methods: Fetal surgery was performed in 8 ewes between 65 and 70 days gestation (term:140d) under anesthesia. Following exposure through a hysterotomy, a left thoracic deformity was created in 9 fetal lambs by either tying 3 ribs together or adding resection of the 7th rib in addition to partial destruction of

the vertebral body.

Results: All 9 lambs who underwent surgery were born at term through vaginal delivery and suffered from a scoliotic and thoracic deformity ranging from mild to severe (Cobb 10 - 70). They were all sacrificed at 2 months of age for necropsy except for one animal who died earlier from failure to thrive. The scoliotic and chest wall deformities were maintained during the post-natal period.

Conclusion: We have successfully created a model of congenital thoracic deformity that can be used to study the impact of the deformity on lung development and to evaluate treatment strategies. This novel approach is attractive because it could theoretically recreate a form of congenital scoliosis/thoracic insufficiency syndrome seen clinically very early in life.

Significance: Congenital human chest wall deformity represents a disease continuum that starts early during fetal life and progresses thereafter. Therefore, the detrimental impact of the thoracic deformity on lung development is established prior to birth. This animal model will allow the evaluation of thoracic growth modulation, the evaluation of lung development during normal growth and in the presence of a prenatal chest wall deformity, as well as the evaluation of the impact of different treatment strategies on the deformity as well as lung development.



Severe deformity created in utero

Poster #3

Failure and Success of Spinal Surgery in Patients with Parkinson's Disease - A Critical Case Series Review in Light of Sagittal Balance

Heiko Koller, MD (German Scoliosis Center); Juliane Zenner, MD; Axel Hempfing, MD; Stephen L. Ondra, MD; Tyler Koski, MD; Frank L. Acosta, MD; Luis Ferraris, MD; Oliver Meier, MD

Introduction: There are few data concerning biomechanical challenges spine surgeons face if treating patients with Parkinson's disease (PPD). We recognized PPD suffering spinal deformity aggravated by burden of PD stress the principles of sagittal balance if treated surgically indicating further investigation.

Methods: Retrospective series of 23 PPD treated surgically. ASA score was \emptyset 2.3. Outcome analysis included review of med records focusing on failure characteristics, complications & radiographic analysis of balance parameters.

Results: 15 fem., 8 male PPD w/ age \emptyset 66.3years at index surg, 67.9y at follow-up of \emptyset 14.5months; mid- to long-term (MLT) data available in 17 pat (73.9%). 10 pat (43.5%) presented w/ failed previous surg. 18 pat (78.3%) underwent multilevel surgery. 16 pat (69.6%) had fusion to S1-S2-Ilium. Med. complications occurred in 7 pat (30.4%), surgical in 12 pat (52.2%). Adjacent segment fractures occurred in 3 of 17 pat (17.6%) w/ MLT-data. Lumbar lordosis L1-S1 was 38.8°, 46.0° and 45.3°. C7-sagittal plumb-line was 12.2cm (8-57), 6.9cm and 7.6cm, resp. 3 of 17 pat (17.6%) had proximal junctional kyphosis (PJK >10°). 5 pat of 20 pat (25%) w/ MTL-data had a positive C7 off-set of >10cm, indicating revision in 4 cases (80%). 6 of 18 (33.3%) had any early perioperative or late revision after index surgery. Fusion was achieved in 10 of 17 pat (58.8%) with MLT-data. Number of patients satisfied/very satisfied was 15 of 17 (88.2%).

Conclusion: The surgical history of PPD treated for spinal disorder and the reasons indicating redo surgery for recalcitrant sagittal imbalance in our sample highlight the mainstays of surgery in PPD: If spinal surgery is indicated, reconstruction of spino-pelvic balance w/ focus on lumbar lordosis & global sagittal alignment is mandatory. If short segment surgery is scheduled in PPD w/ sagittal decompensated imbalance, failure of instrumentation, fusion & decompression is likely.

Significance: Treatment of spinal disorders in PPD is troublesome due to biomechanical challenges imposed by postural dysfunction due to neuromusc. disorder and sagittal imbalance. Besides focus on local disease, decision making in PPD has to address primarily concerns of global imbalance, frequently indicating fusion into the thoracic spine to succeed.

Poster #4

Modified Lenke Classification System for Infantile and Juvenile Idiopathic Scoliosis

Takuya Mishiro, PhD (Takamatsu Redcross Hospital); Lawrence G. Lenke, MD; Linda A. Koester, BS; Keith Bridwell, MD; Scott J. Luhmann, MD

Introduction: There is no universally acceptable system for the classification of infantile and juvenile (age 0 to 9+11) idiopathic scoliosis (IIS, JIS). We developed a new system for the classification of IIS & JIS by modifying the Lenke Classification System for adolescent idiopathic scoliosis (AIS).

Methods: 114 IIS/JIS patients (66 operative/48 nonoperative; 86 females/28 males) were included. Upright AP/lateral x-rays were obtained and measured. The proximal thoracic (PT), main thoracic (MT), and thoracolumbar/lumbar (TL/L) regions were designated as either the major curve (largest Cobb measurement, always structural) or minor curves which are determined to be either structural or nonstructural. Minor curve criterion for the MT curve-the apex is completely off the plumbline; and for the TL/L curve-the apex is completely off the center sacral vertical line (CSVL). Structural characteristics of the PT curve are designated by a Cobb angle of $\geq 35^\circ$ and the height of the bilateral 1st ribs (1st rib opposite the MT curve $\geq 3\text{mm}$ elevation for PT Cobb angle between $10\text{-}35^\circ$). If the PT Cobb angle is $< 10^\circ$, the curve is always nonstructural regardless of the 1st rib height.

Results: This produced the triad classification of curve types (1-6) combined with a coronal lumbar modifier (A, B, C) and a sagittal thoracic modifier (-, N, +) similar to the AIS classification system. Type 1 MT curves were found in 43.9% of cases (n=50), type 2 DT in 23.7% (n=27), type 3 DM in 2.6% (n=3), type 4 TM in 4.4% (n=5), type 5 TL/L in 21.1% (n=24) type 6 TL/L-MT in 4.4% (n=5). Lumbar modifier A was found in 64.0% of cases, B modifier in 17.5% C modifier in 18.4%. Sagittal modifier "-" was found in 11.4% of cases, "N" in 82.5% "+" in 6.1%. The 5 most common classifications include: 1AN (27.2%), 2AN (15.8%), 5AN (7.9%), 5CN (7.9%) 1A- (7.0%).

Conclusion: The classification system of IIS & JIS is based on a modified Lenke Classification System allowing for the classification from only upright AP and lateral x-rays, side-bending x-rays are not needed. The frequency of curve patterns is remarkably similar to the AIS population. The ultimate goal of this modified system is to allow the inclusion and organization of IIS & JIS curve patterns and objectively evaluate various treatment methods.

Poster #5

** JOHN H. MOE AWARD NOMINEE FOR BEST BASIC SCIENCE POSTER

Sequential Release of the Posterior Elements Increases Vertebral Rotation and Kyphosis Generation: A Cadaveric Study

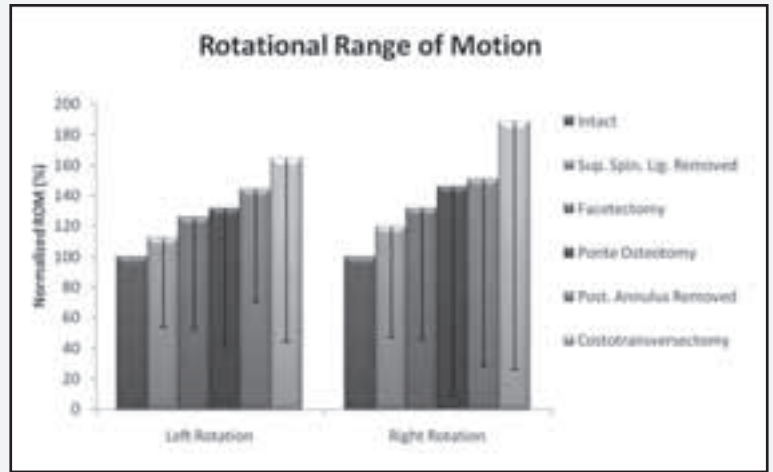
Suken A. Shah, MD (Alfred I. duPont Hospital for Children); William C. Tally, MD; Aditya Muzumdar, MS; Aditya Ingalkhalikar, MS; Mark Moldavsky, BS; Saif Khalil, PhD

Introduction: Most surgery for AIS is performed via a posterior-only approach with the advent of pedicle screw instrumentation. However, to establish spinal flexibility in rigid, severe curves and optimize correction, surgeons employ various posterior release techniques to derotate the spine and re-establish thoracic kyphosis. The aim of this study was to perform sequential releases of the posterior elements and quantify the subsequent increase in rotational motion and kyphosis generation.

Methods: Seven fresh frozen human cadaver spines with ribs intact (T3-L1) were thawed and dissected, avoiding disruption of spinal ligaments, facets and disks. The spines were fixed at T3 proximally and L1 distally and mounted on a 6 DOF spine simulator test frame. Load control protocol was used; an unconstrained pure moment of $\pm 5\text{Nm}$ was used for axial rotation. A total of three load / unload cycles were performed for each sequential posterior element release. Range of motion (ROM) was measured using the Optitrak Certus (NDI, Inc. Waterloo, Canada) motion analysis system. Markers were placed at T4, T5, T6, T7, T8, T9, T10, T11 and T12. The ROM for each release was compared with each other and with the intact specimen and normalized. Single factor ANOVA was run for different data groups at $p < 0.05$.

Results: An interval increase of vertebral rotational motion and kyphosis generation was seen after each subsequent posterior element release compared to the intact specimen (see graph below). The most significant rotational motion increases were observed after the Ponte osteotomy and costotransversectomy; mean increases of 139% and 177% over the intact specimen ($p < 0.05$), respectively. The middle segments (T7-T9) displayed the largest motion differences and the smallest differences were seen at the ends of the specimens, adjacent to the potted vertebrae.

Conclusion: Posterior element releases, both ligamentous and bony, result in sequential increases in spinal flexibility, vertebral derotation and kyphosis generation. The most significant motion increases were observed after the Ponte osteotomy and costotransversectomy. These findings support the use of posterior releases to correct severe curvatures, axially derotate the apex and re-establish thoracic kyphosis.



With sequential release of the posterior elements listed, right and left rotational motion in the specimens increased in a stepwise fashion.

Poster #6

Extension of Previous Fusions to the Sacro-Pelvis vs. Primary Spino-Pelvic Fusions in the Setting of Adult Deformity: A Comparison of Health Related Quality of Life Measures and Complications

Douglas C. Burton, MD (University of Kansas Medical Center); Khaled M. Kebaish, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Richard Hostin, MD; Alexis P. Shelokov, MD; R. Shay Bess, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarnia, MD; International Spine Study Group

Introduction: Patients previously treated with thoracolumbar fusion for spinal deformity may develop degenerative changes below the fusion requiring revision fusion to the sacro-pelvis. We evaluated the differences between patients undergoing revision extension of fusion vs. primary fusion, minimum 2-year fu.

Methods: The revision group (REVISION) included multicenter retrospective evaluation of 44 of 54 consecutive patients (1995-2006) that had a previous long fusion ending from L3-5, revised by extension fusion to the sacro-pelvis for symptomatic degeneration. The primary group (PRIMARY) included 20 of 20 consecutive patients prospectively enrolled (2000-2006) at a single center database that received primary long arthrodesis to the sacro-pelvis for adult deformity. Clinical and radiographic evaluation included demographics, coronal and sagittal measures, postoperative SRS-22 scores, and perioperative complications.

	PRIMARY Group (N=20)	REVISION Group (N=44)
Age (years)	59.2** (41 - 81)	48.5** (21 - 73)
Pre Op TL Cobb (°)	48** (23-87)	36*** (8 - 75)
Pre Op SVA (C7-S1 offset, cm)	0.0* (-4.0 - 14.0)	5.0* (-2.1 - 23.0)
Follow-Up Interval (months)	44.0* (25 - 97)	30.6* (24 - 135)
2-year TL Cobb (°)	17** (7 - 45)	30*** (5 - 56)
TL Cobb Correction (Pre Op - 2yr, °)	31**** (20 - 64)	2*** (-12 - 36)
2-year SVA (cm)	0.9 (-7.3 - 10.0)	2.6 (-6.9 - 10.0)
SVA Correction (Pre Op - 2yr, cm)	-0.4* (-8.5 - 7.0)	2.7* (-7.9 - 17.9)
2-year SRS-22r Score	3.12** (2.79 - 3.54)	3.80** (2.00 - 4.80)
Subjects with ≥1 complication	11 [†] (55% of group)	11 [†] (25% of group)

Non-parametric data, values reported as: median (range)
* p<0.05 ; ** p<0.01 ; *** p<0.001 between groups, 2-tailed Wilcoxon rank-sum test
† p=0.009 between groups, Pearson χ^2 test

Traditional Poster Abstracts

Traditional Poster Abstracts

Results: Mean patient age was 52 years (range 21-81 years). Mean follow up was 43 months (range 23-135 months). PRIMARY had greater median age (59 vs. 49 years; $p<0.01$) and longer follow up (44 vs. 31 months, $p<0.05$) than REVISION. PRIMARY had larger preoperative thoracolumbar curve (median TL; 48° vs. 36° ; $p<0.01$) and less sagittal imbalance (median SVA; 0.0 vs. 5.0 cm; $p<0.05$) than REVISION. Postoperative SVA was similar for PRIMARY and REVISION (median 0.9 vs. 2.6 cm, respectively; $p=0.25$). REVISION had better postoperative SRS-22 scores (median 3.80 vs. 3.12, $p<0.01$) and fewer patients with minimum one complication [11 (25%) vs. 11 (55%), $p<0.05$] than PRIMARY (Table 1).

Conclusion: Significant differences were demonstrated between patients undergoing primary vs. revision extension to the sacro-pelvis. PRIMARY were older, and had larger TL curves, whereas REVISION had greater sagittal imbalance. While PRIMARY had more complications, multiple factors could account for this other than surgery type, including differences in age or number of levels fused. The retrospective nature of the study may have also underrepresented minor complications. Although the groups were heterogeneous, radiographic, SRS-22 and complications analysis indicate revision extension to the sacro-pelvis compare favorably to primary fusion for adult spinal deformity.

Poster #7

Occipital Cervical Rigid Internal Fixation is Anatomically Feasible in Children Two to Six Years Old: A CT Study

Matthew J. Geck, MD (SpineAustin); Dana Hawthorne, BS; MPAS; Anthony Rinella, MD; Jason E. Lowenstein, MD; Timothy George, MD

Introduction: Occipitocervical fusion of the pediatric spine has traditionally been accomplished by the use of cabled grafts and halo fixation. However, rigid internal fixation offers biomechanical advantages and possible increased stability. This study evaluates the feasibility of rigid occipitocervical internal fixation in children 2 to 6 years old.

Methods: 50 head and cervical CT scans in pediatric trauma patients ages 2-6 years old were evaluated for the anatomy of the occiput, C1 lateral mass, C2 pedicle, C2 isthmus, C2 lamina, and a potential C1-2 transarticular path. Two separate spine surgeons assessed the feasibility of occipital cervical fixation in these patients.

Results: C1 lateral mass height/length was adequate for screw fixation ($>5\text{mm}$ width) in all 100 lateral masses. C2 pedicle fixation was considered feasible ($>4\text{mm}$ width/height) in 49 of 100 C2 pedicles, and difficult but possible (3.5-4.0mm) in 25 C2 pedicles. C2 lamina fixation was considered feasible ($>3.5\text{mm}$) in 99 of 100 C2 laminae. C1-2 transarticular screws were considered difficult but possible (3.5-4.0) in 4 of 100 sides. Either C2 bicortical pedicle or C2 lamina screws could be placed in 99/100 sides. There were age related differences in C2 pedicle height between the 2 and 6 year old patients ($p<0.02$). Occipital bone was thickest at the external occipital protuberance in all 50 posterior skulls. This was thicker in the 6 year olds (10.5mmSD1.0) than the 2 year olds (8.4mmSD1.2) ($p=0.005$). Thickness was at least 6 mm in 49 of 50 EOP, and at least 8mm in 42 of 50 EOP. Determination by both surgeons was that an occipital keel plate was feasible and the best fixation option in all 50 skulls.

Conclusion: In this CT feasibility study of 50 pediatric patients age 2-6 years old, occipital fixation with a midline keel plate was possible in all subjects and rigid internal fixation bilaterally at C1 was possible in all, and 49 of 50 could have had internal fixation bilaterally into either the C2 pedicle or the C2 lamina. In this age group, C1-2 transarticular screws were considered contraindicated in 96/100 sides.

Significance: This study demonstrates that internal fixation of the occiput, C1, and C2, is anatomically feasible in children 2-6 years old

Poster #8

Differences in Male and Female Spino-pelvic Alignment in Asymptomatic Young Adults - A Three-Dimensional Analysis Using Upright Low-Dose Digital Biplanar X-Rays

Michiel Janssen (Laboratoire de Biomécanique, École Nationale Supérieure d'Arts et Métiers ParisTech-CNRS) ; Xavier Drevelle; Ludovic Humbert; Wafa Skalli, PhD; René M. Castelein, MD, PhD

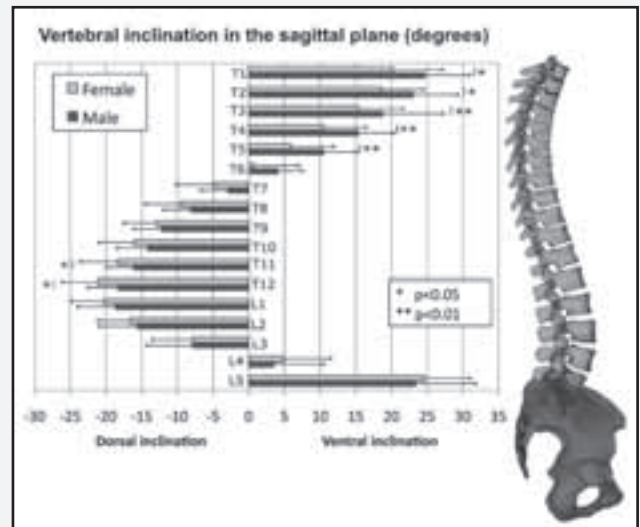
Introduction: Given the fact that some spinal disorders, such as idiopathic scoliosis but also Scheuermann's disease have sex-related prevalence rates, it is surprising that only a few studies have analyzed differences in the normal spino-pelvic alignment between the sexes. Moreover, no study has ever analyzed the differences in sagittal spinopelvic alignment and sagittal inclination of each individual vertebra between the sexes with an accurate 3D reconstruction technique. This is the primary goal. Additionally, in this age of instrumented spinal fusion and an emphasis on restoration of sagittal spinal balance, it is of great importance to have a set of reference values of normal spinal alignment in men and women.

Methods: Simultaneous biplanar radiographs from head to feet in a freestanding upright position were obtained of 30 asymptomatic women (mean age of 25 yrs, range 20-42) and 30 asymptomatic men (mean age of 27 yrs, range 21-49) using the EPS imaging device (Biospace Med, Paris). Subsequently, a 3D reconstruction of the bony shape of the spine, sacrum and pelvis was made by two observers using accurate reconstruction software. Independent samples t-tests were used to analyze differences in the spinal and pelvic parameters between the genders.

Results: Age and BMI was equally distributed between the sexes. The female spine was significantly more dorsally inclined (11° vs 8°; $P < 0.01$). High thoracic and thoracolumbar vertebrae were significantly more dorsally inclined in women (Figure). The inter and intra observer reliability were both excellent.

Conclusion: An important biomechanical consequence of our results is that the female spine is more subjected to dorsally directed shear loads (DDSLs). DDSLs make spinal segments less rotationally stable as was shown by Kouwenhoven et al. in a previous biomechanical study (Spine 2007). This signifies that certain areas may be less rotationally stable already in the normal female population, and may explain why progressive idiopathic scoliosis (under certain still undetermined circumstances during growth) occurs more in girls than in boys.

Significance: This study sheds new light on the well known predominance of girls with idiopathic scoliosis and the etiology of idiopathic scoliosis in general.



Mean vertebral inclination in the sagittal plane (and SDs) of T1-L5 in men (n=30) and women (n=30). All measurements are in degrees. Upper thoracic and thoracolumbar vertebrae are significantly more dorsally inclined in women.

Poster #9

Major Intraoperative Neurologic Monitoring Deficits in Consecutive Pediatric and Adult Spinal Deformity Patients at One Institution

Jonathan R. Kamerlink, MD (NYU Hospital for Joint Diseases); Thomas J. Errico, MD; Shaun Xavier, MD; Ashish Patel, MD; Amar Patel, BS; Alexa Cohen; Mark A. Rieger, MD; Joseph W. Dryer, MD; David Feldman, MD; Baron S. Lonner, MD; Aleksandar Beric, MD; Frank J. Schwab, MD

Introduction: Spinal deformity correction is a demanding realignment of the spine in which neurological monitoring can be used to reduce the risk of neurological deficits related to surgery. The purpose of this study was to assess the pre-op neurological risk in a consecutive series of spinal deformity patients undergoing correction surgery at one institution.

Traditional Poster Abstracts

Traditional Poster Abstracts

Methods: This is a retrospective consecutive review of deformity surgical cases at our institution in 2007. Patients were grouped according to diagnosis: Neuromuscular (NM) scoliosis, Sagittal plane deformity, and Scoliosis. There were 301 cases performed (154 pediatric and 126 adult), 281 cases were monitorable. Intra-operative neurological status was measured with a combination of somatosensory evoked potentials (SSEPs) and/or motor evoked potentials (MEPs).

Results: Comparing each diagnostic criteria and primary vs. revision status, primary NM scoliosis cases had the highest incidence of NMC's (11%). In patients with primarily sagittal plane deformity, NMC's were increased in the setting of larger kyphosis (58° vs. 42°, $p < 0.05$), larger operative change in lumbar lordosis (16.4° vs. 3.9°, $p < 0.05$), and increased blood loss (2.5L vs. 1.6L, $p < 0.05$). Sagittal plane deformity cases had the second highest incidence of NMC's (10.87%). In scoliosis patients, significant increases in NMC's were found with larger pre-operative thoracolumbar/lumbar curves (50.4° vs. 31.5°, $p < 0.05$) and larger blood loss (1.95L vs. 989mL, $p < 0.05$). However, revision surgery did not appear to significantly affect NMC's in this group ($p < 0.05$). Of the 13 NMC's patients, 3 patients had persistent neurological deficit detected by post-operative neurological examination; one patient had a resolving foot drop, one patient had motor paraplegia that improved to walker assisted ambulation, and one patient had a partial foot drop that completely resolved.

Conclusion: Primary neuromuscular scoliosis and revision sagittal plane deformities appear to carry greatest risk for NMC's during surgical intervention. Most observed NMC's did not predict a permanent neurological deficit.

Significance: This study may aid surgeons and patients to better assess neurological risks related to spinal deformity surgery.

Diagnosis	Surgery	NMC	No NMC	Total	Percentage of NMC for each diagnosis
NM Scoliosis	Primary	3	27	30	11.11%
	Revision	0	10	10	0.00%
Sagittal Plane	Primary	0	10	10	0.00%
	Revision	5	46	51	10.87%
Scoliosis	Primary	5	147	152	3.40%
	Revision	0	20	25	0.00%
Pediatrics		6	148	154	4.05%
Adults		7	119	126	5.88%

Poster #10

** JOHN H. MOE AWARD NOMINEE FOR BEST BASIC SCIENCE POSTER

Comparative Study of Pressure and Blood Flow of the Multifidus Muscle during Muscle Retraction between Single Midline and Combined Wiltse-Midline Approach Using a Rat Model

Nakayuki Kato, MD (Dokkyo Medical University School of Medicine); Hiroshi Taneichi, MD; Satoshi Inami, MD; Takashi Namikawa, MD; Daisaku Takeuchi, MD; Chizuo Iwai, MD; Kanako Shiba, MD; Yutaka Nohara, MD

Introduction: The purpose of this study was to compare pressure and blood flow of the multifidus muscle (MM) during muscle retraction between single midline and combined Wiltse-midline approach using a rat model.

Methods: Total of 25 Wistar rats were used. In 12 of them, posterior midline exposure to the transverse processes of L5-6 was done and maintained by a retractor with pressure sensor for 2 hours (Group M). In the remaining 13 rats, Wiltse approaches for lateral exposure were added to the midline approach (Group W). Retraction time for Wiltse and midline approach in Group W was 1 hour each. Blood flow of MM was measured by a laser blood flowmeter.

Results: A mean muscle pressure (g/cm²) was 243 in Group M, 68 in midline of Group W, and 70 in Wiltse of Group W. A mean blood flow (ml/min/100g) was 4.0 in Group M, 7.1 in midline of Group W, and 6.3 in Wiltse of Group W. An average pressure-time product (g/cm² x min) was much higher in Group M (29105) than in Group W (6081) ($p < 0.001$).

Conclusion: Combined Wiltse-midline approach can reduce back muscle pressure and preserve blood flow during muscle retraction.

Poster #11

** JOHN H. MOE AWARD NOMINEE FOR BEST BASIC SCIENCE POSTER

Maximizing Anterior Vertebral Screw Fixation for Spinal Growth Tethering

Eric S. Varley, DO (University of California, San Diego); *Christine L. Farnsworth; Tucker Tomlinson, MS; Claire J. Robertson, BS; Thomas Nunn, BS; Vidhadhar V. Upasani, MD; Peter O. Newton, MD*

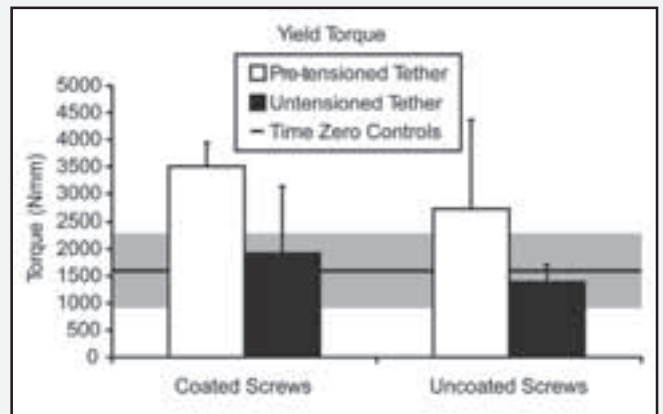
Introduction: Anterolateral spinal column tethering may provide a non-fusion treatment for idiopathic scoliosis. Intra-operative tether tensioning, desirable for immediate deformity correction, may lead to early screw loosening while hydroxyapatite (HA) screw coating may encourage osteo-integration. The aim of this study was to determine the effects of tether tensioning and HA coating on vertebral body screw fixation as measured by screw extraction torque.

Methods: 7 mo-old mini-pigs (n=8) were instrumented anteriorly with screw-staple constructs from T8-T11. Flexible UHMWPE tethers, connecting the 4 screws, were pre-tensioned to 250N (n=4) or not (n=4). Screws were either uncoated (n=4) or coated with HA (n=4). After 12 mos, spines were harvested from T6-T13. Uncoated screws, placed in T6-T7 and T12-T13, served as time zero (T0) controls. Spines were affixed in a bi-axial MTS testing machine with the screw and loading piston axes aligned. Screws were rotated out at a constant rate (0.1°/sec) to a maximum angulation of 30°. Torque and angulation data were processed for yield torque and the angle of yield. The groups were compared with a two-way ANOVA with vertebral level as a covariate (p<0.05) to examine the effects of coating the screws and tensioning the tether. Comparisons to T0 with a one-way ANOVA (p<0.05) evaluated changes with time.

Results: Tensioning produced an initial deformity. All spines developed progressive coronal deformities to 27° over 12 mos. Tensioning increased screw extraction yield torque and yield angle (p<0.001, p<0.05). HA coating increased yield angle (p<0.05) and had a near significant effect on yield torque (p=0.09). T0 screws had lower yield torque than either the HA tensioned or the uncoated tensioned screws (p<0.001, p<0.05). Un-tensioned groups had similar yield torques to the T0 group (p=0.9, p=0.9). T0 screws had a lower yield angle than HA tensioned screws (p<0.05).

Conclusion: Tether tensioning improved screw fixation, perhaps by enhancing biologic responses to greater forces at the bone-screw interface. HA coating had a mild impact on fixation.

Significance: Pre-tensioning an anterolateral tether might seem to increase early screw loosening. In fact, the additional mechanical loading led to improved screw-bone integration.



Poster #12

Biomimetic Calcium Phosphate Coatings as Bone Morphogenetic Protein Delivery Systems in Spinal Fusion

Kamran Majid, MD (William Beaumont Hospital); *Kevin Baker, MS; Michael Tseng, MD; Jeffrey Fischgrund, MD; Harry Herkowitz, MD*

Introduction: Currently, BMP-2 is delivered by soaking a collagen sponge in an aqueous solution of the protein immediately prior to implantation. This physical adsorption of BMP results in poor binding, which leads to rapid diffusion away from the carrier upon implantation. Rapid diffusion yields an initial burst of BMP-2 at the fusion site, which tapers off significantly in the immediate postoperative period. A method by which the BMPs can be delivered in a sustained, localized fashion was developed. The method involves the incorporation of BMPs within the physical structure of a calcium phosphate (CaP) coating, which can be biomimetically deposited on implant surfaces.

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Methods: Collagen sponges (Healos) were coated with biomimetic CaP film (Group 1), CaP film with adsorbed BMP-2 (Group 2), hybrid CaP+BMP-2 film (Group 3) or hybrid CaP+BMP+2 film plus adsorbed BMP-2 (Group 4). Eighteen New Zealand White Rabbits underwent L5-L6 posterolateral spinal fusion. At 6 weeks, animals were sacrificed. Degree of fusion was assessed using weekly radiographs, manual palpation, CT scans and histology.

Results: Solid fusion was demonstrated in groups 2, 3, and 4. Groups treated with adsorbed BMP-2 (Group 2 and 4) showed extension of the fusion mass to adjacent levels. These groups also showed a more extensive osteoclastic response on both CT and histology. (Figure 1) Animals treated with sponges that had incorporated BMP-2 did not show adjacent level extension of the fusion mass and showed little osteoclastic activity.

Conclusion: This study established the equivalence of the hybrid CaP+BMP-2 coatings to the current best practice of physical adsorption of BMPs. This study suggests that incorporation of BMP-2 within a CaP coating may aid in localization of bone growth and reduction in osteoclast-mediated bone resorption.

Significance: 1. Delivery of rhBMP-2 via incorporation within calcium phosphate coatings can enhance the rate of spine fusion. 2. Less bone resorption was observed during CT analysis in connection with rhBMP-2 that had been incorporated within calcium phosphate coatings.

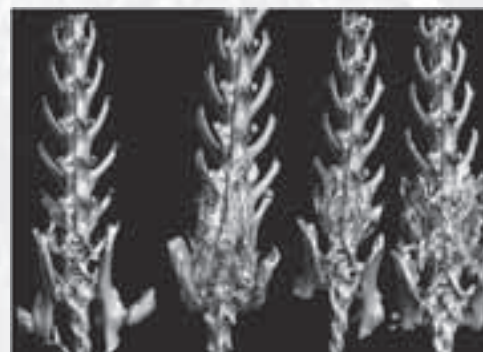


Figure 1. Three dimensional reconstruction images of computed tomography scans performed on representative spines from treatment groups 1-4 (from left to right).

Poster #13

Natural History of Adolescent Idiopathic Scoliosis of 50° or Greater at Maturity: Rate of Progression and Functional Outcomes

Megan K. Raverty, BA (University of Minnesota Medical School); Amir A. Mehbod, MD; Joseph N. Perra, MD; Timothy A. Garvey, MD; Ensor E. Transfeldt, MD; James D. Schwender, MD; John E. Lonstein, MD; Robert B. Winter, MD

Introduction: Curve progression in AIS is said to depend upon skeletal maturity and curve magnitude. Studies have asserted that curves 50° or greater are at the highest risk for complications and progression after maturity. No current studies with long-term follow up have examined only patients with curves of 50° or greater at skeletal maturity. We sought to identify the radiographic and functional outcomes of these patients.

Methods: Records from a tertiary spine center were reviewed to identify patients with a primary diagnosis of AIS with a curve magnitude of 50° or greater at skeletal maturity without surgical intervention and a minimum 10-year follow up. Patients underwent new radiographs and completed a series of questionnaires. Radiographs and clinical data at skeletal maturity were examined and compared with the recent follow up data. Data was compiled to determine curve progression after maturity and functional outcome.

Results: There were nineteen patients with an average follow up of 27 years. At maturity, average curves were 34° for upper thoracic, 52° for thoracic and 48° for lumbar. Four patients underwent surgical treatment after maturity. The remaining 15 patients averaged 45° for upper thoracic, 71° for thoracic and 60° for lumbar curves at current follow up. Average curve progression in degrees per year was 0.4 for upper thoracic, 0.5 for thoracic and 0.5 for lumbar curves. Follow up Oswestry and Roland-Morris scores averaged 11.1 and 4.5 respectively for non-surgical patients, compared to 16.5 and 5 for surgical patients.

Conclusion: Average curve progression in curves greater than 50° was 0.5 degrees per year at an average 27 year follow up for those not requiring surgery. Functional outcomes of patients treated surgically after maturity were similar to those who did not have surgery. A larger series would be required to determine statistical significance of these trends, but this patient population is limited by current standards for surgical intervention.

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Significance: This study suggests that curve progression in AIS greater than 50° may be smaller than previously demonstrated.

Poster #14

Validation Trials of a DNA-Based Prognostic Test (AIS-PT) Designed to Predict Curve Progression in Adolescent Idiopathic Scoliosis Patients

Kenneth Ward, (Axial Biotech, Inc.); Marc V. Singleton, MS; Therese Berry, BS; Lesa M. Nelson, BS; James W. Ogilvie, MD

Introduction: We developed a DNA Prognostic Test (AIS-PT) using a panel of 53 DNA markers associated with curve progression and logistic regression. The goal of this study was to validate the negative predictive value of AIS-PT in the intended use population.

Methods: Two separate retrospective trials were conducted. The first trial included 379 skeletally mature subjects (306 females and 73 males) who had mild AIS (<25° primary curve) initially documented prior to the age of 13. The cohort was selected to mirror referrals from a school screening program so that 80-85% had a curve that remained mild or improved, 10-12% progressed to moderate scoliosis, and 2-4% required fusion. Patients for the second trial (341 females and 61 males) were selected to mirror the cohort of new patients presenting to a referral center (60-65% had a curve that remained mild or improved, 20-25% progressed to moderate scoliosis, and 10-15% required fusion). Ratios for this second study were determined using patient acuity data from 20 representative spine centers. Progression to a severe curve was defined as progression to a >40° curve in an individual still growing or progression to a >50° curve in an adult. AIS-PT scores were calculated (blinded to the clinical data) through Taqman genotyping of all subjects the 53 DNA markers and the prognostic algorithm.

Results: Both trials confirm the sensitivity and specificity of the AIS-PT (see table below). The negative predictive value in Caucasian females was 100% in the "screening" population and 99% in the "high acuity" population. As expected, a smaller percentage of patients were scored as "low risk" in the high acuity trial.

Conclusion: The DNA-based AIS-PT offers outstanding negative predictive value in the intended use population. AIS-PT offers prognostic information not presently.

Significance: AIS prognostic test could reduce inefficiencies in the management of mild scoliosis patients allowing cost savings and reduced x-ray exposure for many patients.

	Sensitivity AISPT Score<40 cut-off	Specificity AISPT Score<180 cut-off	Subjects Scored as Low Risk	Negative Predictive Value AISPT Score<40 cut-off
Research Data (n=2192)	85% (84-85%)	99% (99-100%)	NA	NA
Clinical Trial 1 (n=277)	100% (74- 100%)	99% (99-99%)	64%	100% (99- 100%)
Clinical Trial 2 (n=281)	93% (82-98%)	98% (97-99%)	54%	99% (98-100%)

Table 1: Sensitivity/Specificity and Negative Predictive Value in an intended use population: Female Caucasian data (95% confidence limits shown in parentheses)

Poster #15

Longer Surgical Times May Increase Your Complication Rate

Suken A. Shah, MD (Alfred I. duPont Hospital for Children); Peter O. Newton, MD; Baron S. Lonner, MD; Randal R. Betz, MD; Tracey Bastrom, MA; MA; Michelle C. Marks, PT, MA; Harms Study Group

Introduction: Major spinal deformity surgery is stressful on the patient due to prone positioning, blood loss, fluid shifts, anesthetic effects and autonomic deregulation. Longer duration of surgery may lead to adverse outcomes as the patient's reserves are exhausted. The purpose of this study was to examine duration of surgery as a variable on the incidence of complications.

Methods: From a multicenter, prospectively enrolled database, patients who underwent surgery for AIS with greater than 2 year follow up were reviewed for surgical time and complications. A secondary review of all cases was performed to ensure completeness and accuracy of complications. Using a histogram analysis of

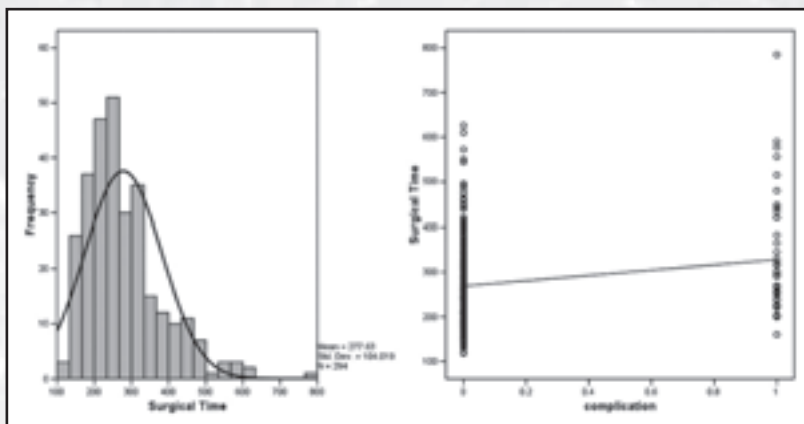
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surgical time, long duration of surgery was defined as > 420 minutes and cases were grouped (I - greater than 420 min and II - less than 420 min) and analyzed.

Results: Patients in Group I (28/289) experienced 9 complications: wound infections/dehiscence (4), implant-related (3), neurologic (1) and excessive blood loss (1) for a rate of 32.1%. Patients in Group II (261/289) had 24 complications for a rate of 9.2%. This difference in complication rate related to surgical time was significant (Chi Square $p=0.002$). There was no significant difference in the preoperative demographics of the groups with regard to curve magnitude or co-morbidities.

Conclusion: Surgical duration of greater than 420 minutes resulted in an increased complication rate of 32.1%, a rate 3.5 times higher than cases less than 420 minutes (9.2%). The most frequent complications were wound issues, implant-related problems, neurologic events/alerts and excessive blood loss. Although complex procedures may have long operative times and an increased complication rate in and of themselves, this data may be useful in counseling the patient/family and perhaps in staging procedures when appropriate.

Significance: In this otherwise healthy population of AIS patients, duration of surgery > 420 minutes was seen to adversely affect outcomes.



Histogram illustrates distribution of surgical time for 289 cases. Scatterplot shows a correlation of complications with increasing surgical time.

Poster #16

Postoperative Superior Mesenteric Artery Syndrome (SMA) is Rare in Contemporary Adolescent Idiopathic Scoliosis (AIS) and Associated with Preop Hypokyphosis, Correction of Thoracic Hypokyphosis and Fusion to L4.

John B. Emans, MD (Harvard Medical School); David W. Polly, MD; John P. Lubicky, MD; David P. Roye, MD; Andrew G. King, MD; Mark A. Erickson, MD; Spinal Deformity Study Group

Introduction: SMA in AIS is well reported in the historical literature with an incidence of 1.1% of AIS surgery by our meta-analysis. Previously cited risk factors include staged procedures, low body mass index (BMI), thoracic kyphosis, pre-operative curve stiffness, Lenke B and C modifier, hyperlordosis, and large curve correction. It remains unclear whether contemporary surgical treatment of AIS, with presumed shorter hospitalizations, less immobilization and greater curve correction without distraction has increased or decreased the incidence of SMA in AIS or changed the risk factors.

Methods: Analysis of pre- and post-operative characteristics of 1316 patients with AIS included in a prospectively collected contemporary database.

Results: Seven of 1316 (0.53%) patients developed SMA post-op, one-half the historical rate of 1.1%. All resolved with non-operative treatment. Pre-operative mean T2-T10 kyphosis was significantly lower for SMA pts. (13.9 deg. vs. 29.9 deg., $p=0.0034$). Correction of thoracic hypokyphosis was significantly greater for SMA pts. (16 deg. vs. 1.2 deg. $p=0.0025$). Last instrumented vertebra (LIV) at L4 was more common in SMA patients (88% vs. 9%). Mean BMI for SMA pts. was lower than those without SMA (19.3 vs. 21.7, $p=0.21$) but was not statistically significant. However for age-matched BMI, one SMA patient was below the 10th percentile and one below the 5th percentile for age. No trends or statistically significant differences were seen in anterior/posterior versus posterior only surgeries, age, preoperative curve magnitude or coronal curve correction, preoperative T12-L2 alignment, operative change of T10-L2 alignment, Lenke curve type, Lenke lumbar curve modifier A,B, or C, blood loss.

Conclusion: SMA syndrome is a less common complication (0.53%) in this group of contemporary AIS surgery

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than in historical series. Pre-op T2-T10 hypokyphosis, correction of hypokyphosis, LIV at L4 and possibly low BMI correlated with increased risk of SMA syndrome.

Significance: SMA prevalence and risk factors in AIS appear to have changed with contemporary surgical methods.

Poster #17

Surgery Before Age Nine in Patients with Early Onset Spinal Deformities: Effects on Thoracic Dimensions

Federico Canavese, MD; Jonathan Sembrano, MD; Charles D'Amato, MD (Shriners Hospital)

Introduction: Patients with severe congenital or idiopathic early onset spinal deformities are commonly smaller and slower to grow than normal. It has been showed that pelvic inlet width measured by computerized tomograms or plain radiographs is an age-independent predictor of the expected thoracic dimensions in unaffected children and adolescents. The specific aim of the present study is to describe the thoracic dimensions observed at maturity in our patients who had fusion of the thoracic spine prior to age nine and to compare them to expected normal values.

Methods: Twenty one patients (11 females, 10 males) with early onset spinal deformities were surgically treated before age nine. By using standard AP and lateral radiographs of spine, thoracic spine height (Th), lumbar spine height (Lh), trunk height (TRh), pelvic width (PW), chest width (CW), chest depth (CD) were measured and compared to established normal reference values referenced to PW. Pulmonary Function Tests (PFT) are reported for 10 patients.

Results: Average age at initial surgery was 5.9 years (range: 1.2 to 8.2). Nine patients were treated with a posterior spinal fusion and twelve had anterior and posterior surgery. The average number of levels fused was 10 (range: 2 to 17). All patients were reviewed at skeletal maturity and the average follow up was 11.6 years (range: 5 to 18.8). Patients were noted to have shortened height, short trunk and disproportionate body habitus. Th, Lh, CW and CD observed values were reduced compared to the expected norms (Table 1). The ratio between CW and CD was below normal values.

Table 1. Observed PW; observed and expected CW, CD, Th, Lh, TSh in both male and female patients

Patient	Sex	PW	Expected CW	Observed CW	Expected CD	Observed CD	Expected Th	Observed Th	Expected Lh	Observed Lh	Expected TSh	Observed TSh
1	F	14.3	25.1-32.7	21.8	13.5-19.1	9.2	26.9-33.4	20.6	16.3-20.2	15.7	43.4-53.4	36.3
2	F	14.1	25.1-32.7	26.8	13.5-19.1	6.3	26.9-33.4	25	16.3-20.2	14.8	43.4-53.4	39.8
3	F	14	25.1-32.7	21.6	13.5-19.1	9.6	26.9-33.4	15.7	16.3-20.2	11	43.4-53.4	26.7
4	F	12.6	21.7-29.3	27.6	11.6-17.1	10.7	23-29.4	23.8	13.8-17.6	11.3	36.9-46.8	35.1
5	F	13.7	23.4-31	16	12.6-18.1	8.8	24.9-31.4	17.3	15-18.9	12.1	40.2-50.1	29.4
6	F	13.2	23.4-31	21.4	12.6-18.1	11.3	24.9-31.4	20.9	15-18.9	17.7	40.2-50.1	38.6
7	F	12.7	21.7-29.3	24.7	11.6-17.1	10.5	23-29.4	25.8	13.8-17.6	18.8	36.9-46.8	44.6
8	F	10.3	18.3-25.8	20.1	9.7-15.1	8.8	19-25.5	17.1	11.2-15	13	30.4-40.3	30.1
9	F	11.1	20-27.6	19.9	10.6-16.1	11.5	21-27.4	18.9	12.5-16.3	8.4	33.7-43.6	27.3
10	F	10.1	18.3-25.8	20.1	9.7-15.1	8.6	19-25.5	7.7	11.2-15	8.1	30.4-40.3	15.8
11	F	8	14.8-22.4	23	7.7-13.2	7.8	15.1-21.5	22.6	8.6-12.5	14	23.9-33.8	36.6
12	M	11.4	21.8-29.3	21.6	11.6-17.1	8.5	22.5-29	18.3	13.2-17.1	11.2	35.9-45.8	29.5
13	M	12.6	23.5-31.1	25.6	12.6-18.1	8.2	24.5-30.9	15.1	14.5-18.4	9.5	39.2-49.1	24.6
14	M	12.1	23.5-31.1	22.1	12.6-18.1	7.1	24.5-30.9	14.6	14.5-18.4	13.8	39.2-49.1	28.4
15	M	12.2	23.5-31.1	25.4	12.6-18.1	7.1	24.5-30.9	21.2	14.5-18.4	14.5	39.2-49.1	35.7
16	M	12.3	23.5-31.1	26.4	12.6-18.1	10.5	24.5-30.9	22.3	14.5-18.4	17.8	39.2-49.1	40.1
17	M	14.6	26.9-34.5	21.4	14.5-20.1	8.5	28.4-34.9	17	17.1-21	15.5	45.7-55.7	32.5
18	M	16.3	>34.5	24.5	>20.1	9.1	>34.9	24.8	>21	14.4	>55.7	39.2
19	M	11.1	21.8-29.3	19.6	11.6-17.1	8.2	11.6-17.1	17	13.2-17.1	11.6	35.9-45.8	28.6
20	M	12.4	23.5-31.1	29.2	12.6-18.1	10.1	24.5-30.9	34.5	14.5-18.4	12.5	39.2-49.1	34.5
21	M	11.6	21.8-29.3	24.4	11.6-17.1	9.5	11.6-17.1	15.4	13.2-17.1	16.9	35.9-45.8	32.3

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Conclusion: Patients with early onset scoliosis treated before nine years of age have significantly reduced TRh, Th, Lh and thoracic dimensions. The thorax becomes elliptical as the anteroposterior dimension grows less than the lateral dimension. Pelvic width which appears to be unaffected by spinal deformity or spinal surgery and can be used as an age independent reference to compare observed thoracic dimensions to those that would have been expected in an individual patient.

Significance: Retrospective, comparative case series.

Poster #18

Indications and Practice of Growing Rods: Characterizing Current Use

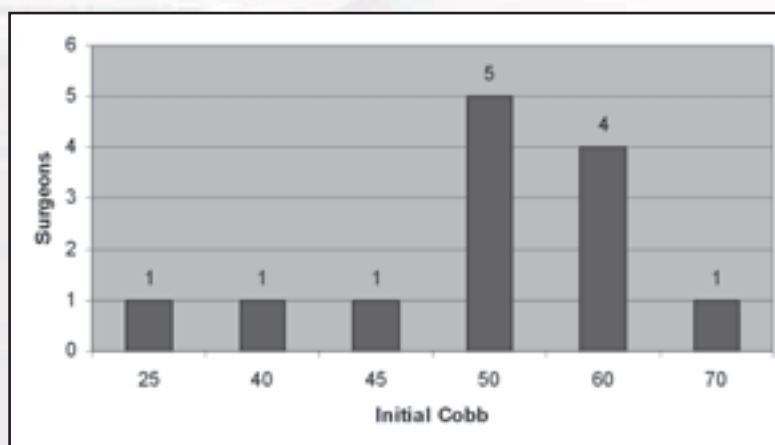
Justin S. Yang, BS; Paul Sponseller, MD (Johns Hopkins Medical Institution); Behrooz A. Akbarnia, MD; George H. Thompson, MD; Pat Kostial, RN, BSN; Pooria Salari; John B. Emans, MD; David L. Skaggs, MD; Muharrem Yazici, MD; Suken A. Shah, MD; Marc Asher, MD; Growing Spine Study Group

Introduction: There is little data on current practice of Growing Rod (GR) treatment. This study characterizes practice among surgeons.

Methods: A multinational group of 16 GR surgeons completed questionnaires about their surgical indications and techniques. The Growing Spine database of 322 patients was analyzed to compare this to actual practice.

Results: Curve size was the most common determinant for initiating GR treatment (12/16), with most surgeons (9/12) setting the minimal curve at 50°-60°. In the database, the average preop curve was 72°±17°, with 88% of patients >50°. Curve rigidity was also a common indication (7/16). Other indications included brace intolerance (5/16) and diagnoses such as NF1 (2/16). The diagnoses in the database were 76 neuromuscular, 75 syndromic, 66 infantile idiopathic, 49 congenital, 9 NF-1 and 47 others. The oldest skeletal age at which surgeons would initiate GR treatment in was 8-10 years (13/16). In the database, the mean initial age is 6±2.5y, with 97% of patients <10 years at GR insertion. Diagnoses considered by some to be contraindications to GR included myelomeningocele (3/16), severe kyphosis (2/16) and chest wall deformities (2/16) but some surgeons considered none of these to be contra-indications (5/16). Most surgeons prefer lengthening every 6 months (12/16). Five surgeons had experienced familial resistance towards regular lengthenings. Scheduling of lengthening was done by family in 7 practices, surgeon in 6 and in 3 practices both. In the database, mean lengthening interval was 9.6±2 months. The most common indication for final fusion was skeletal maturity (13/16); 6/11 surgeons use Risser 4. Other indications for final fusion included complications: infection or implant failure (13/16), curves progressing >90°(7/16), and failure to distract (6/13). In the database, the average age at final fusion was 12±2.1y after mean 3.8±2.2 lengthenings.

Conclusion: Practice variation exists in GR treatment. There is some consensus on indications for GR surgery including curve size, flexibility, diagnosis and age. The most common stated lengthening interval is every six months, but in practice this is not met.



Minimum Cobb criteria for starting growing rod treatment

Poster #19

Tryptase Expression as a Marker of Lung Injury During Thoracoscopic Surgery: A Porcine Model of Single Lung Ventilation

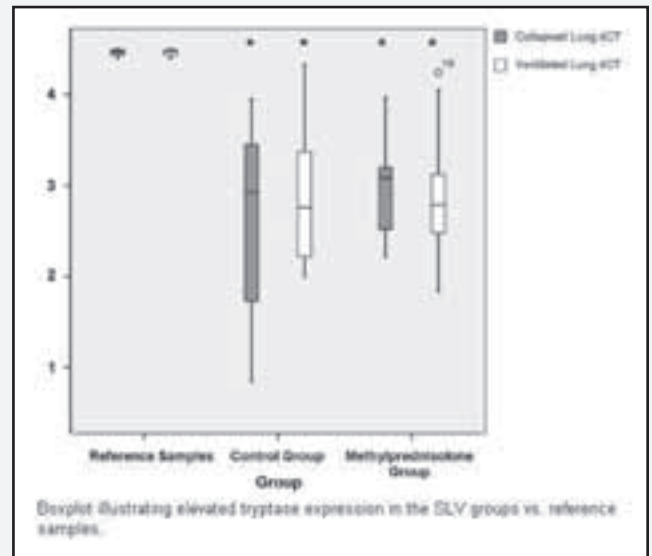
Suken A. Shah, MD (Alfred I. duPont Hospital for Children); Alicia Olivant Fisher, MD; Jillian Heck, BS; Prof. Thomas H. Shaffer, MS.E, PhD; Mary C. Theroux, MD

Introduction: Single lung ventilation (SLV) procedures such as thoracoscopic anterior growth modulation, release, fusion and instrumentation are commonly used for the treatment of pediatric and adolescent spinal deformity. These procedures are known to cause pulmonary injury and have been associated with elevated serum tryptase levels. Methylprednisolone may be useful to attenuate pulmonary injury. The hypotheses of this study were that serum tryptase is a useful marker of lung injury and that premedication with methylprednisolone would ameliorate pulmonary injury during these procedures.

Methods: Twenty juvenile piglets were assigned to either the control (C; n=10) or methylprednisolone pretreatment (MP; n=10) group and subjected to three hours of single lung ventilation. Following the experiment, lung tissue was harvested and tested for genetic expression of tryptase. Tryptase expression levels were compared between lungs, between groups and between both groups and normative reference samples.

Results: There was no difference in the mean tryptase expression levels between animals in the control and treatment groups ($p = 0.44$). Both groups, when compared with normative reference samples, had significantly elevated tryptase expression in both collapsed (C: $p = 0.006$, MP: $p = 0.029$) and ventilated (C: $p = 0.011$, MP: $p = 0.012$) lungs. The collapsed lung in the control group had significantly greater variability when compared to the collapsed lung in the treatment group ($p = 0.011$).

Conclusion: Varying degrees of injury are associated with SLV, likely related to the duration of the procedure and the amount of manual manipulation of the collapsed lung. Tryptase may be useful as a marker of lung injury related to SLV procedures. A low dose of methylprednisolone (2 mg/kg) may be clinically useful to reduce the amount of tryptase released in the collapsed lung. This reduction in tryptase expression might be sufficient to prevent an intraoperative adverse event such as bronchospasm or cardiovascular collapse. In addition, clinicians should be aware of the potential for elevated tryptase levels due to mast cell activation or mechanically-induced degranulation. Further study in children is warranted before use of methylprednisolone can be recommended clinically.



Boxplot illustrating elevated tryptase expression in the SLV groups vs. reference samples.

Poster #20

All Pedicle Screw Instrumentation for Scoliosis Correction in Marfan Syndrome. Is it Worth It?

Wael Koptan, MD (Cairo University Hospital) Yasser ElMiligui, MD; Wael Hammad, MD

Introduction: Spinal deformities are common in Marfan syndrome and have long been treated by instrumentation with a hybrid construct using hooks, sublaminar wires and pedicle screws. All pedicle screw constructs are currently widely used in the treatment of spinal deformities and accurate evaluation of this recent application in Marfan patients is necessary. The aim of this work is to compare the results of segmental all pedicle screw constructs versus hybrid instrumentation analyzing the amount of correction achieved, clinical outcome and the incidence of complications.

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Methods: The results of 27 patients with Marfan syndrome surgically treated between 1998 and 2006 were retrospectively reviewed. Twenty five patients were followed-up for a minimum of 2 years; an average of 4.5y (range 2 - 7y). They included 13 consecutive patients corrected by segmental all pedicle screw constructs (Group 1) and compared to an earlier series of 12 instrumented with a hybrid construct (Group 2). The average age was 16y+1m and 15y+4m respectively. The average preoperative scoliosis was 65.5 degrees (Group 1) and 59.1 degrees (Group 2).

Results: Correction was significantly better in Group 1 with an average of 73.1% postoperatively and 1.5% correction loss at final follow-up compared to Group 2 where correction was 62.9% postoperatively and 3.1% correction loss at final follow-up. The average operative time and blood loss were considerably less in Group 1 with an average of 4.45 h and 570 cc than Group 2 with an average of 6.15 h and 890 cc respectively. Group 2 patients had a longer hospital stay and had 6 complications in 6/12 patients (50%).

Conclusion: A better correction of scoliosis can be achieved in Marfan syndrome patients by multiple levels all pedicle screws technique; with significantly less operative time, blood loss, hospital stay and complications.

Poster #21

Evaluation of rhBMP-2/Fibrin Glue-Associated Edema in Rabbit Muscle Tissue

Emily M. Lindley, PhD; Susan Estes, NP; Evalina L. Burger, MD (University of Colorado, Denver); Vikas V. Patel, MA, MD

Introduction: Recombinant human bone morphogenetic protein type-2 (rhBMP-2) is an osteobiologic often used in orthopaedic surgery to promote bone growth. However, rhBMP-2 use in the cervical spine has led to some reports of soft tissue swelling. The purpose of this study was to (1) quantify local edema associated with rhBMP-2 implantation (along with common vehicles) into rabbit muscle tissue, (2) histologically examine the tissue to quantify areas of muscle necrosis/inflammation and to identify inflammatory cells present.

Methods: The following materials were implanted into the dorsal muscles of 14 rabbits: (1) absorbable collagen sponge (ACS) soaked with 0.1 mL buffer solution, (2) ACS soaked with 0.1 mL of 0.43 mg/mL rhBMP-2 (BMP/ACS), (3) ACS soaked with 0.1 mL of 0.43 mg/mL rhBMP-2 and encapsulated with 0.5 mL fibrin glue (BMP/ACS/FG), and (4) 0.5 mL fibrin glue alone (FG). The rabbits were sacrificed at 2, 3, or 6 days postoperative and given an immediate MRI scan. Muscle tissue surrounding the implants was then harvested for histological analysis.

Results: At all three time points, muscle tissue implanted with BMP/ACS/FG had significantly larger areas of associated edema on STIR images than that of the other materials. Edema surrounding ACS and BMP/ACS significantly decreased over time; muscle tissue implanted with BMP/ACS/FG and FG alone also showed a trend of decreased edema. There were no significant differences in area of muscle necrosis and inflammation across groups when evaluated histologically. Inflammatory cells were seen in all groups and the distribution of these cells was consistent across all groups.

Conclusion: In this pilot study, FG and BMP/ACS alone were not associated with increased edema in a highly sensitive animal model. However, we found a possible synergistic effect of increased edema in rabbit muscle tissue when FG was implanted together with BMP/ACS. Edema in all groups appeared to be transient, decreasing from day 2 to 6 postoperative. There were no differences found during histological evaluation. This suggests there is a disconnect between local edema visible on MRIs and the cellular inflammatory response seen in histology.

Significance: Future studies with larger sample sizes are needed to further investigate these findings.

Poster #22

Computed Tomography (CT) Evaluation of the Difficulty and Accuracy of Thoracic Pedicle Screws Placement in Scoliosis. Does the Magnitude of the Curve Affect the Accuracy or the Difficulty of Thoracic Pedicle Screw Placement?

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Introduction: The pedicle screw (PS) fixation of thoracic spinal segments has been recognized as a powerful option for operation of scoliosis. We evaluated the difficulty and accuracy of thoracic pedicle screw placement for 94 scoliosis cases operated by a single surgeon at a single institution.

Methods: There were 94 scoliosis patients (26 males and 68 females), seventy-three were idiopathic scoliosis (IS), and another 21 (non-IS) were neuromuscular scoliosis in 15 or syndromic in 6 patients. Patients who had bone metabolic disorder or anomaly such as dwarfs, neurofibromatosis and congenital scoliosis were excluded from the study. The average age at the surgery was 44.8 years, and the average magnitude of the curve was 62.7±22.0 degrees. All patients were performed a posterior fusion with instrumentation by a single procedure, and 1303 thoracic pedicle screws were placed with free-hand technique by a single surgeon at a single institution. The postoperative CT scans were evaluated for thoracic pedicle screw accuracy using established 2-mm increments. We evaluated the rate of PS misplacement by the outcome-based classification (Bidre et al. Spine 2008) and the rate of pedicles to which PS was not performed due to the size of pedicle or failure of proving (Give up rate). All patients were divided into 3 groups according to the magnitude of the curve (Group 1: less than 60 degrees, Group 2: curves from 60 to 90 degrees, Group 3: curves over 90 degrees). Fifty-eight patients were in Group 1, 27 patients in Group 2, and 9 patients in Group 3. Accuracy and difficulty were compared among Groups.

Results: Assessments using the outcome-based classification showed no statistical difference of the percentage of unacceptable screw placements among Groups (Group 1: 7.3±8.2, Group 2: 9.7±10.8, Group 3: 12.5±7.9). However, assessments of the Give up rate, Group 3 had a significantly lower rate compared to Group 1 or 2 (Group 1: 13.6±14.5, Group 2: 18.2±13.2, Group 3: 4.2±14.6) (p≤0.01). Neither group exhibited clinical complications.

Conclusion: Thoracic pedicle screw placement can be performed safely for large magnitude curves as long as the cancellous channels are detected by proving. However, the difficulty of screw insertion increases in curves more than 90 degrees.

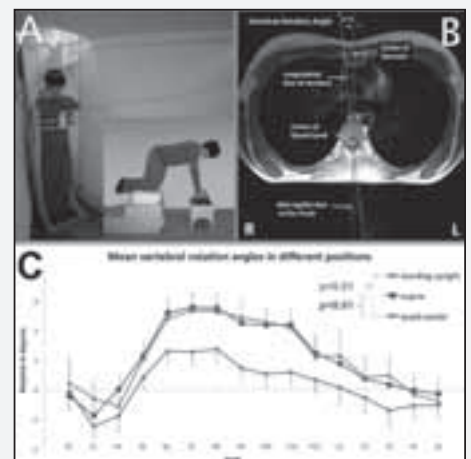
Poster #23

The Effect of Body Positioning on Pre-Existent Vertebral Rotation in the Human Spine

Michiel Janssen (University Medical Center Utrecht); Koen L. Vincken, BSc; Marina Obradov, MD; Marinus De Kleuver, MD; Max A. Viergever, MD; René M. Castelein, MD, PhD; Lambertus W. Bartels, MD

Introduction: There is increasing support for the theory that a fully erect spine (unique in humans) is a prerequisite for the development of AIS. Empirical evidence for this lies in the fact that AIS is only observed in humans, not in other vertebrates. In addition, cadaveric studies show that spinal rotational stability is less under dorsally directed shear loads (DDSLs). (Kouwenhoven, Spine 2007) DDSLs are only present in the vertically orientated human spine, whereas ventrally directed shear loads (VDSLs) predominantly are present in the more horizontally orientated non-human spines. Purpose of this study is to get more insight in the biomechanics of the upright spine in vivo and thus in the etiology of AIS.

Methods: 30 adults with a mean age of 23 years (range 18-29) underwent three scans in an upright MRI-scanner in different positions: 1) standing upright, 2) supine and 3) 'quadrupedal' on hands-and-



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knees (Fig 1A). Vertebral rotation in the transverse plane of each vertebra was measured in all three each positions with semi-automated software by three observers (Fig 1B). A repeated measures ANOVA was performed to analyze differences in vertebral rotation between the positions. Inter and intra observer reliability was calculated.

Results: Mid and low thoracic vertebrae demonstrate a significant rotation to the right in all positions. However, these vertebrae are less rotated in the quadrupedal position as compared to the supine ($p < 0.01$) and standing upright position ($p < 0.01$) (Fig 1C). ICCs for inter and intra observer reliability were good (respectively 0.82 and 0.87).

Conclusion: The pattern of rotations found in all positions is similar to the most prevalent types of AIS (primary thoracic curve to the right). We postulate that once the spine starts to develop a scoliosis, due to a still unknown cause, it will automatically follow this all ready build in pattern. Furthermore, this study supports the theory that a fully erect spine (with DDSs) is a prerequisite for the development of AIS and it indicates that a more horizontally orientated spine (with more VDSLs) may serve as a stabilizing factor in the (early) development of AIS.

Significance: This is the first study that gives more insight in the in vivo biomechanics of the upright spine.

Poster #24

Implications for Scoliosis Monitoring and Management Using a Micro Dose Imaging System

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Introduction: Risks from x-ray radiation are of concern for scoliosis patients especially as most patients are children. The ScolScan is an Effectively Radiation Free (ERF) system that allows for accurate geometric visualization of the vertebra of the spine with a radiation dose 500-600 times less than conventional x-ray. Comparatively, one scan produces the equivalent dose of one day's background radiation.

Methods: This project has combined the low dose of security systems and the image enhancement of medical systems to produce a truly unique scanner that delivers images which can be used to accurately measure the spine with a dose up 600 times less than conventional x-ray. The technology on which the ScolScan is based is different to conventional digital x-ray systems. It employs a new approach to image capture, the key feature of which is a highly sensitive radiation detector which uses a patented linear array of semiconductor scintillation detectors

Results: The system is able to produce a full spine image that clearly visualizes the spine and its landmarks such as the vertebral bodies, endplates, pedicles, transverse and spinous process with a dose of 8-10uSv.

Conclusion: The evolution of a system which allows doctors to accurately and closely monitor progression and treatment outcomes without increasing the risk of carcinoma and other pathologies is a breakthrough.

Significance: A system such as the ScolScan provides the opportunity for earlier detection, more accurate monitoring, better conservative and surgical planning and reduced risk of radiation exposure to the patient.



This is an example of the image quality possible with 600 times less radiation.

Poster #25

The Use of Scoliosis Research Society Outcome Scores and Oswestry Disability Index as an Indicator of Pseudarthrosis in Adult Spinal Deformity: Can Outcome Questionnaires Predict Need for Revision?

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Introduction: Pseudarthrosis (PSAR) rates for adult spinal deformity to the S1/pelvis have been reported to range from 12-24%; however, little data exists on the use of SRS and ODI scores as indicators for PSAR. The purpose of this study was to identify if postoperative SRS and ODI scores can predict need for revision surgery for PSAR.

Methods: Retrospective consecutive patient cohort of primary surgical patients at a single site, with adult deformity (avg age 52.2; range 24.9-66.1) who underwent anterior (avg 4.8; range 2-6) and posterior (avg 10.1; range 4-17) correction with instrumentation to the S1/pelvis, with min of 2 year follow up were included (avg 2.2 yr; range 2-2.5). Patients were subdivided into 2 cohorts: (1) Fused: patients with no radiographic or clinical signs of PSAR (2) PSAR: patients > 1 year post-op with identified PSAR.

Results: Thirty five patients met inclusion criteria, 33 females, and 2 males. One patient was dropped for revision prior to one year. Of the remaining 34 patients 8(23.5%) failed to improve on SRS and ODI, CT scans were obtained and PSAR were considered probable. Six patients(75 %) had revision without instrumentation failure/fracture; however, had documented PSAR at the time of revision surgery. One patient(12.5%) had revision for fractured instrumentation and had documented PSAR at the time of revision. One patient(12.5%) had continued pain and documented PSAR by CT, but declined intervention. No statistical difference between the fused and PSAR group in age, anterior levels, posterior levels, pre-op deformity, or post-op correction. Patients who had PSAR identified had lower SRS, in 4 of 5 domains, and lower ODI at 1 year post-op when compared to fused patients. The PSAR group also failed to have significant improvement in SRS or ODI when compared to pre-op. In comparison, the fused group showed improvement in all domains (chart1).

Conclusion: Surgical exploration still remains the gold standard for identification and treatment of pseudarthrosis. Patients who fail to show significant improvement in SRS and ODI scores by one year postoperatively, despite radiographic findings, may suggest pseudoarthrosis. Hence, revision surgery should be considered.

Significance: SRS and ODI can be used as indicators for pseudoarthrosis.

	Fused n=26			pseudarthrosis n=8		
	Pre-op	One Year	p	Pre-op	One Year	p
Pain	2.77	3.76	0.0223	2.65	2.8	0.65
Function	3.41	4.2	0.015	3.43	3.13	0.42
Self Image	2.42	4.14	0.0002	2.46	2.72	0.43
Mental Health	3.48	4.08	0.3669	3.68	3.8	0.45
Satisfaction	2.52	4.38	0.0066	2.94	3.06	0.71
Total	2.98	4.05	0.0046	3.05	3.12	0.72
ODI	33.2	15.8	0.041	32	30.5	0.85
p < 0.05 = statistical significance						

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Poster #26

Long Term Outcome Of Thoracolumbar Burst Fracture Patients Treated With Short Segment Posterior Pedicle Screw Fixation With Supplemental Laminar Hook Fixation(2HS-1SH Construct)

Burak Kaymaz, MD; Mehmet Ayvaz, MD (Hacettepe University); Muharrem Yazici, MD; Rifat E. Acaroglu, MD; Ahmet Alanay, MD

Introduction: Posterior short-segment pedicle fixation may provide excellent initial correction of kyphotic deformity, but is known to have a high rate of failures. 2HS-1SH construct is a modification of short segment instrumentation to increase the stability of construct while preserving lower mobile segments but the long term independent follow-up is still missing. This study evaluated long term outcomes of 2HS-1SH construct in the surgical treatment of thoracolumbar burst fractures.

Methods: Patients with a single-level thoracolumbar burst fracture consecutively treated between years 1996-2006 were evaluated. Inclusion criteria were: complete medical and radiologic records, minimum follow-up of 2 years, and fractures without posterior column involvement. Nineteen patients fit the criteria and all but two were assessed in this retrospective study.

Results: The mean age and follow-up of patients were 34,4 \pm 11,8 and 6,68 \pm 2,9 years respectively. Twelve patients had more than 5 years of follow-up. Preoperative vertebral height loss and local kyphosis were 41,2 \pm 9,8% and 16,8 \pm 8 degrees, corrected to 16,3 \pm 11,5% and -1,2 \pm 8,5 degrees. Mean losses of correction were 1,7 \pm 11,8% and 4,5 \pm 6,7 at 2 years follow-up, and 1,7 \pm 4,8% and 0,5 \pm 1,2 degrees between 2 years and 5 years. Loss of correction was significant for local kyphosis angle ($p=0,006$) but not for vertebral height ($p=0,716$) between the early post-op and 2 years follow-up. Five patients had losses of correction of more than 5 degrees. Changes between 2 and 5 years were not significant ($p=0,133$) and remained improved when compared with the preoperative value ($p=0,002$). There was no evidence of instrumentation failure or pseudarthrosis in any patient. Removal of instrumentation was needed for only one patient with late infection.

Conclusion: The 2HS-1SH construct is effective in the surgical treatment of thoracolumbar burst fractures. It provides significant correction of vertebral body height and local kyphosis. Although there was an average 4.5 degrees loss of correction at two years of follow-up, it was found to be stabilized at 5 years without any clinical problems.



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E-Poster #1

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Morbidity and Mortality in the Surgical Treatment of 605 Pediatric Patients with Isthmic or Dysplastic Spondylolisthesis: A Report from the Scoliosis Research Society Morbidity and Mortality Committee

Kaiming Fu, MD, PhD (University of Virginia) Justin Smith, MD, PhD; Christopher I. Shaffrey, MD; Sigurd Berven, MD; Theodore J. Choma, MD; Michael J. Goytan, MD; Hilali Noordeen, FRCS; D. Raymond Knapp, MD; Robert A. Hart, MD; Reinhard Zeller, MD; William Donaldson, MD; David W. Polly, MD; Joseph H. Perra, MD; Oheneba Boachie-Adjei, MD

Introduction: Prior reports suggest high complication rates for the surgical treatment of pediatric isthmic and dysplastic spondylolisthesis, but due to their relatively low prevalence, useful estimates of complications remain limited. The SRS prospectively collects MM data from its members. We used these multi-centered data to provide benchmark complication rates.

Methods: Patients who underwent surgical treatment for isthmic or dysplastic spondylolisthesis from 2004-2007 were identified from the SRS MM database. Inclusion criteria for analysis included: age ≤ 21 and a primary diagnosis of isthmic or dysplastic spondylolisthesis.

Results: Of 25,432 pediatric cases reported, there were a total of 605 (2.4%) cases of pediatric dysplastic (n=62, 10%) and isthmic (n=543, 90%) spondylolisthesis, with a mean age of 15 years (range: 4-21). Approximately 50% presented with neural element compression, and less than 1% of cases were revisions. Surgical procedures included fusions in 92%, osteotomies in 39% and reductions in 38%. The overall complication rate was 11%. The most common complications included postoperative neurological deficit (n=31, 5%), dural tear (n=8, 1.3%) and wound infection (n=12, 2%). Perioperative deep venous thrombosis and pulmonary embolus were reported in 2 (0.3%) and 1 (0.2%) patients, respectively.

Conclusion: Pediatric isthmic and dysplastic spondylolisthesis are relatively uncommon disorders, representing only 2.4% of pediatric spine procedures in the present study. Even among experienced spine surgeons, surgical treatment of these spinal conditions is associated with a relatively high morbidity.

E-Poster #2

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Rates of PE and DVT Following Spine Surgery Based on 108,419 Procedures: A Report from the Scoliosis Research Society Morbidity and Mortality Committee

Justin Smith, MD, PhD (University of Virginia); Christopher I. Shaffrey, MD; Charles A. Sansur, MD; Sigurd Berven, MD; Theodore J. Choma, MD; Michael J. Goytan, MD; Hilali Noordeen, FRCS; D. Raymond Knapp, MD; Robert A. Hart, MD; Reinhard Zeller, MD; William Donaldson, MD; David W. Polly, MD; Joseph H. Perra, MD; Oheneba Boachie-Adjei, MD

Introduction: CMS created a list of "never events" and has proposed denial of hospital payment for their treatment. While some are preventable, development of PE or DVT is multifactorial. The Scoliosis Research Society (SRS) prospectively collects morbidity and mortality (MM) data from its members. We used these data to assess occurrence of PE and DVT following spine surgery.

Methods: The SRS MM database was queried for cases from 2004-2007. Cases were stratified based on adult (≥ 21) vs pediatric (< 21), primary vs revision, use of implants and diagnosis. Incidences of clinically evident PE and DVT were calculated per 1000 cases.

Results: 108,419 cases were identified, with overall incidences of clinically evident PE and DVT of 1.38 and 1.18, respectively. Overall incidence of death due to PE was 0.34. Incidences of PE, death due to PE, and DVT were higher in adult (1.69, 0.43, and 1.44, respectively) compared with pediatric (0.43, 0.08, and 0.39, respectively) patients. Incidences of PE, death due to PE, and DVT were higher in cases using implants (1.75, 0.42, and 1.59, respectively) compared with cases without implants (0.58, 0.17, and 0.03, respectively), likely

reflecting increased procedure length and complexity and increased hospital stay. Rates of PE and DVT were calculated based on diagnosis, and a subset of these rates is shown in the table.

Conclusion: Our data suggest that post-surgical PE and DVT, even among skilled spine surgeons, are inherent potential complications. It is important to recognize that the rates of events reported herein reflect clinically evident cases of PE and DVT. Undoubtedly the true incidences of silent PE and DVT are considerably higher. Nevertheless, these data provide general benchmarks of clinically evident PE and DVT rates as a basis for on-going efforts to improve safety of care and argue against their classification as “never events”.

	n	PE incidence (per 1000 cases)	PE deaths (per 1000 cases)	DVT incidence (per 1000 cases)
Adult				
Degenerative Disease	47389	0.89	0.19	0.80
Cervical	11763	0.68	0.34	0.34
Thoracic	552	3.62	1.81	5.43
Lumbar	34731	0.92	0.12	0.89
Fracture	6025	2.82	1.66	1.83
Kyphosis	2012	7.46	1.49	5.96
Spondylolisthesis	10529	1.52	0.19	1.52
Scoliosis	5801	4.31	0.86	4.31
Other	10326	2.32	0.58	1.55
Metastatic tumor	726	12.4	4.13	8.26
Pediatric				
Fracture	623	1.61	none	1.61
Kyphosis	1555	0.64	0.64	2.57
Spondylolisthesis	827	1.21	none	2.42
Scoliosis	20424	0.39	0.05	0.15

E-Poster #3

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Posterior Vertebral Column Resection in Severe Congenital Kyphosis, Scoliosis and Kyphoscoliosis

Selhan Karadereliler, MD; Cagatay Ozturk, MD (Istanbul Spine Center, Florence Nightingale Hospital); Ahmet Alanay, MD; Neslihan Aksu, MD; Omer Karatoprak, MD; Azmi Hamzaoglu, MD

Introduction: We have presented the surgical strategy, correction rates and complications of PVCR in patients with severe congenital kyphosis, scoliosis and kyphoscoliosis with or without intraspinal abnormalities.

Methods: Between 1996-2007; 44 patients (7 kyphosis, 12 scoliosis and 25 kyphoscoliosis) were treated by PVCR. There were 35 female and 9 male patients with an age range from 2 to 28 years. The preoperative MRI showed the intraspinal pathologies as; 7 with tethered cord, 1 with re-tethering, 11 with diastematomyelia with tethered cord, 3 with syringomyelia and Arnold-Chiari malformation type I and 2 with isolated Arnold-Chiari malformation type I (total 24 of 44 patients). Surgery includes pedicle screw placement, neurosurgical procedure if necessary and correction with osteotomy either in same or a separate session depending on the anesthesia time. Neurosurgical procedures for neural axis abnormalities were done simultaneously with corrective surgery in 16 patients. In the remaining 8 patients, neurosurgical procedure was done only with posterior instrumentation and thereafter corrective surgery including osteotomy was performed in another session due to long anesthesia time. PVCR was performed in one area in 41 patients and in 2 different area in 3 patients.

Results: The minimum follow-up was 2 years, average of 8 years. There were 24 one level, 13 two-level and 7 three-level resections. The average correction was 79% in coronal plane decompensation and 72% in sagittal plane decompensation. The mean correction in coronal plane deformity was 61%.

Conclusion: PVCR together with the surgery of intraspinal pathologies either in same session or in a separate session after placing pedicle screws prevent iatrogenic neural injuries, provides well correction of the deformity and prevent patient from the risks of multiple surgeries. Since it is a technically demanding procedure with possible risks for major complications, it should be performed by highly experienced surgical team.

Significance: Vertebral column resection is an effective technique in the surgical treatment of severe kyphosis/scoliosis/kyphoscoliosis.

E-Poster #4

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

The Effect of Bone Mineral Density on Pedicle Screw Triggered EMG Threshold: A Comparative Study

Michael D. Roth, BS (Barnes-Jewish Hospital); Anne M. Padberg, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD

Introduction: Triggered EMG testing to assess pedicle screw placement is well established. Higher false positive rates (low threshold/good screw placement) suggest decreased sensitivity. Low false negative rates (low threshold/misplaced screw) maintain good specificity. DEXA scanning provides objective evidence of osteopenia (t-score >-1.0 to -;2.5) and osteoporosis (t-score ≤- 2.5). We theorized that with t-scores in this range patients will demonstrate higher false positive rates. The purpose of this study was to compare true positive and false positive rates for triggered EMG thresholds between normal bone mineral density (NL-BMD) and osteopenic/osteoporotic (L-BMD) groups.

Methods: Triggered EMG thresholds for 82 patients with L-BMD per DEXA scan results (age 50.0-80.8, 1444 screws) from 2002-2007 were compared to 104 patients with N-BMD (age 16-29; 1784 screws). Screws thresholds <4.0mA were verified with radiographs, fluoroscopy and manual palpation. EMG results were sorted by spinal levels. True positive, false negative and false positive rates were analyzed for each group. Established normative data were: threshold <4.0 mA (strong likelihood of a medial pedicle wall breach); 4.0-8.0 mA (possible breach, rechecking advisable); >8.0 mA (correctly placed screw).

Results: The negative predictive value (NPV; threshold >8.0mA and no breach) was 0.99 for both groups. However, the positive predictive value (PPV; threshold <4.0mA and breach present) for the low BMD group was 0.21 (sensitivity 0.57, specificity 0.99) and the NL BMD group 0.88 (sensitivity 0.93, specificity 0.99).

Conclusion: Triggered EMG is highly specific (0.99) in detecting correctly position pedicle screws in both study groups. Sensitivity is significantly decreased for the L-BMD group (0.57) vs the NL-BMD group (0.93).

Table: Triggered EMGs

Triggered EMG	DEXA >-1.0 Thoracic (NL BMD)	DEXA <-1.0 Thoracic (Osteopenia)	DEXA >-1.0 Lumbar (NL BMD)	DEXA >-1.0 Lumbar (Osteopenia)
Below 4mA	9	1	7	18
4-8mA	171	28	54	68
Above 8mA	933	695	610	901
False positive	1	1	1	14
False negative	1	1	1	2
True positive	8	0	6	4
True negative	1101	723	667	979

E-Poster #5

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Natural History of Spine in Patients with Esophageal Atresia; A Long-Term Population-Based Follow-Up Study

Saara J. Sistonon, MD; Ilkka Helenius, MD, PhD (Turku University Central Hospital); Jari Peltonen, MD, PhD; Risto J. Rintala, MD; Mikko P. Pakarinen, MD, PhD

Introduction: Anomalies of the midline e.g. vertebral column typically associate with esophageal atresia (EA). The risk of scoliosis is further aggravated in these patients due to the repair of EA via thoracotomy immediately after birth. However, the natural history of spinal anomalies and scoliosis in these patients is unknown.

Methods: A retrospective, long-term, population-based study was conducted. 100 adults (57 males;

mean [range] age at follow-up 36 [21-57] years) consecutively treated operatively for EA in infancy in our hospital were examined for spinal deformities and anomalies after mean 36 (21-57) years follow-up. All patients underwent clinical examination and cervical as well as whole spine PA and lateral radiographs at follow-up visit. The results were compared to data obtained from normal population-based controls (n=855).

Results: Vertebral anomalies were noted in 45 (45%) patients, predominating in the cervical spine in 38 (38%). Cervical spine anomalies were mostly fused cervical vertebrae with the preference for C6 and 7 as well as C2 and 3 fusions followed by cervical hemivertebrae. Scoliosis (over 10 degrees) was observed in 56 (56%) patients, over 20 degrees in eleven (11%), and over 45 degrees in one (1%). The risk for scoliosis over 10 degrees was 13-fold (95%CI 8.3-21) and for scoliosis over 20 degrees 38-fold (95%CI 14-106) compared with the control population. 13 (13%) patients reported back pain often or very often at rest. None of the patients have undergone either scoliosis or cervical spine surgery. Thoracotomy-induced rib fusions (OR 3.6, 95%CI 0.7-19) and other associated anomalies (OR 2.1, 95%CI 0.9-2.9) were the strongest predictive factors for scoliosis.

Conclusion: The overall risk of scoliosis is 13-fold among patients with repaired esophageal atresia in relation to general population. The vertebral anomalies associated with EA predominate in the cervical spine and are more common than reported previously. Most of these anomalies were not diagnosed primarily or during growth. Spine surgery is rarely needed.

Significance: Mild scoliosis is common in patients with operated EA. The risk of cervical instability due to block vertebrae remains unknown.

Table 1

Anomaly type	Number (%)
Failure of segmentation	
Vertebral fusion	
Cervical	34 (34)
Thoracic	9 (9)
Unilateral bar	
Thoracic	2 (2)
Lumbar	2 (2)
Failure of formation	
Wedge vertebrae	
Cervical	12 (12)
Thoracic	7 (7)
Lumbar	3 (3)
Butterfly vertebrae	
Cervical	5 (5)
Thoracic	3 (3)
Hemivertebrae	
Cervical	2 (2)
Thoracic	1 (1)
Rib anomalies	
Additional or absent	9 (9)
Fused ribs	30 (30)
Cervical ribs	4 (4)

E-Poster #6

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Neurological Outcome Associated with Severely Misplaced Pedicle Screws. A Case Report

Jean-Marc Mac-Thiong, MD, PhD (CHU Sainte-Justine); Stefan Parent, MD, PhD; Benoît Poitras, MD; Hubert Labelle, MD

Introduction: The prevalence of neurological complications from misplaced pedicle screws might be underreported, especially in case of severely misplaced pedicle screws. This study reports eight cases of severely misplaced pedicle screws in patients with adolescent idiopathic scoliosis (AIS) after posterior surgery.

Methods: We reviewed eight cases with medially misplaced pedicle screws referred to our institution after posterior surgery for AIS. A pedicle screw was considered severely misplaced if the spinal canal intrusion was greater than the pedicle screw diameter. The percentage of spinal canal intrusion was measured on CT scan images with respect to the spinal canal width at the level of the misplaced screw.

Results: Results are summarized in Table 1. In two patients, misplacement of the pedicle screws was recognized during surgery and all implants were removed. They both had motor deficits from which one

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recovered completely. Two patients had early postoperative postural headache from meningeal irritation that disappeared after removal of the misplaced screw. Four patients had an uneventful early postoperative course. One of these patients developed a Brown-Sequard syndrome two years after surgery and underwent complete implant removal and dural repair at the level of one misplaced screw. Another patient had onset of left T3 and T4 paresthesia three years after surgery, and complete implant removal was performed uneventfully. One patient with intact neurological status had uneventful implant removal nine years after surgery for a superficial infection and the last patient refused implant removal and remains neurologically intact three years after surgery.

Conclusion: Improper pedicle screw placement can lead to neurological complications that appear early or late (after 2 years). Late neurological complications were associated with screw loosening in two cases. The neurological status can remain normal for a certain period of time even with a 61% thoracic canal intrusion. No major complication occurred with early or late implant removal.

Significance: The authors recommend removal of severely misplaced pedicle screws due to the risk of early or late neurological complications, especially when there is evidence of screw loosening.

Table 1 – Review of 8 cases with severely misplaced pedicle screws after posterior surgery for adolescent idiopathic scoliosis

Patient	Side and levels of misplaced screws (% canal intrusion)	Early postoperative neurological status	Follow-up
1	L T6 to T9 ? (N/A)*	Complete paraplegia, T8 sensory level (all implants removed at surgery)	Residual paraparesis (4/5 strength) in lower extremities at 2-year follow-up
2	L T4 (50%) L T5 (56%) L T6 (41%) L T7 (49%) L T8 (33%) R T9 (24%) R T10 (26%) R T11 (46%) R T12 (25%)	Paraparesia (all implants removed at surgery)	Normal neurological status returned on POD#1
3	L L3 (48%)	Postural headache starting POD#6	L L3 screw removal and laminectomy POD#15. Complete implant removal after 4 years for pain. Normal neurological status
4	L T4 (42%) R T10 (31%) L L1 (21%)	Postural headache starting POD#7	L T4 screw removal and laminectomy replaced by T3 hook POD#15. Normal neurological status
5	L T4 (61%)	Uneventful	L T6 Brown-Sequard after 2 years. Complete implant removal, L T4 laminectomy and dural repair. Residual abnormal proprioception LLE and gait
6	L T3 (53%) L T4 (42%) R T5 (57%) L T11 (34%)	Uneventful	L T3 and T4 paresthesia after 3 years. Complete implant removal
7	L T6 (28%)	Uneventful	Partial distal implant removal after 6 years for prominent implant and complete implant removal after 9 years for prominent implant and superficial infection. Normal neurological status
8	L T3 (49%) L T4 (31%) R T10 (26%)	Uneventful	Normal neurological status. Refuses implant removal

* No CT scan available.

† Measurements were performed after implant removal from extrapolation of screw path on CT scan images.

E-Poster #7

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Scoliosis Research Society Morbidity and Mortality of Adult Scoliosis

Charles A. Sansur, MD (University of Virginia); Jeffrey D. Coe, MD; Justin Smith, MD, PhD; Christopher I. Shaffrey, MD

Introduction: This is a large retrospective review for the treatment of degenerative and idiopathic adult scoliosis (AS) from the SRS Morbidity and Mortality index. This database was reviewed to obtain an updated assessment of complication incidence, and to determine if the rate of complications depends on various clinical parameters.

Methods: The SRS Morbidity and Mortality database was queried to identify cases of AS from 2004-2007. Complications were identified and analyzed based on patient age, type of scoliosis, use of osteotomy, revision surgery status, and surgical approach. Age was stratified into ≤ 60 and >60 . Surgical approach was stratified into: anterior only, posterior only, anterior and posterior, and unspecified.

Results: 4980 cases of AS were submitted from 2004-2007. There were a total of 521 complications (10.5%). The most common complications were dural tear 142 (2.9%), superficial wound infection 46 (0.9%), deep wound infection 73 (1.5%), implant complication 80 (1.6%), acute neurologic deficits 49 (1.0%), delayed neurologic deficits 41 (0.5%), epidural hematoma 12 (0.2%), wound hematoma 22 (0.4%), pulmonary Embolus 12 (0.2%), pulmonary complication 31 (0.5%), deep venous thrombosis 9 (0.2%). There were 17 deaths making the mortality rate (0.3%). Age and scoliosis type did not result influence the complication rate ($P=0.32, 0.20$). Patients who underwent osteotomies, who were having revision surgery, and who were undergoing anterior and posterior surgery had significantly higher rates of complication ($P=0.0006, 0.006, 0.03$).

Conclusion: The rate of complications for treatment of AS is 10.5%. Complication rate is significantly higher in patients undergoing osteotomies, revision procedures, and combined anterior/posterior approaches. Complication rate is not influenced by age or scoliosis type.

Significance: This report of complications for adult scoliosis is based on the largest known sample of patients undergoing surgery using modern surgical techniques. It reviews the factors that significantly influence the rate of complications and may be useful for spine surgeons while they contemplate performing surgery on adults with scoliosis.

E-Poster #8

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

The Rate of Change in Spinopelvic Parameters Following Spondylolisthesis Surgery

Patrick J. Cahill, MD (Shriners' Hospital For Children); Jahangir Asghar, MD; Jason R. Smith, PA-C; Sean C. Marvil, BS; Mark E. Tantorski, DO; Amer Samdani, MD; David H. Clements, MD; M. Darryl Antonacci, MD; Randal R. Betz, MD

Introduction: Measurements of spinal deformity such as those for compensatory lumbar curves change over time following spinal deformity. The time frame magnitude of these changes in scoliosis is predictable and has been reported. Radiographic parameters of the spinopelvic relationship are abnormal in children with spondylolisthesis. There are no data, however, quantifying the long-term changes and the timing over which these changes following surgical treatment. We present our results detailing the changes in these parameters over the first two post-operative years.

Methods: A retrospective review of the medical records and radiographs was conducted of twenty-seven consecutive patients from a single institution with spondylolisthesis treated with fusion and instrumentation. All patients had a minimum of 2 years follow-up. Pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS) and lumbar sagittal alignment (LSA) were measured at various time points until to 2 years post-op. Statistical analysis was performed using a mixed-model analysis of covariance (ANCOVA) for repeated measures.

Results: The average age was 14.7 years. There were 19 females and 8 males. Age and sex had no effect

on the change in spinopelvic parameters. There was no significant alteration in PI over time ($p=0.702$). PT significantly decreased during the first 3 months after surgery ($p=0.020$) but did not change thereafter ($p=0.392$). There was not a significant change postoperatively in SS but a trend towards an increase in SS ($p=0.093$) was noted. LSA L1-S1 increased in the first three months post-op ($p=0.046$) but then remained unchanged ($p=0.092$).

Conclusion: The abnormal relationship of the spine to the pelvis in children with spondylolisthesis changes with time following spondylolisthesis surgery. All of the statistically significant changes brought the measurements closer to the values reported in unaffected children. The PT and LSA change within the first three months while the SS has a steady gradual change. PI, a measurement of fixed pelvic morphology, predictably did not change.

Significance: The abnormal spinopelvic relationship in spondylolisthesis in children continues to change over time following surgery, particularly in the first three months.

E-Poster #9

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Factors Predictive of Perioperative Morbidity and Mortality After Spinal Deformity Surgery in Patients 75 Years and Older

Frank L. Acosta, MD (Northwestern Memorial Hospital); Brian A. O'Shaughnessy, MD; Heiko Koller, MD; Chris J. Neal, MD; Oliver Meier, MD; Christopher P. Ames, MD; Tyler Koski, MD; Stephen L. Ondra, MD

Introduction: As the population continues to age, relatively older geriatric patients will present more frequently with complex spinal deformities that may require surgical intervention. No study has analyzed factors predictive of complications after major spinal deformity surgery in the very elderly (75 and older).

Methods: Review of the medical and surgical records of 21 patients age 75 and older who underwent thoracic or lumbar fixation across 5 or more levels for spinal deformity. Age, comorbidities, operative data, major and minor complications, and deaths were recorded. Factors predictive of perioperative complications were identified by logistic regression analysis. Postoperative ODI and SRS-22 scores were collected in 10 patients.

Results: Mean patient age was 77 years (14F:7M). Mean follow-up was 41.2 months (range 24-81 months). Fifteen patients (71%) had at least one comorbidity. Average of 10.5 levels were fused. Thirteen patients (62%) had at least one complication, and 8 (38%) had at least one major complication. There were no deaths. Increasing age was predictive of any postoperative complication ($P=0.03$). Major complications; however, were not predicted by age or comorbidities as a whole. In a subset analysis of comorbidities, only hypertension was predictive of a major complication ($P=0.02$, OR 10, 95% CI 1.3-78). Complications were not associated with adverse outcomes by ODI or SRS-22 scores.

Conclusion: Patients age 75 and older undergoing major spinal deformity surgery have an overall complication rate of 62%, with older age increasing the likelihood of a complication. Patients in this age group with a history of hypertension are 10 times more likely to incur a major perioperative complication. Mortality risk for these patients; however, is not increased and complications are not associated with adverse outcomes.

Significance: Complication rates after spinal deformity surgery in patients 75 and older are significant. Increasing age is predictive of any postoperative complication. Hypertension specifically is associated with a 10-fold increase in the rates of major perioperative complications in this cohort. Mortality; however, is not increased in this age group.

E-Poster #10

The Impact of Reciprocal Regional Alignment Changes Distant from the Site of Spinal Osteotomies Affects Post-Operative Spinal Balance

Virginie Lafage, PhD (NYU Hospital for Joint Diseases); Frank J. Schwab, MD; Oheneba Boachie-Adjei, MD; Jean-Pierre C. Farcy, MD; Alexis P. Shelokov, MD; Richard Hostin, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Michael F. O'Brien, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; International Spine Study Group

Introduction: Treatment of complex spinal deformity in adult patients requires an understanding of the effect of regional changes on global balance. While the regional impact of an osteotomy can be planned, the impact on distant segments of the spine remains poorly understood. The objective of this study is to analyze reciprocal regional corrective changes in the unfused segments of the spine away from the site of osteotomies as it relates to the final radiographic outcome.

Methods: This is a consecutive, multicenter retrospect review of 134 consecutive adult patients (24M, 110F, mean age= 54 +/- 12 yo). 29 subjects underwent thoracic resection procedures ("Thoracic group"), and 105 underwent lumbar resection procedures ("Lumbar group"). Resection levels ranges from T2 to L4 (Table). Radiographic analysis included pre and postoperative assessment of Thoracic Kyphosis, Lumbar Lordosis, SVA, Pelvic tilt, Pelvic incidence. Paired independent t-test analysis (SPSS) was computed to evaluate the changes in radiographic parameters

Results: In "Thoracic group", preop thoracic Kyphosis of 58° was corrected to 38° (p<0.001) and localized correction measured to 11°. For the unfused lumbar segment (12 patients), spontaneous Lordosis changed from 70° to 62° (p<0.05). Preop SVA improved from 2.4cm to -1cm (p=0.006) and pelvic tilt improved from 19deg pre-op to 13deg (p<0.001) In "Lumbar group", the average correction at the osteotomy was 23°. Lumbar Lordosis increased from 20° to 49° (p<0.001). For the unfused thoracic segment (34 patients), Kyphosis increased from 22° to 35 post op (p=0.002). Pre op SVA improved from 14cm to 4cm post-op (p<0.001) and pelvic tilt improved from 33° to 25° (p<0.001).

Conclusion: In an attempt to correct spinal imbalance several parameters play important roles in pre-operative planning. If reciprocal changes related to regional deformity correction can be anticipated, then better post-operative alignment can be achieved. Furthermore, limiting resection to the site of maximum deformity may addresses the regional malalignment and result in reciprocal and spontaneous changes in unfused segments leading to improved restoration of overall spinal balance. This may eliminate the need to perform longer fusions of the spine.

Resection level	T2	T3	T4	T5	T6	T7	T8	T9	T11	T12	L1	L2	L3	L4
#	1	1	1	2	2	4	6	5	3	4	7	20	50	28

Resection distribution by vertebral level

E-Poster #11

**LOUIS A. GOLDSTEIN AWARD NOMINEE FOR BEST CLINICAL POSTER

Validation of Surgeon Perception of Navigated Pedicle Screw Position: A Cadaveric Study

Edward Rainier Santos, MD (University of Minnesota); Jonathan N. Sembrano, MD; Charles Gerald T. Ledonio, MD; Carlos Castro, MD; Walter H. Truong, MD; David W. Polly, MD

Introduction: A surgeon's ability to detect pedicle wall violations intraoperatively is crucial for optimal screw placement. Postoperative CT scans are traditionally used to assess screw position. However, a second procedure is needed in the presence of symptomatic screw malposition. The use of intraoperative navigation facilitates optimal screw placement, and in the event of a perceived screw malposition, revision of the screw can be done in the same sitting. There have been no studies looking at the validity of a surgeon's perception of pedicle screw position after three-dimensional(O-arm)image guided screw placement.

Methods: Four hundred nineteen screws were inserted using three-dimensional image (O-arm) guidance transpedicularly from C2 to S1 in 9 fresh frozen cadavers. The screw positions were randomized into three groups: "IN" (fully contained within the pedicle), "OUT-lateral" or "OUT-medial". Screw tracts were created using navigation, and then probed. After screw insertion, the surgeon stated whether he perceived the screw to be in, out laterally, or out medially. After all the pedicle screws had been inserted and O-arm imaging done, a second surgical team dissected the spine and determined pedicle screw position at each level. The surgeon's perception of screw position was compared with the findings on visual inspection. Specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV) were calculated.

Results: The overall specificity, sensitivity, PPV and NPV of surgeon perception of pedicle screw position was 87%, 80%, 78% and 88% respectively (Table 1). Medial wall violations were better detected than lateral wall violations. Accuracy and precision of pedicle screw insertion in the cervical spine was significantly less than in the thoracic and lumbosacral spine.

Conclusion: Surgeon perception is both accurate and precise in the thoracic and lumbar spine, but has unacceptable accuracy and precision in the cervical spine.

Significance: This study showed that surgeon perception of pedicle screw position is accurate and precise in the thoracic and lumbosacral spine. In the cervical spine, surgeon perception is not reliable, and alternative methods of fixation such as lateral mass screws should be considered.

Table 1. Results of validation calculations between surgeon perception and visual inspection

	CERVICAL	THORACIC	LUMBOSACRAL	OVERALL	IN vs LAT	IN vs MED
SENSITIVITY (%)	61	90	95	87	90	97
SPECIFICITY (%)	78	80	80	80	77	82
PPV (%)	52	81	85	78	86	90
NPV (%)	84	89	93	88	84	94

E-Poster #12

Degenerative Lumbar Scoliosis Managed with Posterior Decompression and Instrumented Fusion: Long-Term Results and Conclusions

Christopher Furey, MD (Case Western Reserve University); Sanford Emery, MD; Henry Bohlman, MD

Introduction: Our objective was to evaluate a series of patients with degenerative lumbar scoliosis who underwent posterior decompression and instrumented fusion, with special attention to the need for additional surgery and its effect upon ultimate clinical outcome.

Methods: 56 patients underwent surgery over an 8 year period with an average follow-up of 7.2 years. The proximal extent of the fusion was chosen as the lowest neutral vertebra (L1/L2 in 37 patients; T10/T11 in 19 patients). The distal extent of the fusion was L5 in 45 patients and was only extended to S1 if there was L5-S1 spondylolisthesis (4 patients), a prior L5 laminectomy (4 patients), or a need to perform an L5 laminectomy (3 patients).

Results: Relief of leg pain was excellent in 49 patients, good in 5. Relief of back pain was excellent in 42 patients, good in 10, and fair or poor in 4 patients. 50 patients were fully satisfied with the surgery, 3 partially satisfied, and 3 dissatisfied. The VAS improved from a pre-op average of 7.2 to a post-op average of 2.9 ($p=0.03$). 10 patients (18%) required additional surgery. Proximal junctional kyphosis (PJK) occurred in 4 patients, each originally fused to L1 or L2. Risk factors for PJK were a body mass index >1.5 and osteoporosis. 2 of 45 patients originally fused to L5 developed distal degeneration requiring extension of the fusion to S1. 5 of 11 patients originally fused to S1 required additional surgery: 2 with a pseudarthrosis and 3 with an intact fusion but with painful, loose instrumentation. In those who had additional surgery, the average VAS improvement was 4.0, compared to 5.1 in those with no additional surgery ($p=0.04$). In those who had additional surgery, the post-op Oswestry was 14.2, compared to 12.8 in those with no additional surgery ($p=0.03$).

Conclusion: Surgical management of degenerative lumbar scoliosis effectively relieved pain and most patients were satisfied with their outcome. However, by 7 years, 18% had additional surgery and their

clinical outcomes were significantly worse.

Significance: When extension of a fusion to the sacrum is necessary in patients with degenerative lumbar scoliosis, pedicle screw instrumentation alone has a high failure rate. In this scenario, a concurrent interbody fusion should be included.

E-Poster #13

Does Appearance Influence Outcome in Adult Scoliosis?

Steven D. Glassman, MD (Kenton D. Leatherman Spine Center); Leah Y. Carreon, MD, MSc; Justin Smith, MD, PhD; Frank J. Schwab, MD; Prof. Se-Il Suk, MD, PhD; William C. Horton, MD; Keith H. Bridwell, MD

Introduction: Appearance is recognized as a pivotal issue in the management of adolescent idiopathic scoliosis, whereas pain and disability are considered the primary drivers for adult deformity surgery. However, a recent study showed that appearance was an important consideration in surgical decision making for adult scoliosis as well. The purpose of this study is to determine whether appearance, or change in appearance, significantly affect HRQOL after adult scoliosis surgery.

Methods: Prospectively collected data from 188 adult scoliosis patients (88% females, mean age = 49.7 years) enrolled in a prospective multi-center database for adult spinal deformity were reviewed. SRS-22, SF-12, and ODI were assessed on the basis of net mean change from baseline to two years post-treatment. At baseline, associations between the SRS-22 Appearance score and responses to the Appearance questions (Questions 4, 6, 10, 14 and 19) was evaluated. Associations between baseline SRS-22 Appearance scores, SF-12 PCS, ODI and radiographic parameters were also analyzed. At two years, associations between change in SRS-22 Appearance score and change in HRQOL, two-year SRS Satisfaction score and radiographic parameters were evaluated.

Results: At baseline, all SRS-22 Appearance questions except "appearance in clothes" correlated well with the overall domain score. There was a small degree of correlation between SRS Appearance and SF-12 PCS (0.344), ODI (-0.346), sagittal balance (-0.232) and curve magnitude (-0.215). There was no correlation between coronal balance and curve type. At two years post-op, there was a low correlation between change in SRS-22 Appearance and change in SF-12 PCS (0.265) and change in ODI (0.269). Change in curve magnitude correlated with change in SRS-22 Appearance (0.242), but the correlation was small.

Conclusion: While prior studies of adult scoliosis patients have indicated that appearance is an important factor in their decision to undergo scoliosis surgery, change in appearance appears to make a relatively minor contribution to their post-surgical HRQOL outcomes. Concern regarding appearance should be regarded with caution as a primary indication for surgery in adult scoliosis patients.

E-Poster #14

Major Complications Following Adult Spinal Deformity Surgery: Is There a High Risk Patient Profile?

Nicola Hawkinson, NP (NYU Hospital for Joint Diseases); Frank J. Schwab, MD; Beverly J. Kelly, MD; Jean-Pierre C. Farcy, MD; Gregory M. Mundis, MD; Matthew E. Cunningham, MD, PhD; Behrooz A. Akbarnia, MD; Richard Hostin, MD; Robert A. Hart, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; R. Shay Bess, MD; International Spine Study Group

Introduction: Perioperative complication rates for adult spinal deformity (ASD) have been reported as high as 80%. Reported risk factors include age, co-morbidities, and blood loss. While risk scores exist in other surgical disciplines, a system is lacking for ASD. The goal of the study is to identify major peri-operative complications and determine if patient profiles can be defined in the setting of ASD surgery

Methods: Retrospective, consecutive, multi-center (n=8) review of major peri-operative (<6wks post-op) complications in ASD patients (documented coronal or sagittal deformity). Major complications were identified and categorized as: pulmonary, neurological, cardiovascular, gastrointestinal, and infectious. Clinical chart reviews were conducted to obtain; ASA grade, co-morbidities, preoperative lab values, and

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intra/post-operative parameters. Incidence of complications and patient profiles were described.

Results: 72 patients (18M, 54F) were identified in a review of 953 consecutive ASD patients. Mean age was 54yo (18-79) with a total incidence of 99 major and 133 minor complications. Mean operative time was 491mn, mean EBL was 2440ml and mean transfusion was 3100ml RBC's. 54% were revision cases (mean 1.9 previous surgeries) and 50% were staged procedures. 44% of patients were ASA grade III (mean ASA 2.33). There was a mean co-morbidity rate of 2.5 per patient. Most common comorbidities were hypertension, depression/anxiety, coronary artery disease and hypothyroidism. The mean length of ICU stay was 3.4 days. Most common major complications included excessive (>4L) intraoperative bleeding (n=11), return to the OR for deep wound infections (n=11) and pulmonary embolus (n=10)

Cardiac Arrest	Cord Deficit
Death	Nerve Root Injury
Coagulopathy	Vessel Organ injury
Excessive Bleeding if >4liters	Malignant Hyperthermia
Bowel/Bladder deficit	Death
Deep Vein Thrombosis	Cauda Equina Deficit
Infection deep-return to OR	Motor Deficit/ Paralysis
Myocardial Infarction	Neuropathy
Optic Deficit/Blindness	Pneumonia
Pulmonary Embolism	Acute respiratory failure
Sepsis ¹	Stroke
Acute Respiratory distress Syndrome	Cholecystitis
Pancreatitis	Unplanned return to OR
Prolonged ICU stay*greater than 72 hr	

1 For one or more days after the major operating room procedure code

Conclusion: The inherent risk in ASD surgery may not be avoidable. An improved understanding of risk profiles in patients and procedure-related parameters is critical. Such information can assist in pre-operative risk-benefit decisions and pre-emptive approaches to reduce risk. This study reveals that patients affected by major complications in ASD surgery may not be 'typical' high risk patients. This study will form the basis for a prospective multi-center study and aid in the development of a risk scoring system for ASD (RSSS=RS3)

E-Poster #15

** JOHN H. MOE AWARD NOMINEE FOR BEST BASIC SCIENCE POSTER

Quantitative Histology of the Neurocentral Synchronosis in a Growing Animal Scoliosis Model

Hong Zhang, MD (Texas Scottish Rite Hospital for Children); Daniel J. Sucato, MD, MS

Introduction: The neurocentral synchronosis (NCS) plays a role in the growth of the immature spine. This study was to histologically evaluate the growth inhibition of the NCS by pedicle screw fixation and to correlate curve magnitude with the fusion rate of the synchronosis in a growing animal scoliosis model.

Methods: 2-months old pigs were assigned to 3 groups: control (n=2) without pedicle screw fixation; single-screw (n=3): right single pedicle screw crossing the NCS from T7 to T14; double-screw (n=3): as in previous group only 2 screws in each pedicle. The animals were euthanized at 6 months, quantitative histology of the NCS were performed measuring NCS fusion rate, hypertrophic zone (HZ), proliferative zone (PZ), and chondrocyte height (CH).

Results: A scoliosis curve was seen in neither of the 2 animals in the control, 1 of 3 in the single-screw, and 3 of 3 in the double-screw group (30, 42, and 42 degree). The scoliosis convexity was always ipsilateral to the screws which fused the NCS while allowing continued growth of the concave NCS. The NCS fusion rate in the double-screw (92%) was greater than the single-screw (49%) which was greater than the control (0%) (P<0.05). The HZ (146.3 um) and PZ (54.3 um) of the synchronosis in the screw side were smaller than the control NCS (HZ = 205.2 um; PZ = 104.8 um) (P<0.0001). The CH of the double-screw NCS (9.1 um) was smaller than the single-screw (11.8 um) which was smaller than the control group (19.9 um) (P<0.05).

Conclusion: A pedicle screw crossing the NCS creates fusion around the screw-site with decreased height of the hypertrophic and proliferative zones and a decrease in chondrocyte height resulting in scoliosis with the convexity on the side of screw fixation. Unilateral double pedicle screws provide a greater epiphysiodesis effect on the NCS and correlated with a greater degree of deformity.

Significance: This study demonstrates a pedicle screw crossing the NCS induces asymmetric closure of the NCS to produce structural scoliosis due to the continued growth of the opposite NCS. This no-fusion strategy may have some role in the treatment of growing patients with spinal deformity.

E-Poster #16

Reduction of Mean Arterial Pressure During Surgical Exposure Safely Reduces Operative Blood Loss and Transfusion Requirements

Kushagra Verma, MS (NYU Hospital for Joint Diseases); David Vecchione, BA; Laura E. Dean, BS; Joshua D. Auerbach, MD; Baron S. Lonner, MD

Introduction: Reduction of mean arterial pressure (MAP) during surgery to control operative blood loss has been debated in terms of efficacy and potential for neurologic complications. The purpose of this study was to analyze the management of MAP for its impact on blood loss, transfusion requirements, and complication rates.

Methods: We reviewed medical records from 340 adolescent idiopathic scoliosis (AIS) patients treated with spinal fusion by a single surgeon from 2000-2007. Variables assessed included: age, gender, body mass index (BMI), associated comorbidities, pre-operative hematocrit, radiographic measurements, perioperative data, and complications. MAP was estimated from the anesthesia flow sheet during both surgical exposure (SE-MAP) and the entire surgery (Avg-MAP). Surgical exposure was defined as the time from incision to the point of instrumentation. Patients were also stratified into groups by SE-MAP (Group 1: <66; Group 2: 66-75; Group 3: >76) and analyzed with a t-test for relative blood losses. Blood loss was also analyzed with a multivariate regression analyses (statistical significance $p < 0.05$).

Results: Mean blood loss was 920 ± 777 ml for posterior spinal fusion (PSF, $n=183$), 319 ± 168 ml anterior spinal fusion (ASF, $n=127$), and 1190 ± 755 for combined procedures ($n=30$). Regression analysis identified the MAP during surgical exposure to be a predictor of blood loss ($p < 0.05$). This was true for patients undergoing ASF or PSF. There were no neurologic complications.

Conclusion: Proper management of blood pressure during surgical exposure safely reduces operative blood loss and transfusion requirements in the AIS patient. MAP below 65 during surgical exposure is well tolerated and did not lead to any neurologic complications.

Significance: Reduction of MAP during surgical exposure reduces blood loss and transfusion requirements. Allogenic transfusions can lead to adverse outcomes and is a common concern for families considering spinal fusion surgery.

SE-MAP Group	ASF Blood Loss (ml)	PSF Blood Loss (ml)	Transfused Units All Patients
1	276 +/- 130	739 +/- 767	0.5 +/- 0.72
2	347 +/- 178*	1022 +/- 731*	0.42 +/- 0.65
3	431 +/- 267*	1033 +/- 848	0.71 +/- 0.98*
	* $p < 0.05$ (grp 1 vs 2; grp 1 vs 3)	* $p < 0.05$ (grp 1 vs 2)	* $p < 0.05$ (grp 2 vs 3)

E-Poster #17

Male vs. Female Adult Deformity Surgery: Is There a Difference in Complications and Outcomes?

Geoffrey A. Cronen, MD (Florida Medical Clinic); Lukas P. Zebala, MD; Lawrence G. Lenke, MD; Daniel S. Mulconrey, MD; Peter S. Rose, MD; Joshua D. Auerbach, MD; Brenda Sides, MA; Keith H. Bridwell, MD

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Introduction: Research has shown that gender affects surgical outcomes in adolescent idiopathic scoliosis. The study purpose was to assess genders role on outcomes in adult spinal deformity.

Methods: Consecutive case series of 62 adult deformity patients with minimum 5 level fusion at a minimum 2-year follow-up (F/U). 32 males were matched (age, curve type, surgical approach, instrumentation) to 30 females (2 males without matches). Radiographic and functional outcomes were compared at preop and F/U. Complications were listed as recommended by Glassman et al (Spine 2007).

Results: Male and female patients had similar average age (29.4 vs 32.2 years, $p=0.07$). Males had larger preop main curve Cobb (65.3 vs 55.5°, $p=0.03$), T2-T5 Cobb (11.6 vs 4.8°, $p=0.01$) and C7 plumb (0 vs -17.9 mm, $p=0.02$) than females. Males had more postop T2-T5 kyphosis (13.2° vs 8.1°, $p=0.01$) and C7 plumb kyphosis at F/U, but other radiographic measures were similar. Males had longer surgical times (468 vs 411 min, $p=0.04$) and greater intraoperative blood loss (1198 vs 928 ml, $p=0.03$). Males had greater preop ODI (45.6 vs 21.6, $p=0.01$) than females. Males had significant ODI improvement at F/U (26.1, $p=0.04$) but not females (16.6, $p=0.38$). Male preop SRS total score (62.8) was similar to female (63.0, $p=0.97$) and both males (74.1, $p=0.04$) and females (76.7, $p=0.01$) had improvement at F/U. 10 males (17 complications, 13 major) and 3 females (3 complications, 1 major) had postoperative complications ($p=0.09$). 4 males and 0 females ($p=0.13$) had revision surgery during F/U.

Conclusion: Male adult deformity patients had greater initial curve magnitude than females, but achieved similar deformity correction. Males had longer surgical times and greater blood loss than females. A trend for greater perioperative complication and revision surgery occurred in males. SRS total score improved significantly in both groups, but surprisingly ODI improved only in males at F/U.

Radiographic Parameter	Time	Male	Female	p-value
Age (years)		29.4±12.1	32.2±12.8	0.07
Operative Time (min)		468±133	411±113	0.04
EBL (ml)		1198±586	928±415	0.03
Complications		10	3	0.09
Revision		4	0	0.13
Major Curve (°)	Preop	65.3±15.4	55.5±11.4	0.03
	Postop	31.6±17.0	33.5±13.2	0.84
	2y/final	32.2±18.5	35.2±14.7	0.64
Trunk Shift (mm)	Preop	-2.1±17.9	3.2±14.6	0.57
	Postop	-7.3±15.8	-1.0±17.5	0.15
	2y/final	-8.3±12.9	-2.5±6.6	0.21
Clavicle Angle (°)	Preop	-1.8±4.1	-0.4±2.9	0.34
	Postop	0±4.9	0.7±2.4	0.75
	2y/final	-0.9±2.9	0.6±3.3	0.22
Coronal Balance (mm)	Preop	-11.5±15.0	-1.3±15.8	0.07
	Postop	-7.9±24.2	-5.4±10.9	0.74
	2y/final	-8.9±20.7	-0.6±14.1	0.22
T2-T12 (°)	Preop	58.2±21.8	52.8±25.5	0.19
	Postop	47.1±12.5	46.7±18.2	0.83
	2y/final	50.6±16.2	49.2±15.4	0.68
T5-T12 (°)	Preop	47.2±24.1	47.7±28.2	0.98
	Postop	36.2±12.8	39.9±1.2	0.42
	2y/final	38.3±14.9	36.7±15.4	0.44
T2-T5 (°)	Preop	11.6±10.7	4.8±5.4	0.01
	Postop	13.2±7.1	8.1±5.9	0.01
	2y/final	14.9±11.1	10.8±8.4	0.13

Radiographic Parameter	Time	Male	Female	p-value
T10-L2 (°)	Preop	15.7±23.4	1.6±21.7	0.08
	Postop	4.8±16.9	6.6±10.8	0.81
	2y/final	7.6±13.7	5.4±13.1	0.89
T12-S1 (°)	Preop	-63.0±19.5	-67.8±20.0	0.21
	Postop	-55.3±17.7	-47.8±36.1	0.3
	2y/final	-52.6±37.0	-54.7±37.1	0.81
C7 Plumb (mm)	Preop	0±30.6	-17.9±30.3	0.02
	Postop	7.7±31.6	-10.4±21.1	0.03
	2y/final	-8.8±28.4	-23.1±30.3	0.02
SRS Total	Preop	62.8±16.9	63.0±10.3	0.97
	2yr/final	74.1±14.8	76.7±13.7	0.6
SRS Domain	Preop			
Activity		3.4±1.1	3.8±0.6	0.25
Self-Image		3.1±0.8	2.9±0.7	0.43
Mental Health		3.4±0.5	3.7±1.0	0.3
Pain		3.0±1.0	3.3±1.0	0.43
Subscore		3.3±0.8	3.4±0.7	0.62
Satisfaction		2.9±1.1	3.4±0.8	0.31
SRS Domain	2yr/final			
Activity		3.9±0.9	3.8±0.7	0.67
Self-Image		3.8±1.0	3.8±0.7	0.88
Mental Health		3.7±0.8	4.0±0.8	0.21
Pain		3.8±1.0	4.0±0.9	0.64
Subscore		3.8±0.9	4.0±0.6	0.33
Satisfaction		4.0±1.2	4.2±0.9	0.46
ODI	Preop	45.6±23.6	21.6±17.3	0.01
	2yr/final	26.1±23.5	16.6±14.5	0.16

Significance: Adult deformity males achieve similar radiographic outcomes after surgery as females but with greater operative time and blood loss. Adult males may have more complications and need for revision surgery than females. At F/U, both groups had improved SRS total scores, but surprisingly ODI improved significantly only in males.

E-Poster #18

Pediatric Iliac Column Morphology Changes During Growth

Arun K. Reddy, MD (Children's Mercy Hospital) ; Richard M. Schwend, MD; Douglas C. Rivard, MD

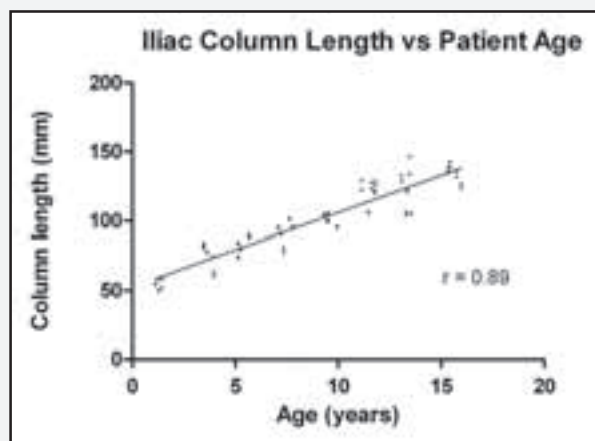
Introduction: The iliac columns have been increasingly utilized for pelvic implant anchorage in pediatric spinal deformity, particularly early onset scoliosis. The purpose of this study was to establish age specific iliac column measurements for growing children.

Methods: Pelvic CT scans of 40 normal children (five in each age group 1, 3, 5, 7, 9, 11, 13 and 15 years) were reconstructed into multi-planar and 3D formats using Vitrea®Software. The 80 iliac columns were noted to be relatively straight columns extending from the PSIS to the AILS. A virtual screw trajectory was made along the iliac columns, and measurements were obtained, including the length of this screw trajectory and maximum diameter of a screw that could safely be placed.

Results: One year old children had a mean iliac column length of 54.9 (SD 3.7) mm which could accept a screw diameter of 4.6 (SD 0.4) mm. By age 15 years the column length was 135 SD 5.9 mm with a screw diameter of 12.4 (SD 1.6) mm. Significant linear increases with age were noted for column length, maximum screw diameter, volume, distance of center of screw above the sciatic notch and distance of center of screw above the acetabulum ($p < 0.0001$). The strongest correlation was for iliac column length to patient height ($r^2 = 0.94$) and to patient age ($r^2 = 0.89$) (graph). The transverse plane column angle from the midline was constant with increasing patient age (mean 19.8 (SD 3.5) degrees), whereas the sagittal column angle from vertical increased from 30.7 (SD 4.2) degrees at age one year to 39.1 (SD 4.6) degrees at age 15 years.

Conclusion: There are predictable linear increases in iliac column length and diameter and relatively constant transverse plane orientation between ages 1 and 15 years.

Significance: This normative data suggests that predictable age specific implant size and orientation is possible when extending spinal instrumentation into the pediatric pelvis.



E-Poster #19

Pulmonary Cement Embolism after Multilevel Percutaneous Vertebroplasty

Cagatay Ozturk, MD (Istanbul Spine Center, Florence Nightingale Hospital); Ahmet Alanay, MD; Selhan Karadereliler, MD; Mursel Debre, MD; Neslihan Aksu, MD; Azmi Hamzaoglu, MD

Introduction: The reported incidence of pulmonary cement embolism in vertebroplasty is 4.6%. The aim of this study was to determine the frequency of pulmonary cement embolism after multilevel (more than 3 levels) PV in our institution.

Methods: Between 2002-2007, 598 percutaneous vertebroplasties were performed in 148 patients (106 women and 42 men) in our institution. Except 16 patients in whom multilevel vertebroplasty was performed in two stage (2 or 3 day interval), all procedures were performed in single stage. If the patient have an excessive osteoporosis (t score < 3.0), prophylactic vertebroplasty should be done in order to prevent further neighboring vertebral fractures. Postprocedural chest radiographs were obtained for all patients and assessed for the presence of pulmonary cement emboli.

Results: The minimum follow-up period was 2 years. The mean age of the patients was 77 years. 52% of the procedures were done in thoracic region and the rest in lumbar region. Pulmonary cement embolism was detected on chest radiographs and confirmed with chest computed tomography (CT) in 11 patients treated with multilevel percutaneous vertebroplasty for osteoporotic fracture. Single stage procedure was performed in all 11 patients. Five of these 11 patients developed mild dyspnea and chest discomfort 1-5 hours (mean 2.5 hours) after the procedure. The remaining 6 patients with pulmonary cement emboli detected by chest radiographs were asymptomatic. The frequency of pulmonary cement embolism was 7.4%.

Conclusion: The incidence of pulmonary embolism caused by cement in multilevel VP (7.4%) is higher than general occurrence rate reported in literature (4.6%). To avoid this complication, the cement should be injected with caution and under fluoroscopic control during the pasty polymerization phase. There were no pulmonary embolism in patients in whom multiple level VP were done in two different session. So, in our opinion, vertebroplasty more than 3 levels should be done in two different sessions.

E-Poster #20

Which is a Better ALIF Graft at the Base of a Long Fusion to the Sacrum in Patients Over Age 60: Titanium Mesh Cage vs. Patellar Allograft?

Brian A. O'Shaughnessy, MD (Northwestern University); Frank L. Acosta, MD; Patrick A. Sugrue, MD; Jamal McClendon, MD; Tyler Koski, MD; Stephen L. Ondra, MD

Introduction: ALIF is commonly performed at caudal segments of long posterior fusions to the sacrum. In patients over age 60, we hypothesized that PAs would result in equally high fusion rates as TMCs and perhaps less settling.

Methods: Patients over 60 who had a long (>6 levels) posterior fusion to the sacrum between 2002-2005 were studied. A matched cohort analysis was performed comparing ALIFs with TMCs to PAs. ALIFs were performed through a mini-open approach. In addition to either a TMC or PA, 4-mg of rhBMP-2 was used at each level. Minimum f/u for all patients was 2 years.

Results: 35 patients (9M/26F), mean age of 69.7±5.5 years, had a total of 72 ALIFs performed (41 TMC/28 PA). Mean f/u 4.7±0.9 years. The TMC cohort had 18 patients and 37 ALIFs (2.1±0.8 levels/pt). The PA cohort had 17 patients and 35 ALIFs (2.1±1.2 levels/pt). Mean number of posterior fusion levels were similar (TMC=11.6±5.2 vs PA=9.5±4.2). Final improvement in lumbar lordosis (TMC=8.41° vs PA=10.6°) and sagittal vertical axis (SVA) (TMC=25.2 mm vs PA=31.9 mm) were also similar. There was no statistical difference in loss of lumbar lordosis prior to solid fusion (TMC=4.75° vs PA=2.26°, P=0.452). A greater number of ALIFs in the PA group were "definitely fused" (TMC=54.1% vs PA=91.4%, P=0.005); a similar number were "probably fused" (TMC=94.6% vs PA=100.0%) according to Bridwell's fusion assessment. There was no case of PA graft resorption. There was a greater prevalence of graft settling in the TMC population (TMC=51.4% vs PA=17.1%, P=0.003). The amount of graft settling was also greater in the TMC group (TMC=5.35±1.8 mm vs PA=2.51±1.2 mm, P=0.012).

Conclusion: Both TMCs and PAs are viable ALIF grafts at the caudal segments of a long fusion to the sacrum in patients over age 60. PAs, however, are more easily judged to be fused and result in significantly less graft subsidence than TMCs.

Significance: An ALIF graft with a modulus of elasticity closer to that of native bone, such as a PA, may be a better option in the aging spine than TMCs. Additionally, the ease of fusion assessment and revision makes PA an attractive structural graft option for ALIF.

E-Poster #21

A New Low Profile Sacro-Pelvic Fixation Using S2 Alar Iliac (S2AI) Screws in Adult Deformity Fusion to the Sacrum: A Prospective Study with Minimum Two-Year Follow-Up

Khaled M. Kebaish, MD (Johns Hopkins Hospital); Albert Pull ter Gunne, MD; Ahmed S. Mohamed, MD; Ryan Zimmerman; Phebe S. Ko, BS; Richard L. Skolasky, ScD; Joseph R. O'Brien, MD, MPH; Paul D. Sponseller, MD;

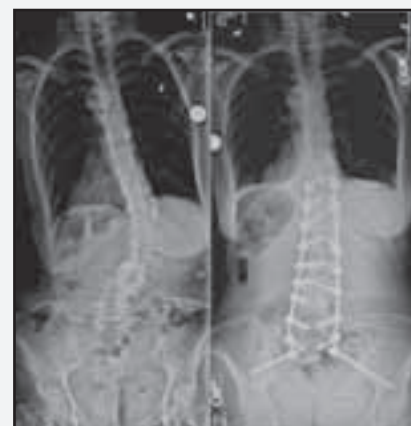
Introduction: Adult deformity patients undergoing long fusion to the sacrum often require fixation into the ilium. There are many techniques currently available, some are technically difficult & require complex connectors that may affect the construct stability

Methods: We prospectively reviewed 52 consecutive adults undergoing long fusion to the Sacrum using (S2AI) Screws. The technique uses a starting point in the S2 Ala, directed toward the anterior inferior iliac spine, allowing an in-line anchor without additional dissection. Functional outcome, radiographic data and complications were collected. 46 patients completed 2 yrs follow-up, mean 2.5 yrs.

Results: The mean age was 59.8 yrs (± 13.0 , 23.8-80.8). 76.9 % female, 45 patients had multiple co-morbidities. Mean radiographic changes were (pre-/post): thoracic kyphosis 7.4° (34.2/41.3), lumbar lordosis 13.0°(34.3/47.3), thoracic curve 10.9°(22.3/15.1), lumbar curve 15.1°(30.4/15.3), pelvic obliquity 1.6 (± 5.1 , -5.5-19.1). At 2 yrs, 92% of the patients showed radiographic fusion at L4-S1. 2 patients had 3 (S2I) screws fracture, neither required revision. Re-operation was performed on 5 patients: improper screw placement (1), pseudoarthrosis proximal to L4 (2), junctional stenosis (1), residual deformity (1). Overall complication rate was 40.4 % (7.7 % minor, 34.6 % major). Complications specific to S2-iliac fixation: screw breakage 2, screw misplacement 1. There was statically significant improvement in all SRS 22 domains; (pre-/post): pain 1.1 (2.17/3.22), self image 1.1 (2.12/3.19), activity 0.8 (2.39/3.16), mental 1.2 (1.89-3.07), and satisfaction 0.9 (1.91/2.84). The ODI showed a mean decrease 13.4 (40.16/26.79), the SF-12 improvement (physical 12.3, mental 2.2). The VAS showed 5 patients with right SI-joint area pain (mean 4.8), 4 patients had left side pain (mean 5.5). There was one superficial and one deep wound infections.

Conclusion: S2 Alar Iliac (S2AI) fixation is an easy, safe & effective method to achieve sacropelvic fixation. Complications related to the technique are rare and the revision rate is low

Significance: We are introducing a new technique for sacro-pelvic fixation that has the potential to simplify fusion to the sacrum, lower complications & improve outcome in spinal deformity surgery



Pre & post-operative radiographs using S2AI sacropelvic fixation in a 64 yo female with degenerative scoliosis

E-Poster #22

Kyphectomy and Segmental Spinal Fusion in Children with Myelomeningocele Kyphosis

Haluk Altiok, MD; Craig J. Finlayson, MD; Peter F. Sturm, MD (Shriners Hospitals for Children); Kim Hammerberg, MD; Sahar Hassani, MS

Introduction: The prevalence of rigid kyphosis of the lumbar spine in myelomeningocele patient ranges from 8% to 15% depending on the series. The deformity is progressive in all cases and is recalcitrant to nonsurgical treatment. Progression of these curves can range from 4° to 12° per year. Skin breakdown, poor balance and support and related sitting problems, compression of the abdominal contents, and respiratory compromise are usually the leading indications for surgical treatment. Kyphectomy and segmental spinal fusion is not only technically challenging but also associated with significant risks and complications.

Methods: This was a retrospective study of patients with myelomeningocele kyphosis who were treated with kyphectomy and segmental spinal fusion. 33 patients underwent the procedure over a 16 year period. Complete chart and radiological reviews were available for 21 patients who had at least 2 year follow-up.

Results: Average age for the study group at the time of surgery was 8 years (range, 3-19 years). All patients

were thoracic level except one with L1 level. Skin breakdown was the most common indication for surgery and was noted in 17 of 21 patients. Pelvic fixation was carried out with a modified Dunn-McCarthy technique in 20 patients. Estimated blood loss average was 739cc. There was one death intra-operatively. Skin and wound healing problems were encountered in 9 patients. Pseudoarthrosis was present in 5 of the patients. Hardware failure was noted in 6 patients, 3 of whom had a pseudoarthrosis. The initial kyphosis (average 123°) was reduced to 22.5° (range 4° to 70°) with an average improvement of 82%. Kyphosis correction at final follow-up was 79.5%. The average decrease in lordosis was 47% (0-82%). At final follow-up, the average lordosis was 33.8°.

Conclusion: Surgical correction of myelomeningocele kyphosis is a technically challenging operation with potential peri and post operative complications. Despite this, surgical correction of the deformity and maintenance of the correction is possible with excellent pelvic fixation using the modified Dunn-McCarthy technique.

Significance: This study provides information in regards to the management of myelomeningocele kyphosis based on the experience of a single institute over 16 year period.

E-Poster #23

Dual Growing Rod Instrumentation with Pedicle Screw Foundation at a Single Institution: Assessment of Outcomes and Complications

Lukas P. Zebala, MD (Washington University School of Medicine); Timothy R. Kuklo, MD, JD; Lawrence G. Lenke, MD; Scott J. Luhmann, Joshua D. Auerbach, MD; Keith H. Bridwell, MD

Introduction: Early onset scoliosis (EOS) is often refractory to nonoperative treatment and frequently requires growing rod (GR) techniques. The study purpose was to report GR outcomes with pedicle screw fixation (PS) at one institution.

Methods: Consecutive case series of 16 patients (6M, 10F) with minimum 2-year follow-up (F/U) treated with GR for progressive scoliosis (6 idiopathic, 8 syndromic and 2 congenital). Average age at initial surgery was 4.9±1.8 years. All patients had dual rod (3.5 or 4.5 mm) submuscular GR with mainly PS anchors. 4 patients had anterior spinal fusion prior to GR. Average F/U was 3.5±1.5 years.

Results: There were 6.1±3 lengthenings/pt (total surgeries 8.0±3) at an interval of 7.7±2.3 months. 9 patients had an unexpected return to the OR with 66% having multiple returns (range, 1-3). Main curve Cobb improved from 73.°±16.9 to 46.8°±14.9 (p<0.001) after GR and 43.8±17.5° (p<0.001) at last F/U. Coronal and sagittal balance, T2-T12, T5-T12 and T12-S1 Cobb angles were not statistically different at F/U. T1-S1 length increased from 26.2±4.3 cm to 29.9±4.2 cm (p=0.04) after initial GR insertion and 32.9±3.9 cm (p<0.001; total 6.9±2.0) after last F/U, and average growth was 1.2±0.4 cm/year. T1-T12 length increased from 15.5±3.0 cm to 17.8±2.7 cm (p=0.05) after initial GR insertion and 20.2±3.9 cm (p=0.002) after last F/U. 10 patients had broken rods with 70% having multiple occurrences of broken rods. 127 PS were implanted with only 12 (9%) PS revisions for loosening (no catastrophic failures) during F/U. 3 infections (1 superficial, 1 deep, 1 superficial at ICBG site) occurred during F/U. 2 patients had definitive fusion during F/U.

Conclusion: GR with PS is effective in controlling coronal (37% main curve correction) and sagittal deformity. GR provided an average spinal elongation of 3.7 cm and an average of 3.2 cm of spinal growth at last F/U. Broken rods are common (59%) but did not compromise outcome and were easily revised. PS appear safe and effective (9% needing revision) as anchors without catastrophic failure.

Significance: GR with PS anchors is effective at controlling scoliosis and allows for spinal growth. PS complications were minimal. Broken rods are common and families should be advised of this occurrence.

E-Poster #24

Selective Treatment of the Thoracic Curve by VEPTR in the Growing Spine: What Happens to the Lumbar Curve?

Amer F. Samdani, MD (Shriners Hospitals for Children, Philadelphia); John Birknes, MD; Reed C. Williams; Norman Ramirez, MD; John M. Flynn, MD; Randal R. Betz, MD

Introduction: Selective thoracic fusion for AIS relies on spontaneous correction of the lumbar curve. It remains unknown whether or not these principles apply with growing systems. The purpose of this study was to examine the response of the lumbar curve after treatment of the thoracic curve.

Methods: We retrospectively identified 14 patients with two-year follow up who had undergone unilateral VEPTR placement with caudal instrumentation between T11-L2. Pre-op and two-year radiographs were analyzed for: thoracic and lumbar Cobb angles, coronal/sagittal balance, lumbar rotation/apical translation, and Lenke modifier. Paired t-test was used to compare preoperative and two-year data.

Results: The mean age at surgery was 5.2 years with a mean follow-up of 3.3 years. Diagnoses included congenital (10), infantile (3), and neurofibromatosis (1). The thoracic curves improved from 62±16 to 39±15 degrees (p<.001), for a correction of 40%. The lumbar curves improved from 38±17 to 20±10 degrees (p<.001), for a correction of 49%. Overall coronal balance improved from 3.0±1.8 cm to 1.5±1.4 cm (p=.001). No differences were seen in sagittal balance, rotation, or apical translation.

Conclusion: In the growing child, selective instrumentation of the thoracic curve with VEPTR may result in a compensatory decrease of the lumbar curve. This may spare lumbar motion segments when definitive fusion is performed.

Significance: Selective treatment of the thoracic curve in the growing spine may result in a compensatory decrease in the lumbar curve. This may spare motion segments when definitive fusion is undertaken.

Table 1: Summary of Results

	Avg Age	Follow-up	Thoracic Cobb Correction	Lumbar Cobb Correction	Coronal Balance Imprvd
VEPTR ≥ L2	5.2 yrs	3.3 yrs	40%	49%	1.5cms

E-Poster #25

Biomechanical Importance of S1 and Iliac Fixation When Instrumenting to the Pelvis: Analysis of Four Modern Lumbosacral Fixation Techniques

John Tis, MD; Melvin D. Helgeson, MD; Anton E. Dmitriev, MSc, PhD(c); Ronald A. Lehman, MD (Walter Reed Army Medical Center)

Introduction: We set out To evaluate the stabilizing potential of four techniques of lumbosacral fixation: modified Galveston technique, iliac screws connected caudal to S1, iliac screws connected cephalad to S1, and S2 screws without iliac screws.

Methods: Thirty two(n=32) calf spines (L2-Sacrum/pelvis) were tested under axial rotation, flexion/extension, and lateral bending. Groups included: Group 1 - Modified Galveston technique(no S1 fixation) (n=8); Group 2 - S1 screws & iliac screws w/ crosslinks distal to S1 (n=8); Group 3 - S1 screws and iliac screws w/ crosslinkscephalad to S1 (n=8); and Group 4 - S1 and S2 screws without iliac fixation (n=8). Following non-destructive testing, specimens were fixed& flexed to failure, with peak failure moment (Nm).

Results: During ROM testing, all reconstructions significantly reduced lumbosacral ROM under all methods of loading. There was a significant increase in flexion/extension at L6-S1; without S1 fixation (Group 1) compared to Groups 2,3,4. When crosslinks were not included, Group 3 had sig. less ROM in axial rotation compared to Group 4 (S1,S2). Furthermore, there was a trend towards decreased axial rotation ROM (p=0.08) when comparing Group 3 to Group 1. There were no sig. differences between groups for lateral bending at L3-S1 or L6-S1. There was a sig. decrease in ROM when crosslinks were added to the constructs in all 4 groups. During destructive testing, peak failure moments for the different reconstructions were 71.7 Nm, 65.4 Nm, 73.9 Nm, 32.2 Nm, respectively. Group 4 showed a sig. reduction in peak failure compared to

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Group 1 ($p < 0.001$), Group 2 ($p = 0.001$), and Group 3 ($p < 0.001$). There was no significant difference between Groups 1, 2, and 3 during destructive testing.

Conclusion: S1 screws are essential when instrumenting to the ilium. S2 screws were inferior to iliac fixation (iliac screws or Galveston technique). Crosslinks significantly improve construct stiffness when placed near the S1 sacral screws.

Significance: S1 screws are essential when instrumenting to the ilium. S2 screws were inferior to iliac fixation (iliac screws or Galveston technique). Crosslinks significantly improve construct stiffness when placed near the S1 sacral screws.

E-Poster #26

Transpedicular Bi-Vertebrae Wedge Osteotomy and Discectomy in Lumbar Spine for Severe Ankylosing Spondylitis

Yan Wang, MD (Chinese PLA General Hospital); Yonggang Zhang, MD; Xuesong Zhang, MD

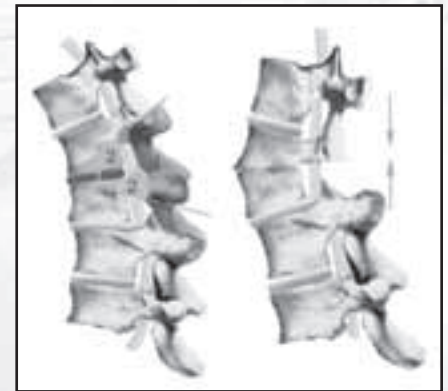
Introduction: We have developed a modified single stage PSO technique, involving a transpedicular bi-vertebrae single wedge resection in the lumbar spine to manage the sagittal plane deformity in ankylosing spondylitis with Chin-brow vertical angles beyond 90° . We report our experience, surgical technique and minimum 2 year results.

Methods: From Jan 2003 to May 2007, eight patients (3 males, 5 females) with severe ankylosing spondylitis in our institution underwent a single stage transpedicular bi-vertebrae wedge osteotomy and discectomy. The operation technique includes resection of the posterior elements of two adjacent vertebrae, resection of the inferior-posterior aspect of proximal vertebra and the superior-posterior aspect of the distal vertebra, followed by posterior instrumentation with pedicle screws and spinal fusion. Preoperative and postoperative height, Chin-brow vertical angle, sagittal balance and sagittal Cobb angle of the vertebral osteotomy segment were documented. Intraoperative, postoperative and general complications were registered.

Results: The mean follow-up was 18.7 ± 6.1 months (range 14 to 54 months). The mean duration of surgery was 236 minutes (range, 198-310 minutes), and the average volume of intraoperative blood loss was 2200 ml (range, 1600-3860 ml). The patients' height increased from 120.5 ± 12.0 cm to 159.6 ± 12.4 cm ($p = 0.000$). The mean Chin-brow vertical angle was improved from $102.8 \pm 9.7^\circ$ to $19.3 \pm 13.9^\circ$ ($p = 0.000$). The spinal sagittal Cobb angle of the vertebral osteotomy segment was corrected from kyphosis $38.6 \pm 16.5^\circ$ to lordosis $26.6 \pm 10.1^\circ$ ($p = 0.000$). One patient with involvement of the cervical spine suffered a extension spinal fracture at C5/6 as the operating table was extended. Translation at the osteotomy site occurred in one patient during the correction. Fusion of the osteotomy was achieved in all patients, and no loosening or breakage of pedicle screws was found.

Conclusion: In cases of severe ankylosing spondylitis kyphosis with Chin-brow vertical angles beyond 90° , a single stage transpedicular bi-vertebrae wedge osteotomy and discectomy is an effective corrected method of correction.

Significance: This method is highly effective in correcting sagittal imbalance requiring more than 50° correction at the osteotomized level.



Schematic illustration of transpedicular bi-vertebrae wedge osteotomy and discectomy. (A): Lateral view outlines the bone block to be resected and the resecting sequence; (B): Closure of the vertebra wedge osteotomy and discectomy; excellent stability of anterior column (bone-on-bone) was achieved

E-Poster #27

Diagnostic Efficacy of CT Guided Percutaneous Biopsy in Spinal Lesions

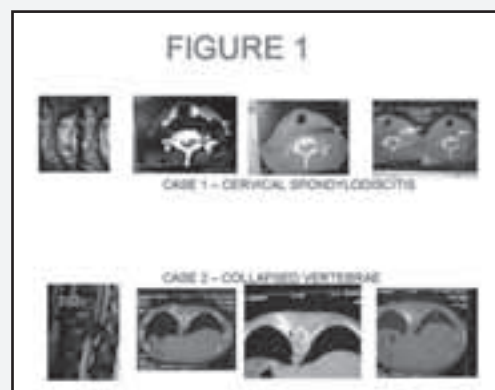
Vishal Kundnani, MS, FASSI (P.D. Hinduja Hospital & M.R.C); Uday M. Pawar, MD; Abhay Nene, MD

Introduction: 1.To determine the efficacy CT-guided biopsies in spinal lesions in regards to Predictive value, Diagnostic Yield, Accuracy and Safety 2.To emphasise the technique & importance of fine resolution CT guided percutaneous biopsy for spinal lesions

Methods: Between 2003-2007, 282 procedures performed in 266 patients with spinal lesions of various nature, without definitive diagnostic clinico-radiological features, (Spondylodiscitis -136, collapsed vertebrae-61, lytic vertebrae-14, sclerotic lesion-18, MRI abnormal signal-37) subjected to CT guided percutaneous biopsy, performed under local anaesthesia on a day care basis, were studied prospectively in this study. Biopsy specimens were sent for histopathological, cytological analysis & Bacteriologic studies with needful culture /sensitivity studies performed when indicated clinico radiologically. An independent observer blinded for objective of study analyzed the results for Diagnostic Yield (Ability to generate tissue sample adequate for pathologic examination) and Accuracy (Ability to generate correct diagnosis in positive cases) confirmed later during definitive treatment / surgery. Statistical analysis was done to evaluate the diagnostic predictive value.

Results: The time taken for biopsy, including the pre-biopsy CT examination time, varied from 21 min to 60 min (median 35 min). In 241 patients representative tissue good enough for histopathological evaluation was obtained (227 single session, 12 patients 2 session, 2 patients three session), while 25 patients had inconclusive results (diagnostic yield of 88.41%) because of scanty tissue / non-representative tissue. None of the patients had any major complication (Pneumothorax / Haemothorax, Neurological injury) during the procedure and subsequently at 6 month follow up. The overall diagnostic yield and accuracy rate for spinal lesions were 88.41% and 95.74%. Positive predictive value of diagnostic procedure was >95 %

Conclusion: Percutaneous biopsy method used in conjunction with CT guidance has excellent potential to result in preoperative diagnosis of spinal lesions with great safety and precision thus avoiding unnecessary surgery for doubtful diagnosis.



E-Poster #28

Post-Operative Complications following Surgery for Degenerative Lumbar Scoliosis in Patients Older than Age 70

Christopher Furey, MD (Case Western Reserve University); Sanford Emery, MD; Jung Yoo, MD; Henry Bohlman, MD

Introduction: Our objective was to identify the nature and frequency of major post-operative complications in older patients undergoing posterior decompression and fusion for degenerative lumbar scoliosis and to determine their effect upon clinical outcome.

Methods: 67 consecutive patients underwent surgery over an eight year period. The average follow-up was 5.6 years. Each patient had a posterolateral fusion with iliac crest bone graft and forty patients had pedicle screw instrumentation. Clinical outcome was evaluated with a visual analogue score, an Oswestry Disability Index, and a specific inquiry as to the effect of the complication on one's ultimate outcome.

Results: 4 patients had major medical complication: 1 patient died of a massive MI and heart failure, 2 others had an MI, 1 a pulmonary embolus, and 1 a massive CVA. Surgical complications requiring additional surgery in the immediate post-operative period occurred in 8 patients: 2 deep space infections, 2 epidural hematomas, 2 malpositioned pedicle screw, and 1 pseudomeningocele. Statistically significant risk factors for development of a medical complication included diabetes, smoking, a body mass index of greater than 1.5, and a history of cardiac disease which required prior intervention. Statistically significant

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risk factors for development of a surgical complication were osteoporosis, prior lumbar surgery, a fusion of more than 5 levels, and surgery lasting more than 4 hours. The average improvement in VAS was 5.2 in patients without a complication and 4.9 in patients with a complication ($p=.04$). The post-operative ODI was 9.2 in those without a complication and 11.1 in those with a complication ($p=.03$). 6 of 10 surviving patients felt their complication had a severe effect upon their ultimate outcome. The occurrence of a complication increased the hospital stay an average of 1.4 days ($p=.03$) and the cost of treatment an average \$5200 ($p=.02$).

Conclusion: Proper patient selection and attention to detail will help minimize the incidence and severity of these complications.

Significance: Post-operative complications following surgical management of degenerative lumbar scoliosis significantly affects clinical outcome, lengthens the hospital stay, and increases the cost of treatment.

E-Poster #29

Disproportional Systemic Bone Growth and Ossification in Adolescent Idiopathic Scoliosis

Hiu-Yan Yeung, PhD (The Chinese University of Hong Kong) Feng Zhu, MD; Wang William Wei-jun, PhD; Vivian W. Y. Hung; Tsz-ping Lam, BS, MS; Prof. Ling Qin; Kwong-man Lee, MD; Yong Qiu, PhD; Prof. Jack Cheng

Introduction: Abnormal anthropometric measurements during the peripubertal growth spurt has been documented in AIS. Previous MRI studies of the spine have suggested a disproportionate endochondral and membranous ossification in AIS. The present study aim at investigating whether disproportional ossification and skeletal growth occurred in the peripheral bone of AIS patients Vs normal controls using the radius as the target bone.

Methods: Skeletally mature AIS girls with different severity ($n=290$) were recruited from the Scoliosis Clinic together with age-matched healthy girls ($n=80$) as normal control. The anthropometric parameters including body weight, arm span, radius length, and body mass index (BMI) were recorded. The midshaft of non-dominant radius was scanned with peripheral quantitative computed tomography (pQCT) and the radius width was calculated from the cross-sectional area. Radius geometry ratio was derived from the ratio of radius width to radius length. The Anthropometric parameters were compared between AIS and control with adjustment for age. The radius geometry ratio was further correlated with curve severity in AIS girls using Pearson's correlation test.

Results: This analysis showed that the arm span and radius length were longer in AIS girls. The BMI of AIS girls was significantly lower than the controls. The radius geometry, in severe AIS girls was significantly lower than the controls and was found to correlate with the curve severity ($r=-0.120$; $p=0.039$).

Conclusion: The abnormal radius geometry ratio supported the presence of systemic growth abnormalities in AIS. Disproportional endochondral ossification (which is responsible for the growth in length) vs. membranous ossification (responsible for the appositional growth of the diameter and width) could explain for the observation. The disproportionate skeletal growth was also found to be positively associated with the curve severity of AIS girls.

Significance: Abnormal skeletal growth has been suggested to play an important role in the etiopathogenesis of AIS. The radius geometry could be an important new prognostic factor in predicting curve progression in AIS and merits further larger scale longitudinal studies.

E-Poster #30

A New Measure to Quantify Chest Wall Deformity in Scoliosis Patients. Does Rib Hump Measurement Correlate with Anterior Chest Wall Deformity Post Surgery?

Matthew J. Shaw, MBBS FRCS (Mater Childrens Hospital); Clayton Adam; Maree T. Izatt; Robert Labrom, MD; Geoffrey Askin, MD

Introduction: The primary aims of scoliosis surgery are to halt the progression of the deformity, and to reduce its severity (cosmesis). Currently, deformity correction is measured in terms of posterior parameters (Cobb angles and rib hump), even though the cosmetic concern for most patients is anterior chest wall deformity. In this study, we propose a new measure for assessing anterior chest wall deformity and examine the correlation between rib hump and the new measure.

Methods: 22 sets of CT scans were retrieved from the Paediatric Spinal Research Database. The Image J software (NIH) was used to manipulate formatted CT scans into 3-dimensional anterior chest wall reconstructions. A 'chest wall angle' was then measured in relation to the first sacral vertebral body. Two observers measured chest wall angles on two separate occasions one week apart. Inter and intra observer measurement differences were calculated for the new measure, and results correlated to clinical rib hump measurements for the same patients.

Results: The new anterior deformity measure was used to assess 22 sets of CT data (11 preop and 11 postop). Correlation analysis and linear regression were performed to investigate the relationship (if any) between rib hump and the new anterior deformity measure. The mean absolute intraobserver difference (repeated measures of anterior deformity by the same observer) was 0.9° (range $0-3^\circ$, SD 0.7°). The interobserver error (SD of the difference between measurements by 2 different observers) was $\sqrt{2} \times \text{SD} = 1.6^\circ$. There was no statistically significant relationship between anterior deformity and rib hump (linear regression $R^2=0.001$, correlation coefficient $=0.03$).

Conclusion: The chest wall angle is a reliable tool in the analysis of chest wall deformity. No correlation was found between the new measure and rib hump angle. This suggests that there is no correlation between anterior and posterior deformity measures. While most surgical procedures will adequately address the coronal imbalance & posterior rib hump elements of scoliosis, they do not reliably alter the anterior chest wall shape.

Significance: This study suggests that anterior chest wall deformity is to a large degree an intrinsic deformity, not directly related to vertebral rotation.

E-Poster #31

The Feasibility of Radiation-Free Diagnostic Monitoring in Adolescent Idiopathic Scoliosis using a Novel, Upright Positional MRI Protocol

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Introduction: The concerns over the oncologic potential of cumulative doses of ionizing radiation in children and adolescents being monitored in AIS has led to the search for radiation-free diagnostic imaging modalities, including MRI. We hypothesize that a novel, upright positional MRI protocol can produce reliable spinal curvature images compared with traditional Xray, and may serve as a radiation-free alternative to traditional diagnostic monitoring for curve progression in AIS.

Methods: Twenty consecutive patients (13F, 7M, average age 13.7yrs, range: 11-17yrs) with a diagnosis of AIS seen by a single surgeon were enrolled. Average major curve magnitude was 30.6° (range: $10-69^\circ$). Subjects underwent traditional plain radiographic scoliosis imaging (36" cassettes), followed within 1 week by upright MRI using a standardized protocol. Complete MRI data acquisition was performed in <7minutes using a steady-state gradient echo 3D pulse sequence (TE=5.608, TR=14.720, Flip angle=30 deg). The two volumes were stitched together to facilitate multi-planar reconstruction analysis. Two independent observers measured the major and minor Cobb angle magnitudes on each set of plain film and MRI images.

Results: There was excellent inter-rater reliability between plain film radiography and upright MRI measurements for major Cobb angle ($R=0.91$) and very strong reliability for minor Cobb angles ($R=0.81$). Intra-rater reliability for both Xray and MRI measurements of major Cobb angles was excellent ($R=0.96, 0.95$, respectively). Intra-rater reliability for both Xray and MRI measurements of the minor Cobb angles was also excellent ($R=0.96, 0.92$, respectively).

Conclusion: Our results show that upright positional MRI is capable of producing major and minor Cobb

angle measurements that highly correlate with traditional plain film radiographic measurements, and may therefore be a radiation-free alternative/substitute for diagnostic screening in AIS.

Significance: Radiation-free diagnostic screening for AIS can be performed safely, quickly (total data acquisition time: <7min), and with costs comparable to Xray imaging. We submit that upright, positional MRI may serve as an alternative/replacement for traditional ionizing imaging techniques.

E-Poster #32

The Effect of Implant Burden vs. Curve Magnitude on the Health of the Intervertebral Disc in Four Fusionless Scoliosis Treatment Strategies

John T. Braun, MD (U of Vermont)

Introduction: Though several fusionless scoliosis implant strategies have demonstrated effectiveness in animal models and humans, little data is available on the effect of these novel treatments on the health of the disc. Our previous work suggested a negative impact on instrumented but not subadjacent discs using two different implant strategies. The current study evaluates the role of implant burden and curve magnitude on disc health using four clinically relevant strategies.

Methods: Scoliosis was created in nineteen 8-week-old female goats using four different fusionless scoliosis implant strategies (T7-12). Treatment groups included 2 SMA staples per level (n=6), submaximally tensioned ligament tether (n=6), 3 SMA staples (n=3) and maximally tensioned ligament (n=4). Six untreated goats served as controls. At six months, instrumented and subadjacent discs were harvested and analyzed. Qualitative and quantitative analyses were performed using H&E sections of the discs, endplates and surrounding vascularity.

Results: All 25 animals completed the 6 month study without complication. Mild curves were created in the 2 staple and 3 staple groups (6.5 degrees in each) with more severe curves created in the submax and max ligament groups (41 and 53 degrees, respectively). Implant burden appeared to have a greater negative effect on the health of the instrumented discs than curve magnitude with cell density most decreased in the 3 staple group and least affected in the submax ligament group ($p < 0.01$). The subadjacent discs remained healthy in all groups.

Conclusion: The data in this study demonstrate that all four clinically relevant fusionless scoliosis implant strategies negatively impacted the health of instrumented but not subadjacent discs. The degree of change in the disc was more correlated with implant burden than curve magnitude.

Significance: This study improves our understanding of clinically relevant fusionless scoliosis implant strategies and their effect on the intervertebral disc.

E-Poster #33

Translational vs. Derotational Correction of Adult Scoliosis: A Comparison of Clinical and Radiographic Outcomes

Dennis Crandall, MD (Sonoran Spine Center); Jan Revella, RN

Introduction: Computer finite element analysis has shown decreased stress and improved deformity correction with segmental translational forces vs. rod derotation. This study compares clinical and radiographic outcomes in adult scoliosis patients corrected using these two techniques. This is also the largest series of adult scoliosis corrected by low-stress translation ever reported.

Methods: A prospective nonrandomized study of 126 consecutive adult scoliosis patients age 61 (19-88yrs) underwent posterior instrumented correction by one surgeon, followed 46mo (24-84mo); the first 17 by rod derotation/in situ rod bending, the next 109 by low-stress translation by slowly pulling the spine to a contoured rod via pivoting reduction posts attached to screws, simultaneously correcting both coronal and sagittal deformity. Anterior surgery: 15/17 derotation, 57/109 translation patients. Osteotomies: Derotation- 2, Translation- 4. Clinical and radiographic results (curves, sagittal T5-12, T10-L2, T12-S1, balance, pelvic

incidence) were analyzed by curve type.

Results: Translation group curves of 42°(range 10- ;87°) corrected 70% to 13°(0-48°) was better (P<0.01) than derotation group curves of 55°(25- ;84°) corrected 47% to 30°(10-59°). Translation group idiopathic scoliosis of 57°(26- ;87°) corrected 69% to 18°(4- ;48°) compared to 49% derotation group correction (thoracic curves 65%vs51%, thoracolumbar 76%vs44%, lumbar 76%vs67% , double major 60%vs34%). Translation vs derotation group correction for degenerative scoliosis was 72%vs 49%,. Derotation group complications included 3 nonunions(17%), 2 screw loosening, 1 broken rod, 1 infection. Translation group had 10 nonunions(9%), 5 infections, 10 adjacent fractures, 1 screw pullout, 1 broken rod. Oswestry preop 45(4-84) improved to 27(0-70); VAS preop 6.2(1-10) improved to 2.7 (0-8), not statistically different between groups at 2 years and later.

Conclusion: This study showed better deformity correction of by translation than rod derotation for all types adult scoliosis, without increased complications. Thoracolumbar, lumbar, and degenerative scoliosis benefited most.

Significance: Translation appears superior to rod derotation in correcting adult scoliosis.

E-Poster #34

The Effect of Tethered Cord Release on Scoliosis in Tight Filum Terminale

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Introduction: The association between neuromuscular scoliosis and tethered spinal cord has been well-documented, and most of these studies were based on patients with myelomeningocele. There have not been studies examining the effects of spinal cord untethering on scoliosis in children with tight filum terminale.

Methods: 45 pediatric patients with tight filum terminale who had undergone untethering were retrospectively reviewed to understand the effects of untethering on scoliosis progression

Results: 26 girls and 19 boys underwent tethered cord release at a mean age of 4.5 years. 14 of 45 (31%) patients presented with scoliosis. 5 patients had thoracic scoliosis, 7 had thoracolumbar scoliosis, and 2 had lumbar scoliosis. After untethering surgery (mean follow-up of 28 months), 7 curves progressed > 10 degrees (5 patients eventually underwent surgical fusion). 2 patients had curves that improved, and 5 stabilized. In the group of 31 patients without scoliosis on presentation, 2 patients developed de novo scoliosis > 10 degrees during the follow-up period. Therefore, at the end of follow-up period, 36 of 45 patients (80%) had stable or improved spinal alignment, while 9 of 45 patients (20%) progressed. In the multivariate analysis, patients who presented with a Cobb angle greater than 35 degrees were most likely to progress (p=0.002, OR=21). There was no operative morbidity or mortality associated with scoliosis surgery.

Conclusion: A significant number of children with tight filum terminale were found to have scoliosis in agreement with the literature. Tethered cord release may not stabilize scoliosis in a substantial number of these patients. Most patients with progressive curves needed scoliosis correction and spinal fusion.

Significance: A significant number of children with tight filum terminale were found to have scoliosis in agreement with the literature. Tethered cord release may not stabilize scoliosis in a substantial number of these patients. Most patients with progressive curves needed scoliosis correction and spinal fusion.

E-Poster #35

Comparative Radiographic Analysis Of The Sagittal Spinopelvic Alignment Between 100 Asymptomatic Adults And 100 Sagittally Imbalanced Patients: What Are The Critical Radiographic Parameters?

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Introduction: To find the better sagittal parameters for evaluation of sagittally imbalanced patients through the comparison with normal asymptomatic adults volunteers.

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Methods: Sagittal standing radiographs of the whole spine and pelvis in 200 adults (100 asymptomatic volunteers, 100 sagittally imbalanced patients who had a subsequent balancing operation) were evaluated. The following parameters were included: thoracic kyphosis (T5-T12), T12 horizontal angle, lumbar lordosis (T12-S1), sacral slope, pelvic incidence, pelvic tilt, C7 plumb, T12 plumb, C7 plumb to bicoxofemoral head distance and distance from posterosuperior endplate of S1 to bicoxofemoral head.

Results: The mean differences between two groups were 5° for thoracic kyphosis (32 NA vs. 26 SI, $p < 0.0001$), 31° for T12 horizontal angle (-22 NA vs. 10 SI, $p < 0.0001$), 45° for lumbar lordosis (-60 NA vs. -15 SI, $p < 0.0001$), 14° for sacral slope (38 NA vs. 24 SI, $p < 0.0001$), 19° for pelvic tilt (13 NA vs. 32 SI, $p < 0.0001$) and 5° for pelvic incidence (51 NA vs. 57 SI, $p = 0.003$). The mean differences between two groups were 16.3cm for sagittal vertical axis (-0.9cm NA vs. 15.5cm SI, $p < 0.0001$), 12.2cm for C7 plumb to bicoxofemoral head distance (-4.9cm NA vs. 7.4cm SI, $p < 0.0001$), 4.6cm for T12 plumb to S1 (-1.9cm NA vs. 2.8cm SI, $p < 0.0001$) and 4.1 cm for S1 to bicoxofemoral head distance (4cm NA vs. 8.1 cm SI, $p < 0.0001$). Sagittal vertical axis had strong positive correlation with C7 plumb to bicoxofemoral head distance ($r = 0.96$, $p < 0.0001$); T12-horizontal angle ($r = 0.83$, $p < 0.0001$); pelvic incidence+thoracic kyphosis+lumbar lordosis ($r = 0.80$, $p < 0.0001$); T12-horizontal angle+thoracic kyphosis ($r = 0.77$, $p < 0.0001$); lumbar lordosis ($r = 0.74$, $p < 0.001$); and thoracic kyphosis+lumbar lordosis ($r = 0.69$, $p < 0.001$).

Conclusion: T12-horizontal angle and summation of pelvic incidence, thoracic kyphosis and lumbar lordosis demonstrated stronger correlation than summation of thoracic kyphosis and lumbar lordosis.

Table 1: Comparison between two groups

	Normal (n=100)	Patients with sagittal imbalance (n=100)	P- value
Thoracic kyphosis (TK:T5-T12)	32±11.9°	26±20.3°	0.025
T12 horizontal angle	-22±8.5°	10±12.2°	<0.0001
Lumbar lordosis (LL:T12-S1)	-60±11.6°	-15±20.3°	<0.0001
Sacral slope (SS)	38±7.5°	24±16.3°	<0.0001
Pelvic incidence (PI)	51±10.1°	57±14.5°	0.003
Sagittal vertical axis (SVA)	-0.8±3.1cm	15.5±5.5cm	<0.0001
C7 plumb to femoral head	-4.9±3.1cm	7.4±6.3cm	<0.0001
T12 plumb to sacrum	-1.9±2.2cm	2.8±4.6cm	<0.0001
Bicoxofemoral head to S1 distance	4.0±1.6cm	8.1±2.1cm	<0.0001
TK+LL+PI	23±13.7°	68±18.3°	<0.0001
TK+T12 horizontal angle (=LL+SS)	10±9.0°	36±14.9°	<0.0001
TK+LL	-28±11.8°	12±23°	<0.0001

Table 2: Correlation with Sagittal vertical axis

	Correlation coefficients	P- value
C7 plumb to bicoxofemoral head	0.96	<0.00001
T12 lower end plate-Horizontal angle	0.83	<0.00001
Thoracic kyphosis + lumbar lordosis + pelvic incidence	0.80	<0.00001
T12 horizontal angle (=LL+SS) + Thoracic kyphosis	0.77	<0.00001
T12 plumb to sacrum	0.73	<0.00001
Lumbar lordosis	0.74	<0.00001
Thoracic kyphosis + lumbar lordosis	0.68	<0.00001
Bicoxofemoral head to S1 distance	0.64	<0.00001
Sacral slope	-0.34	<0.00001
Pelvic incidence	0.27	<0.00001
Thoracic kyphosis	-0.12	0.099

Significance: These spinal sagittal parameters can be used as a baseline in the evaluation of sagittally imbalanced patients as well as consideration for correction of sagittally imbalanced patients.

E-Poster #36

Pre-Operative Pelvic Parameters Must be Considered to Achieve Adequate Sagittal Balance after Lumbar Osteotomy

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Introduction: Lumbar osteotomies are increasingly applied in the setting of adult sagittal spinal deformity and may be effective in obtaining appropriate spino-pelvic re-alignment. Additionally, it has been established that correction of global sagittal spinal balance improves self reported clinical outcomes. The study aims to investigate the impact of pre-operative radiographic spino-pelvic parameters on post-operative sagittal vertical axis offset (SVA) with the hypothesis that patients with a larger pelvic tilt (PT) will require larger wedge resections

Methods: This is a multicenter consecutive retrospective review of 105 patients (mean age 54yo, 22M, 83F) who underwent lumbar PSO procedures for correction of major sagittal mal-alignment (mean pre SVA=14.3cm). Pre- and post-op free standing full length sagittal xrays were analyzed for regional curves (LL, TK), pelvic parameters (PI, PT) and global balance (SVA). Only patients with a pre-op SVA ranging from 10 to 20cm and with a post-op SVA less than 5cm were retained. The group was subdivided by pre-op pelvic tilt (low/high, cutoff =35°). Independent t-test analysis was used to determine differences in local/regional correction required to achieve the desired SVA correction

Results: A total of 14 patients were identified in the low_PT group and 16 in the high_PT group. There were no statistical differences in pre-op SVA, thoracic kyphosis (TK) and post-op SVA. The low_PT group had a significant lower lumbar lordosis (12° vs 31°, p=0.002) and a lower PT (23° vs 41°, p<0.001). Analysis of the surgical intervention demonstrated that high_PT group required a larger osteotomy resection (resp. 29° and 20°, p<0.001) and a larger regional change of lumbar lordosis (resp. +41° and +26°, p<0.001) to achieve an acceptable post-op SVA (<5cm).

Conclusion: It has been accepted that improvements in surgical outcomes in patients with sagittal malalignment relates to global and pelvic radiographic parameters. An understanding of spino-pelvic alignment may help the surgeon during complex re-alignment procedures. This study demonstrates that in the presence of increased pelvic retroversion (high PT), a larger angular lumbar osteotomy and regional correction is required to obtain a satisfactory post-operative SVA offset.

E-Poster #37

Sequential-Simultaneous Posterior-Anterior-Posterior vs. Posterior Only Surgery for the Treatment of Posttraumatic Kyphosis

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Introduction: The purpose of this study was to compare the clinical and radiological effectiveness of sequential-simultaneous posterior-anterior-posterior surgery and posterior only surgery in surgical reconstruction of posttraumatic deformity.

Methods: From 2001 to 2007, 21 patients (group 1) were operated by sequential-simultaneous approach and 16 patients (group 2) underwent posterior only surgery. The average age was 48 (range; 23-62) years in group 1 and 56 (22-74) years in group 2. Preoperative, immediate and last follow-up standing AP and lateral roentgenographies were evaluated to determine correction of sagittal alignment and its maintenance

during follow-up including the measurements of global and local kyphosis or lordosis, pelvic incidence, sacral slope and pelvic tilt. Functional status of the patients were assessed by Oswestry score.

Results: The average follow-up was 3.2 years. For group 1, the average correction ratio in the sagittal alignment is 82%. The mean values of pelvic incidence, sacral slope and pelvic tilt changed from 440, 300 and 140 preoperatively to 530, 400 and 130 respectively at the last control. Oswestry functional scores decreased from preoperative 48 % to 11%. For group 2, the average correction ratio in the sagittal alignment is 80%. The mean values of pelvic incidence, sacral slope and pelvic tilt changed from 460, 310 and 150 preoperatively to 550, 420 and 130 respectively at the last control. Oswestry functional scores decreased from preoperative 56 % to postoperative 16%. There were neither pseudoarthrosis nor hardware failure seen. Analysis from last follow-up X-rays showed solid fusion in all patients without significant loss of correction in the sagittal plane.

Conclusion: The controversy between combined surgery versus posterior only surgery depends of classification of posttraumatic spinal deformities based on three criteria: the region involved, the neurological status, the presence of any sagittal or frontal plane deformities outside the local kyphosis and the presence of co-morbidities to avoid anterior surgery. Surgical treatment via posterior approach only is helpful especially in older population by lowering the rate of mortality and morbidity.

E-Poster #38

Inter- and Intraobserver Reliability of Cobb Angle Measurement: Endplate vs. Pedicle as Bony Landmarks for Measurement- A Statistical Analysis

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Introduction: The purpose of this study is to evaluate the reliability of the pedicle method of Cobb angle measurement and compare it with the conventional end plate method of measurement.

Methods: Three hundred and eighteen whole spine pre-operative antero-posterior radiograms of children with varying degrees of idiopathic scoliosis involving the thoracic spine were evaluated. These radiograms were grouped based on the child's age (<7 years, 7 to 10 years and > 10 years), the position of the upper end vertebra (upper end vertebra at or above T5 and upper end vertebra caudal to T5) and based on curve severity (mild, <20°; moderate 20°-40° and severe >40°). Three observers independently examined the radiograms using the endplate method and the pedicle method three times each using digitized computer system. Both intra observer and interobserver agreements were assessed by calculating intraclass correlation coefficient (ICCC). Additionally a Bland-Altman plot was made where the strength of the relationship between the score differences and their mean was indicated by the slope of a regression line.

Results: The single ICCC values were better for all observers for <7 year age group using the pedicle method, indicating lesser intra observer variability. The average ICCC values, indicating inter observer variability, were similar for all age groups. All the ICCC values lied in the excellent or substantial group. Tests for significance showed no significant difference between the two methods of measurement.

Conclusion: Differences in measurement values with the pedicle method and end plate method of measurement of Cobb angle are not statistically significant. Either method can be used for measurement when using computer digitized system, which may have helped to minimize measurement discrepancies between these two methods.

Significance: While measuring the Cobb angle in children less than 7 years of age, using pedicle as a landmark would increase the accuracy in measurement.

E-Poster #39

The Effect of Spinal Fusion on Quality of Life for Patients with Severe Neuromuscular Scoliosis

Stuart V. Braun, MD (Tufts Medical Center); Michael J. Goldberg, MD

Introduction: There is little argument that we are able to improve spinal balance and reduce curve magnitudes in patients with severe neuromuscular scoliosis, but there is very little evidence that this has a positive impact on the many other factors involved in the care of these patients.

Methods: Subjects were identified from a homogeneous cohort of patients previously identified and reported on in 1994. These subjects have severe scoliosis, >50° or previous spinal fusion and profound CP, GMFCS Level V. Two groups were identified, those that underwent instrumented spinal fusion and those treated non-operatively. The overall functional outcomes and health related quality of life were compared using a validated instrument, Caregiver Priorities and Child Health Index of Life with Disabilities Questionnaire (CPCHILD). The care burden of patients was also compared; by evaluating time taken by caregivers to perform specific activities of daily living for these patients. The mean results from both groups were then compared and analyzed for significance using a parametric ANOVA statistical analysis.

Results: Of the original 37 patients, 13 are still residing at the same institution and reported on. Two patients were unable to complete the survey, the remaining subjects are no longer living. The results from the CPOCHILD data for the two groups demonstrated no statistical differences in any of the domains. CPOCHILD: Personal care p=0.65; Positioning p=0.30; Comfort/Emotion p=0.14; Communication p=0.30; Health p=0.42; Quality of life p=0.96; Total p=0.29. There was also no statistical difference in the burden of care in the two groups. Burden of care: Bathing/Hygiene p=0.37; Dressing p=0.27; Transferring/Position p=0.65; Toileting p=0.51; Feeding p=0.79. Patients with spinal fusions had lower scores in areas such as comfort/emotions, but spine fusion patients trended to require less time by caregivers for dressing, bathing/hygiene, and positioning.

Conclusion: In profoundly involved patients with CP and severe scoliosis, spinal fusion does not clearly improve quality of life or ease the burden of care.

Significance: This study cast doubt as to whether spinal fusion improves the quality of life for the patients and their providers in this unique population.

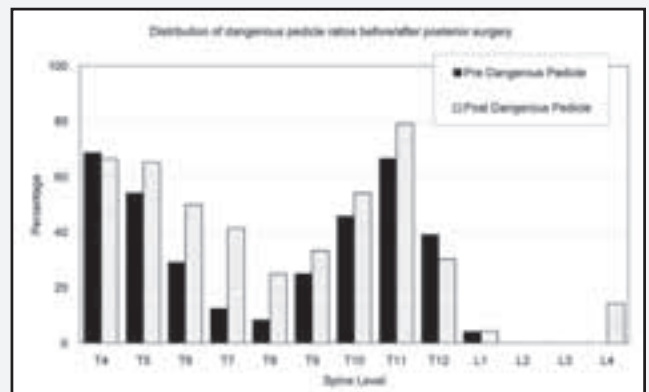
E-Poster #40

The Aorta Movement in Patients with Scoliosis After Posterior Surgery

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Introduction: Few reports evaluated precise positions of the aorta after surgery. The purpose of this study is to evaluate the aorta movement after the posterior correction and fusion in scoliosis surgery.

Methods: 24 right-thoracic scoliosis patients underwent posterior instrumentation and fusion. The Cobb angle changed from 66.4°±13.7° to 20.3°±7.4°. Computer tomography was analyzed from T4 to L4 in 293 vertebral bodies of 24 patients. We selected the middle of the base of the left superior facet as the origin of this coordinate system. A line connecting the two middle points of both bases of the superior facets is defined as X-axis. The angle formed by the Y-axis and a line connecting the origin and the center of the aorta was defined as the left pedicle-aorta angle. Length of a line connecting the origin and the edge of the aorta was defined as the left pedicle-aorta distance. We defined a potentially dangerous pedicle when an absolute value of the left pedicle-aorta angle is within 30° AND the pedicular line-aorta distance is less than 40 mm.



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Results: The aorta had tendency to migrate to the anterior and medial direction after surgery. The aorta movement relative to the spine ranged from 0 to 19.5 mm and its movement was less than 10 mm in 91.4 %. The aorta movement at each spine level ranged from 3.9 to 6.4mm. Dangerous pedicle ratio increased from 27.0% to 36.6% and its change was significantly different at T7 ($p=0.02$).

Conclusion: The aorta had tendency to migrate to the anterior and medial direction after surgery. The aorta movement relative to the spine ranged from 0 to 19.5 mm and its movement was less than 10 mm in 91.4 %. The aorta movement at each spine level ranged from 3.9 to 6.4mm. Dangerous pedicle ratio increased from 27.0% to 36.6% and its change was significantly different at T7 ($p=0.02$)

Significance: This study teaches surgeons to be cautious about the relative movement of the aorta to the antero-medial direction after posterior correction and fusion.

E-Poster #41

Body Image in Patients with Adolescent Idiopathic Scoliosis: Validation of the Body Image Disturbance Questionnaire-Scoliosis Version

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Introduction: Appearance concerns in AIS can result in distress and impairment in daily functioning, or body image disturbance. Although there exist studies and validated outcomes measures that have characterized the appearance concerns of adolescents with AIS, no studies have examined body image disturbance in this population. The Body Image Disturbance Questionnaire (BIDQ) is a self-report instrument that measures dissatisfaction, concern and distress that is related to an aspect of appearance, and results in some degree of impairment in social relations, social activities, or occupational functioning. The purpose of this study was to validate a modified version of this measure in a population of adolescents with AIS.

Methods: Thirty-one patients (mean age: 13.8; 72% female) with AIS were enrolled into a multi-center, cross-sectional study designed to validate the Body Image Disturbance Questionnaire-Scoliosis version (BIDQ-S). Participants completed self-report questionnaires including the Body Image Disturbance Questionnaire-Scoliosis version and had complete SRS outcomes data. Descriptive statistics and Pearson correlations were calculated.

Results: Preliminary results confirmed that the BIDQ was internally consistent (Cronbach's alpha = 0.82), and corrected item total correlations ranged from 0.43-0.67. The BIDQ-S was significantly correlated with each SRS domain and total score (Pearson's coefficient: -0.48 - 0.73, p-value ranges 0.000 - ; 0.02). Additional validity measurements are under way using measures of depression and body image.

Conclusion: The BIDQ has previously been shown to be an accurate instrument that can be used to assess appearance-related distress and impairment in the clinical setting. Based on our results, the BIDQ-S appears to be an internally consistent instrument that correlates with all SRS domains and total SRS scores in a scoliosis population, confirming that quality of life and body image are related psychosocial constructs. This user-friendly instrument is the first to examine body image disturbance in AIS, and provides a more comprehensive evaluation of how altered body image impacts daily functioning.

E-Poster #42

Inserting Pedicle Screws at the Fracture Level Prevents Failure of Short Constructs in Thoracolumbar Burst Fractures

Ferran Pellisé, MD, PhD (Hospital Vall d'Hebron); Lledó Batalla, MD; Alberto Hernández, MD; Mariano Reynier; Joan Bago, MD; Carlos Villanueva, MD

Introduction: Traditional short non-segmental posterior fixation of burst fractures suffers from high rates of failure. Recent publications show that construct stability may improve by inserting additional screws at the

fracture level (6-screws construct). No clinical study has evaluated the longevity of short-segment fixation using pedicle screws at the fracture level (6SC). Aims: To evaluate the efficacy and longevity of short-segment fixation (6SC) in burst fractures of the thoracolumbar junction, the most kyphogenic area.

Methods: All patients with non-osteoporotic burst fracture of T11, T12, L1 or L2 surgically treated by 6SC, between 1 January 2000 and 31 December 2005, in the same institution were reviewed. For each patient, two independent investigators evaluated preoperative, postoperative, 6-month and 2-year data. The final value for continuous variables was the mean of measurements. For categorical variables it was decided by consensus.

Results: Among 89 patients who met the inclusion criteria, 69 (80.2%) with a mean age of 35.4 years were assessed. Mean load-sharing score was 5.8 ± 1.49 (range, 2-9). Surgery was undertaken at 11.3 ± 7 days after the fracture. Mean operating time was 110 minutes, bleeding 438 cc. Surgery restored anterior body height (preop 64.5%, postop 86.3% $P=.000$) and improved kyphosis: vertebra (preop 17.3, postop 6.7 $P=.000$); instrumented area (preop 15.8, postop 2.6 $P=.000$); T11-L2 (preop 15.2, postop 3.5 $P=.000$). Time elapsed until surgery influenced surgical correction ($r=0.521$, $P=.000$). Kyphosis of the instrumented area deteriorated slightly after surgery: 0-6 months 2.8 ($P=.005$); 6-24 months 2.5 ($P=.032$). Loss of correction was greater in fractures with more severe comminution ($r=0.57$, $P=.004$): 1 degree ± 2.7 when load-sharing < 7 , and 5 degrees ± 5.2 when load-sharing > 6 .

Conclusion: Inserting pedicle screws at the fracture level prevents failure of short posterior fixations when treating thoracolumbar burst fractures. The 6-screws construct is effective for early fracture reduction and has an acceptable postoperative loss of correction in highly comminuted fractures.

Significance: Inserting pedicle screws at the fracture level prevents failure of short posterior fixations when treating thoracolumbar burst fractures.

E-Poster #43

An Algorithm for Treating Adult Thoracic Major Spinal Deformity is Helpful in Guiding Surgical Treatment

Frank J. Schwab, MD (NYU Hospital for Joint Diseases); *Virginie Lafage, PhD; Keith H. Bridwell, MD; Steven D. Glassman, Christopher I. Shaffrey, MD; Jean-Pierre C. Farcy, MD*

Introduction: Adult spinal deformity treatment approaches vary due to a lack of treatment algorithms. A Classification of Adult Spinal Deformity ("Classification") has been established but validation of treatment has been limited. The purpose of this study is to evaluate outcomes following surgery for thoracic major deformity based upon a consensus algorithm developed by the Spinal Deformity Study Group.

Methods: Multi-center analysis of consecutive adult patients. Type I,II,III curves (thoracic only/major) treated surgically included: 164 patients 1yr, 98 with 2yr follow up (radiographs, health related quality of life (HRQOL) data and operative details). The consensus treatment algorithm calls for fusion 2 levels above and below the end vertebrae of the thoracic curve, 50% correction of the coronal Cobb angle and apical derotation (2 grades by Nash-Moe). Statistical comparison of outcomes (reaching minimal clinically important difference, MCID) was made between groups dependant upon adherence with algorithm guidelines.

Results: 119 patients (76%) had fusion levels per algorithm. Only 38% reached MCID threshold for ODI, 41% for SRS activity at one year (31%, 49% respectively two year). Patients treated per algorithm were significantly more likely to reach MCID thresholds at one and two years post-op ($p=0.02-0.03$). At two years patients treated per algorithm were more likely to also reach SRS appearance MCID ($p=0.03$). By coronal Cobb, 37% of patients reached 50% or more correction (per algorithm), and those were more likely to reach MCID for SRS appearance ($p=0.002$ year one, $p=0.04$ year two). Correction of axial rotation of 2 grades was noted in 26%, and was not correlated with reaching any MCID thresholds.

Conclusion: Adult thoracic major spinal deformity treatment has had little guidance from outcomes. Combining Classification and treatment algorithm (2 levels above and below coronal end levels of a curve, 50% Cobb reduction) showed adherence to guidelines lead to significantly improved outcome.

Significance: The Classification of adult spinal deformity can be combined with a treatment algorithm.

In the setting of thoracic major curves the algorithm effectively guides ideal treatment for best outcome based upon HRQOL measures.

E-Poster #44

Radiographic and Clinical results of L5 and S1 Pedicle Subtraction Osteotomies (PSO) for the Correction of Spinal Sagittal Imbalance

Hassan Alish, MS; Ahmed S. Mohamed, MD; Khaled M. Kebaish, MD (John Hopkins Hospital)

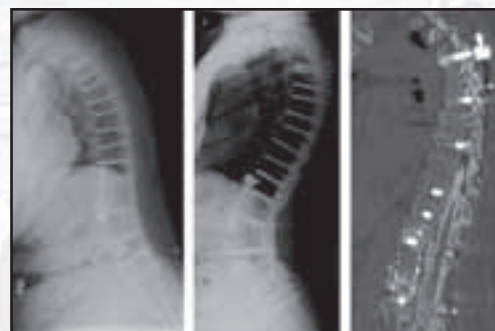
Introduction: Pedicle subtraction osteotomy at L5 or S1 is rarely performed due to the difficulty in achieving distal fixation and the concern about higher complications compared to those performed at a more proximal level. It can be more effective in correcting a focal deformity at the lumbosacral junction or the sacrum.

Methods: Retrospective review of 14 consecutive patients who underwent a PSO at L5 or S1 between 2005 & 2007. Detailed radiographic measurements were done at preoperative and at final follow up. Functional outcome data were collected prospectively, including SRS-22 and Oswestry Disability Index (ODI). Values are reported as means followed by the minimum and maximum values in the range.

Results: Fourteen patients received a PSO at L5 or S1. Ten at L5 and four at S1 for Lumbosacral deformities. Diagnoses included; sacral fractures (n=4), pseudoarthrosis (n=2), congenital kyphoscoliosis (n=1), ankylosing spondylitis (n=1), Charcot's spine (n=1), and Lumbar flat back(n=1). Complications were, two superficial wound infections and one L5 radiculopathy which resolved within 6 months. There was no pseudoarthrosis or loss of fixation. Mean follow-up was 2.24 yrs (1.39, 3.15 yrs). Mean lumbar lordosis pre-operative was -28.7° (5.8, -63.6), improving to -50.3° degrees (-21.2 , -73.8) at last follow-up. An overall 22.2° (8.3, 37.5) correction. At baseline, SVA was $+182.9$ mm ($+103.9$, $+303.4$), decreasing to $+18.7$ mm (-66.0 , $+146.9$). A mean 164.2 mm (73.1, 268.4) correction of sagittal balance. Patients also reported significant clinical improvement; ODI score decreased from an average 66.5 ± 13.1 (48, 84) to 40.2 ± 18.8 (24, 72) at last visit. The mean SRS-22 score was 2.3 (1.3, 2.9) prior to surgery, improving to 3.0 (2.2, 3.4) at last follow-up.

Conclusion: L5 and S1 PSOs are technically more difficult procedures, however they are effective in the correction of lumbosacral sagittal imbalance. Clinical and radiographic outcomes are satisfactory with comparable complications to other levels PSOs and without an increased risk of neurologic injury or loss of fixation.

Significance: PSOs at L5 & S1 can safely be done when indicated in patients with lumbosacral sagittal imbalance with satisfactory outcome and without an increased risk of complications.



Preoperative radiograph (L) and postoperative radiograph & CT (R) of 64yo F status post L5 PSO for sacral fracture

E-Poster #45

Outcome and Surgical Strategies in the Treatment of Sacral Fractures Complicating Long Posterior Spinal Fusion

Ahmed S. Mohamed, MD; Albert Pull ter Gunne, MD; Richard L. Skolasky, ScD; Khaled M. Kebaish, MD (Johns Hopkins)

Introduction: Little work considering the management of sacral fractures complicating long post. spinal fusion. Our aim is to assess the radiographic and clinical results.

Methods: A retrospective review of a prospectively collected database of patients who have had long post. spinal fusion between 2000 and 2007. Radiographic analysis including coronal curves, lumbar lordosis, thoracic kyphosis, sacral inclination, pelvic incidence, sagittal and coronal balance. Patient-centered outcomes were used to assess the clinical improvement. Values reported as means and range.

Results: Eleven patients who had sacral fractures following a posterior spinal fusion, mean current age is 62.60(47-75,SD=9.01), females (9/11=81.82%).one patient had an undisplaced fracture and was treated non operatively.The remaining 10 patients required surgical treatment.Mean duration of hospital stay was 7.30 days.90.91%(10/11) of the patients had at least one comorbidity.Mean duration of follow-up was 25.18 months(4-52,SD=15.75). All patients were treated by revision post.surgery, 3 patients were treated by sacral osteotomy and all had instrumentation extended to S2 with the use of S2 sacro-pelvic screws. SVA was 16.09(-0.9- ;35.44,SD=13.15) and 7.82(-2.25-18.72,SD=7.05) at last follow-up. The preop pelvic incidence was 68.69(49.81-98.32,SD=16.08)and 75.15(61-89.49,SD=10.07) at last follow-up. The preop.Sacral inclination 46.97(27.62- ;63.92,SD=10.79)and 47.42 (30-66.22,SD=13.98)at last follow-up.SRS pre-op activity score was 2.33(SD=0.51)and 3.26(SD=0.19) post-op.SRS pre-op satisfaction score was 2.01 (SD=0.95)and 3.05(SD=0.54) post-op. The intraop. neurological problem was 22.22% in form of dural tear and was repaired immediately. There was only one patient had numbness over right big toe postop. and recovered later on.

Conclusion: This retrospective case series demonstrates that among 11 patients,all benefited from S2 screw use in management of sacral fractures complicating long post.spinal fusion, along with significant clinical improvement between the pre and post-op assessment based on the SRS domain scores.

Significance: To our knowledge this study is the first to evaluate the outcome of surgical treatment and the use of S2 screws in the management of sacral fracture complicating long posterior spinal fusion

E-Poster #46

Comparison of Complications among Growing Spinal Implants

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Introduction: Previous studies report a complication rate of 57-119% with growing spine surgery, but this may be an underestimate. The purpose of this study was to evaluate the complication rate of growing spine surgery with various types of spinal implants.

Methods: The medical records of 36 consecutive children with spinal deformity treated with various types of growing implants by a single surgeon were evaluated by an unbiased reviewer for complications. Major complications were defined as unplanned surgery or neurologic injury. Based on construct type, patients were separated into three groups: (A) standard dual growing rods with proximal and distal spine anchors, (B) hybrid growing rods with rib anchors proximally and spine anchors distally, and (C) VEPTR devices.

Results: The mean age of patients at initial implantation was 4+10 and mean follow-up was 51 months (24-117 months); on average, 4 lengthenings were performed on each patient over the study period. We found 72 complications in 26/36 patients (72%) that required unplanned surgery including 18 revisions for rod breakage, 31 revisions for migrated anchors, and 18 irrigations for infection. Two children (5.6%) developed a clinical neurologic deficit that required implant removal. Broken down by construct, Group A had 23 major complications in 10 patients for a complication rate of 230%. Group B had 6 major complications in 7 patients for a rate of 86%, and Group C had 45 major complications in 19 patients for a complication rate of 237%. (Table 1) The groups were similar in terms of preoperative Cobb angle, kyphosis, age, and BMI; these factors did not seem to influence the complication rate.

Conclusion: The complication rate in this series is greater than that reported by multi-center study groups. Hybrid constructs of traditional spinal implants attached to multiple rib anchors proximally seem to have the fewest complications.

Significance: To the best of our knowledge this is the first study comparing various growing spine implants (growing rods, hybrid devices, and VEPTRs) among similar patients. Families and surgeons considering growing rod surgery should be aware of the potential risks particularly the need for unplanned surgery.

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Table 1: Complications of Growing Spine Surgery

Complications	Ccx rate	Ccxs/cm growth	Ccxs/year treatment	Ccxs/planned surgeries
Dual Growing Rods	230%	0.20/cm	0.52/yr	0.47/surgery
Rib Hybrid	86%	0.19/cm	0.36/yr	0.29/surgery
VEPTR	237%	0.97/cm	0.52/yr	0.44/surgery

cm = centimeter; yr = year; CCx = complication

E-Poster #47

Morphometric Analysis of Vertebral Growth in the Skeletally Immature Spine

Hong Zhang, MD (Texas Scottish Rite Hospital for Children); Daniel J. Sucato, MD, MS; Pamela Nurenberg, MD; Anna M. McClung, RN

Introduction: There is a relationship between growth of the spine and the development of spinal deformity. The purpose of this study was to analyze the morphology of the pedicle, vertebral body and spinal canal in the normal immature spine using MRI. We set out to characterize the three-dimensional growth of the vertebra in-vivo and define the dynamic growth of the normal growing spine.

Methods: 34 pediatric normal patients with a normal straight spine who had MRI from T1 to L5 were assigned to 3 groups: infantile (n=11), 0-3 years of age; juvenile-young (n=16), 4-7 years of age; and juvenile-old (n=7), 8-10 years of age. True transverse MRI images were utilized for pedicle (width and length), vertebral body (height, depth and width), and spinal canal area measurements.

Results: (Table): The mean increase of the pedicle width and length was 0.7-mm (16%) and 3.2-mm (18%) from the infantile to the juvenile-young, and was 0.9-mm (15%) and 2.2-mm (11%) through the juvenile-old group. The mean increase of the vertebra body width, depth and height was 3.6-mm (15%), 4.5-mm (27%) and 3.1-mm (27%) from the infantile to the juvenile-young, and was 2.9-mm (10%), 1.9-mm (9%) and 2.1-mm (15%) through the juvenile-old group. The mean increase of the spinal canal area was 41-mm² (19%) from the infantile to the juvenile-young and was only 1.8-mm² (0.7%) through the juvenile-old group.

Conclusion: The current study established the growth of the pedicle, spinal canal and vertebral body In-Vivo in the normal pediatric population. The vertebral growth rate in the infantile and the juvenile-young period was significantly greater than in the juvenile-old period. Spinal canal area is commensurate with the growth of the pedicle width and has little growth after the juvenile-young period. Pedicle screw fixation would not influence on the size of the spinal canal after the early juvenile period but may significantly disturb the pedicle growth in length.

Significance: This study was done to characterize the dimension and dynamic growth of the vertebra in the skeletally immature spine. It provided significant information for treatment of early onset spinal deformities.

Table: The Pedicle, Vertebral Body and Spinal Canal Measurements

	Pedicle Width (mm)			Pedicle Length (mm)			Vertebral Body Width (mm)			Vertebral Body Depth (mm)			Vertebral Body Height (mm)			Spinal Canal Area (mm ²)		
	0-3 Years	4-7 Years	8-10 Years	0-3 Years	4-7 Years	8-10 Years	0-3 Years	4-7 Years	8-10 Years	0-3 Years	4-7 Years	8-10 Years	0-3 Years	4-7 Years	8-10 Years	0-3 Years	4-7 Years	8-10 Years
T1-T3	3.4	3.9	4.6	16.6	18.1	20.2	21.8	25.0	25.1	13.7	15.5	15.5	7.8	9.7	10.9	175.2	224.3	228.2
T4-T6	3.0	3.3	3.4	16.3	19.1	20.5	19.3	21.8	23.3	15.8	118.4	19.8	8.9	11.3	12.7	166.4	206.6	211.6
T7-T9	3.4	3.7	3.8	17.2	19.4	20.8	21.0	22.9	24.7	16.6	20.6	22.8	9.7	12.9	14.1	176.8	209.1	213.4
T10-T12	4.2	4.9	5.5	17.8	20.9	23.1	23.8	27.0	29.5	16.2	21.2	23.5	11.3	14.8	16.6	206.2	244.3	241.1
L1-L5	5.4	6.3	7.7	18.4	22.4	25.0	28.4	32.9	37.1	17.3	22.9	25.2	12.8	16.6	18.8	279.1	321.7	322.4

E-Poster #48

Predicting Ideal Spinopelvic Balance in Adult Deformity

Chris J. Neal, MD (Northwestern University); Jamal McClendon, MD; Frank L. Acosta, MD; Tyler Koski, MD; Stephen L. Ondra, MD

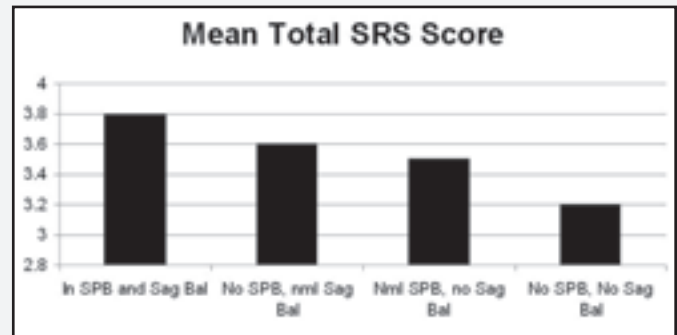
Introduction: Spinopelvic balance describes the relationship between the pelvis and the spine. Developing a formula to describe this relationship can allow its application to adult deformity surgery.

Methods: Using the literature for normal values, a mathematical relationship between the spine and pelvis was derived for 2 age groups, adults (18-60) and geriatric (>60), by dividing the pelvic incidence (PI) by the sum of the main thoracic kyphosis (TK) and lumbar lordosis (LL). This relationship is termed the spinopelvic constant (r). An equation was then constructed: $PI=r(LL+TK)$. A retrospective review was performed using post-operative patients in our spinal deformity database. The difference between the predicted, as determined by the formula, and the measured sum of LL+TK was then calculated to determine the degree of spinopelvic imbalance.

Results: The spinopelvic constant in adult (-2.57) and geriatric population (-5.45) was calculated. The formula was applied to 41 adult deformity patients (13 adults, 28 geriatric). There were significant differences in outcome measures across the spinopelvic balance groups at the .05 level; being 0 to 10° of predicted resulted in the best outcomes. Sagittal and spinopelvic balance were then compared. A patient was in sagittal balance if they were +/-50mm from neutral and in spinopelvic balance if they were +/- 10° of predicted. Four categories were compared: 1) those in sagittal and spinopelvic balance (n=17), 2) those in sagittal but not spinopelvic balance (n=11), 3) those in spinopelvic but not sagittal balance (n=5), and 4) those in neither sagittal nor spinopelvic balance (n=8). There were significant differences in outcome measures across the sagittal/spinopelvic balance groups at the .05 level. From this analysis, patients that are in both sagittal and spinopelvic balance have better outcomes than those who are in neither. However, the results between those that are either in sagittal or spinopelvic balance, but not the other, are roughly equivocal.

Conclusion: Restoring spinopelvic balance in adult deformity patients may be important in determining surgical outcomes independent of sagittal balance.

Significance: Restoration of spinopelvic balance may improve outcomes in adult deformity patients.



Comparing the mean Total SRS Score to sagittal and spinal pelvic balance shows the best outcomes in patients in both sagittal and spinal pelvic balance, the worse outcomes in patients in neither sagittal or spinal pelvic balance and equivocal results in patients with either sagittal or spinal pelvic balance. SPB=Spinopelvic balance SB=Sagittal Balance

E-Poster #49

Segmental Resection Osteotomy and Dual Axial Rotation Corrective Technique for Severe Angular Kyphosis

Zhongqiang Chen, MD (Peking University 3rd Hospital); Qiang Qi, MD; Zhaoqing Guo, MD; Weishi Li, MD; Yan Zeng, MD; Chuiguo Sun, MD

Introduction: Design a new surgical correction and fixation technique for severe angular kyphosis. Observe the feasibility, safety and effectivity of the surgery.

Methods: From May 2004 to December 2006, we treat 23 cases severe kyphosis (average Cobb angle 86.9°, range 50°-130°) with segmental resection osteotomy, section distraction, dual axial rotation correction and instrumentational fusion technique (Figure 1). Radiographic assessment for sagittal alignment of the total spine and kyphosis Cobb angle, including 9 cases of combined scoliosis Cobb angle, was performed before and immediately after operation, and at last follow-up (minimum 2 years). The Frankel Grading

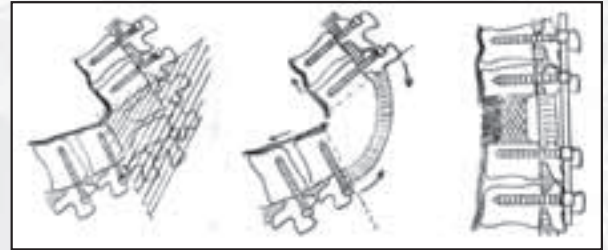
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system for neurological function and Oswestry Disability Index (ODI) were evaluated preoperatively and at last follow-up. Patients Satisfactory Index (PSI) was also used for clinical evaluation at last follow-up.

Results: The mean surgical time was 6.7 hours. The average blood loss was 3700ml. The complications include 1 shifting of artificial vertebrae, 5 nerve root injury, 3 dural tear and 1 transitory dysfunction of lower extremity. All of these complications recovered after feasible treatment. All the patients were followed 2 years or more after surgery. The average kyphotic angle was 86.9° preoperatively, which was improved to 25.6° immediately after surgery, and got an average correction rate of 72.17%. At follow-up, the average kyphotic angle was 27.4°, and correction rate was 69.87%. The 9 cases who combined with scoliosis had an average Cobb angle of 31.2°, which decreased to 3.4° immediately after surgery, and the correction rate was 90.06%. The correction rate was kept until follow-up (83.39%). Some patients got an improved neurological function. Except for 4 cases who had no symptoms before surgery, the average ODI was 18.47 preoperatively, and 10.47 at follow-up. The average improvement of ODI was 43.31%. The PSI result showed a total satisfied rate of 91.30%.

Conclusion: Segmental resection osteotomy, dual axial rotation correction and instrumentational fusion technique is an effective and safe way to treat severe angular kyphosis. The correction rate was satisfactory. It had a good long term results.



E-Poster #50

Patients Perceive Perioperative Complications as More Severe and Having Greater Negative Consequences than Surgeons

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Introduction: The clinical and medicolegal consequences of perioperative complications following spinal deformity surgery negatively impact outcomes. Patient outcomes following perioperative complications have been evaluated, but a complications disability measure does not exist. We evaluated surgeon and patient perceptions of different complications to help create an adverse event impact instrument.

Methods: Descriptions of 22 spine surgery complications were administered to 14 spine surgeons and 15 adult spinal deformity patients. Participants assigned visual analog severity based numerical value to each complication (0-10; 0 = not severe, 10 = worst possible). Questions included perceived; 1) complication severity =SEVERITY, 2) complication impact upon procedure satisfaction=SATISFACTION, and 3) complication impact on quality of life=LIFE. Values were evaluated using ANOVA and student's t-test.

Results: Mean SEVERITY difference between surgeons (5.2, range 1.1 ± 1.9=blood transfusion-10.0 ± 0.0=death) and patients (6.4, range 2.6 ± 2.6=UTI- 9.2 ± 2.3=stroke) approached significance (p=0.068). Mean SATISFACTION was similar for surgeons (5.0; range 0.7 ± 1.0=blood transfusion-10.0 ± 0.0=death) and patients (5.9; range 2.1 ± 2.3=UTI- 9.0 ± 2.8=death; p=0.22). Mean LIFE was significantly lower for surgeons (4.8; range 1.0 ± 1.0=UTI, to 10.0 ± 0.0=death) than patients (6.3; range 1.8 ± 2.3=UTI, to 9.5 ± 1.0=stroke; p<0.05). Patients perceived blood transfusion, deep vein thrombosis, dural tear, heart attack, lung failure, pulmonary embolus, and stroke significantly worse on all measures (SEVERITY, SATISFACTION, and LIFE) than surgeons (p<0.05). Patient and surgeon scores for dural tear and blood transfusion demonstrated the greatest discrepancy in all measures.

Conclusion: Perioperative complications may worsen patient outcomes and have medicolegal consequences. We found significant variation between surgeon and patient perceptions of spine surgery complications. Patients believed complications would have more severe impact on satisfaction and quality of life. This discrepancy highlights potential need for improved surgeon communication and patient education. Future research will compare these results to patients incurring complications.

E-Poster #51

Beneficial Influence of Titanium Mesh Cage on Infection Healing and Spinal Reconstruction in Hematogenous Septic Spondylitis

Panagiotis Korovessis, PhD (General Hospital 'Agios Andreas') Thomas Repantis, MD

Introduction: There is a controversy concerning the optimal treatment for pyogenic spondylitis regarding approach, instrumentation and staging. This series investigates if the use of titanium mesh cage on the site of infection could be beneficial for successful outcome of the operative treatment for pyogenic spondylitis.

Methods: Twenty-four patients aged 57 ± 16 years suffering from persistent or complicated septic spondylitis were treated by a total of 25 single stage combined surgeries (first: anterior debridement/partial vertebrectomy plus mesh cage filled with autologous bone graft; second: pedicle screw fixation with open and minimal invasive techniques). The indications for surgery included neurologic compromise, significant vertebral body destruction with kyphosis associated with segmental instability, failure of medical treatment, and/or epidural/ paravertebral abscess formation. Needle biopsy was performed in all patients before surgery. Patients were evaluated before and after surgery in terms of pain and neurologic level, sagittal segmental spinal balance, radiologic fusion and recovery.

Results: All but 1 tetraplegic patient, who died because of massive clot lung embolism 2 months after surgery, were followed for 56 months (range, 31-116 months) The VAS score improved from 6.5 before surgery to 1.8 after surgery. The segmental kyphotic deformity was corrected at an average of 6° , without cage settling. An insignificant loss of kyphosis correction of an average 0.6° was measured in the thoracolumbar junction only. Blood loss, surgical time, and surgical complications were significant less in the patients who operated with minimal invasive technique. Patients with incomplete neurologic impairment improved after surgery. Physical function (SF-36) averaged 72 1 year after surgery. All operated patients had resolution of infection. There was neither migration of mesh cage nor posterior instrumentation failure at the last follow-up observation.

Conclusion: A radical debridement of spinal infection and anterior insertion of titanium cage, filled with autogenous bone graft, secured with pedicle screw instrumentation should have had a beneficial influence on the eradication of infection, segmental and global spinal reconstruction and fusion.

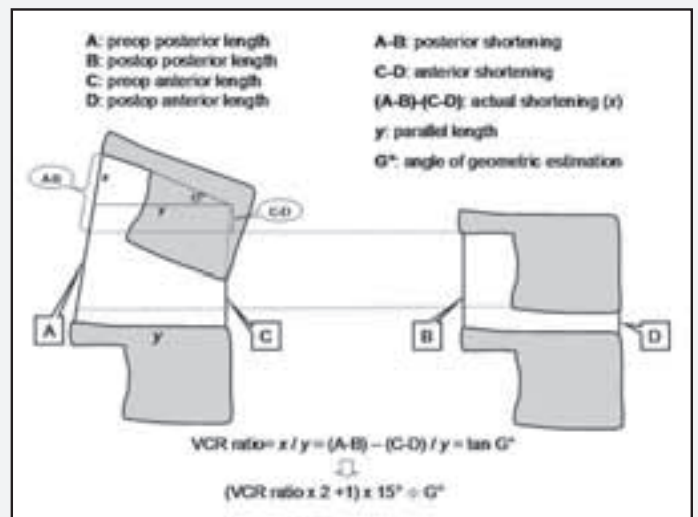
E-Poster #52

How Much Kyphosis Correction can be Obtained with Posterior Vertebral Column Resection (VCR)?

Woojin Cho, MD, PhD (Washington University School of Medicine) ; Lawrence G. Lenke, MD; Linda A. Koester; Brenda Sides, MA; Christine Baldus, RN, MHS

Introduction: Recently posterior VCR (PVCR) has been performed to correct severe rigid spinal deformities and was proven to be relatively safe and effective. However, there is no scientific reference to the correlation between the amount of correction achieved and the shortening of the vertebral column with PVCR.

Methods: Among 88 PVCR patients treated by a single surgeon, 26 patients with primarily a kyphotic deformity and clear anatomical landmarks visible on pre and post-op x-rays were selected, and several anatomical lines and angle measurement were utilized as depicted in Fig. 1. (Left side is preop and right side is postop. The vertebra above and below are supra-adjacent and infra-adjacent vertebra respectively. The body at the level of resection was



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omitted.) Two approximations were calculated. The geographic approximation(G)= (tanG * 2+1)*15°. The rough approximation(R) is about the same amount of x, if y≥40; twice of x, if y<40. The change in segmental kyphosis (the angle between one level above and below) was measured(K) and compared with the geometric(G) and the rough approximation(R).

Results: The absolute Mean ± SE for K-G and K-R was 0.99 ± 0.14°, 4.33 ± 0.55°, respectively. 99% confidence interval(CI) for mean of K-G and K-R was 0.60~1.38°, 2.79~5.88° respectively. K-G is not significantly different from 0.5° (p=0.001). K-R is also not significantly different from 3° (p=0.01). The validity of this approximation was also tested with 20 patients, which was also high(p=0.0009, 0.02;respectively). In other words, the actual kyphosis correction(K) was very close to the 2 approximations G and R and thus can be predicted by these.

Conclusion: With both approximations, the amount of kyphosis correction can be estimated precisely. If the vertebral body was small, the amount of kyphosis correction was exaggerated.

Significance: Preoperative planning can be made with the formula for the geographic approximation(G), and the intra-operative rough planning can be made with the rough approximation(R). The size of the vertebral body affects the amount of kyphosis correction with the same amount of vertebral column shortening.

E-Poster #53

Epsilon Aminocaproic and Tranexamic Acid Decrease Osteoblast Differentiation and Mineralization In Vitro

Firas M. Kara, MD, PhD; Kushagra Verma, MS (NYU Hospital for Joint Diseases); Shaun Xavier, MD; Thorsten Kirsch PhD, Thomas J. Errico, MD

Introduction: The two most common antifibrinolytic treatments, tranexamic acid (TXA) and epsilon aminocaproic acid (EACA), have not been evaluated in vitro for their potential interaction with osteoblast cells. The purpose of this study was to evaluate the effect of TXA or EACA on osteoblastic differentiation and mineralization in vitro.

Methods: Murine osteoblastic cell line (MC3T3-E1) was cultured for 17 or 21 days in alpha-MEM media with 50µg/ml vitamin C and 10mmoles beta-glycerolphosphate enrichment. EACA and TXA were added at concentrations of 10, 50, 100, 500 or 1000 µg/ml. To evaluate osteoblastic differentiation, alkaline phosphatase (ALP) activity was quantified on day 17. Alizarin red activity was measured on day 21 to assess osteoblastic mineralization.

Results: Osteoblastic differentiation and mineralization were decreased under the presence of EACA or TXA. With exposure to EACA, ALP activity decreased up to 62% on day 17 and alizarin red activity decreased up to 38% on day 21. With exposure to TXA, ALP activity decreased up to 63% on day 17 and alizarin red activity decreased up to 42% on day 21. The response to both medications was dose dependent.

Conclusion: With exposure to TXA or EACA, ALP and Alizarin red activity were both significantly decreased in a dose dependent manner. This reflects a disruption in osteoblastic differentiation and mineralization in vitro, which may have clinical implications.

Significance:

We find that antifibrinolytic treatments interfere with osteoblastic cells, which are responsible for mediating spinal fusion after instrumentation.

The use of these treatments may affect the rates of spinal fusion observed clinically.

EACA (µg/ml)	Day 17 ALP (µg/mg)	Day 21 Alizarin (% of control)	TXA (µg/ml)	Day 17 ALP (µg/mg)	Day 21 Alizarin (% of control)
0	81.7	100%	0	82.3	100%
10	63.7	76%	10	48.4	88%
50	52.3	78%	50	28.6	70%
100	59.9	74%	100	41.3	59%
500	42.8	67%	500	25.2	63%
1000	30.9	62%	1000	30.7	58%

E-Poster #54

Correlation of Risser Sign, Skeletal Age of Hand and Wrist with the Histological Grade of Iliac Crest Apophysis in Girls with Adolescent Idiopathic Scoliosis

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Introduction: The evaluation of the remaining growth in the patients with AIS is highly significant in predicting the curve progression and thus influencing the treatment strategy in AIS. The present study aimed to investigate the value of the skeletal age of hand and wrist, digital skeletal age (DSA) and Risser sign in maturity assessment in the girls with AIS by associating with the HG of iliac crest apophysis.

Methods: 53 AIS girls with a mean age of 14.0yrs undergoing spinal instrumentation with autogenous bone graft were recruited. Year since menarche (YSM) was recorded while the skeletal age of hand and wrist, DSA and Risser grade were evaluated radiologically. Using a standardized histological grade of proliferative chondrocyte zone of the iliac crest apophysis, correlation between the HGs and the radiological and clinical skeletal maturity parameters was analyzed.

Results: The HGs were negatively correlated with the radiological skeletal ages with the highest correlation coefficient between HGs and skeletal age of hand and wrist. The negative correlations between HGs and the chronological age, YSM were significant and could be enhanced by combining with the skeletal age of hand and wrist or DSA. No proliferative chondrocyte zone of the apophysis was detected when patients were either over 16yrs old or Risser grade 5, and 2yrs post-menarche or over 15yrs old in patients with DSA Stage III and Risser grade 4.

Conclusion: Radiological skeletal age of the wrist and digits can provide important information for maturity assessment in girls with AIS. It can also enhance the sensitivity of chronology age and YSM in determining the remaining growth potential.

Significance: Skeletal age of the wrist and digits are recommended to enhance the accuracy of maturity assessment in girls with AIS.

E-Poster #55

The Effect of Operative Position during Posterior Spinal Fusion for AIS: Does it Influence Sagittal and Axial Alignment of the Thoracic Spine?

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Introduction: Correction of all 3 planes during PSF for AIS remains a challenge. This study was to examine the effects of the position of the chest roll on thoracic kyphosis and its influence on axial alignment of the thoracic spine.

Methods: An IRB approved retrospective review of 25 consecutive patients with Lenke 1, 2, 3 and 4 AIS curves positioned prone on the Jackson spinal table. The inclusion criteria consisted of patients with pre-positioning standing lateral radiographs. Plus, lateral radiographs of the patient positioned prone on the Jackson table. One with the chest roll positioned approximately 2 cm below sternal notch (ST). A second lateral radiograph with the chest roll positioned proximal to the level of the xiphoid process (Xi). Axial measurements with a scoliometer and the rib hump index on radiograph were recorded. A statistical analysis using SPSS software was performed to measure for significant differences between the groups.

Results: The mean coronal deformity on standing AP radiograph was 58 degrees with the median apex of the deformity at T9. The mean erect standing thoracic kyphosis measurements were 9.2 degrees. The Scoliometer reading on the Adam's forward bend was 21.2 degrees. In the prone, position the mean thoracic kyphosis for the sternal notch chest pad was 4.9 degrees (range: -3 degrees to +17 degrees) and the mean kyphosis for the xiphoid positioned chest roll was 13.8 degrees (range: +6 degrees to +24 degrees, P=0.0093). The mean scoliometer reading between the two groups (Xi-16.5, St-12.2, P=0.021). This was further exhibited by the significant difference in the rib index. (Xi-1.74, St- 1.41, P=0.039).

Conclusion: The Xiphoid placed chest roll as compared to the standard sternal position resulted in a statistically significant increase in the amount of thoracic kyphosis averaging 9 degrees. However, there was also an associated with increase in the thoracic deformity with the altering of the position of the chest roll clinically with a scoliometer and by the rib hump index on radiograph.

Significance: When positioning a patient on the Jackson spine table, the placement of the chest roll influences thoracic sagittal plane. Due to the complex planar coupling of the spine, the axial plane is concurrently affected

Table # 1-Prone Intra-operative position Measurements

	Sternal Chest roll	Xiphoid Chest Roll	P Value
Main Thoracic Kyphosis (T5-T12)	4.95°	14.77°	P=0.0093
Rib Index* (D1/D2)	1.41	1.74	P=0.039
Prone Scoliometer Measurements	12.22°	16.15°	P=0.021

E-Poster #56

Biomechanical Effects of Transverse Connectors on a Cervical Spine Rod-Screw Construct. An In Vitro Human Cadaveric Study

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Introduction: Contrary to the thoracic and lumbar spine, the biomechanical effects of Transverse Connectors on cervical spine rod-screw constructs remains unknown. Thus, no agreement is found in literature on their usefulness in such cases.

Methods: Eleven human cadaveric cervicothoracic spines (C2-T1) were biomechanically tested using an unconstrained, custom-designed spine simulator, under extension-flexion, lateral bending, and axial rotation loading. After intact analysis, all specimens were instrumented from C3 to C7, using the same posterior rod-screw construct. Sequential destabilizations were performed to create 3 models: (A) wide laminectomy; (B) 50% facetectomies; (C) 100% facetectomies. Using a load-control protocol (max +/-2Nm), three configurations were randomly tested for each model: no TC; one TC; two TC. Range of motion (ROM) for each model and condition were compared under the same load, in each direction of the motion.

Results: Stiffness was reduced by the destabilization procedure except for Model A. Flexion-extension was not significantly changed by the addition of 1 or 2 TC. Lateral bending was reduced by the addition of 2 TC's in Model B and C (90%, and 91%, normalized value to "NoTC" condition, p<0.05). Axial Rotation was significantly reduced for all Models (61% for A, 59% for B, 61% for C, normalized value, p<0.05).

Conclusion: The rod-screw construct gave excellent stabilization to every model. The addition of one and two TC increased the stiffness of the constructs, in every direction of the motion. Significant differences appeared for axial rotation, lateral bending in Model B and C. In these cases, 2 TC appeared to produce more stiffness compared to one. These results suggest the addition of 2 TC clinical situations deemed most unstable.

Significance: - Previous studies showed excellent stabilization potential for the cervical spine rod-screw, without the addition of transverse connectors (TC). This biomechanical study, using human cervical spines, by simulating 3 different surgical situations, showed increase of the stiffness of a cervical spine rod-screw construct by the addition of 2 TC, for axial rotation in every situation and for lateral bending in the most unstable situation.

E-Poster #57

The Effect of Posterior Spinal Releases on Axial Correction Torque: A Cadaver Study

Patrick Bosch, MD (University of New Mexico); Shakeel Durrani, MD

Introduction: Posterior only approaches for spinal deformity are increasingly popular, with many surgeons utilizing more extensive posterior releases, such as Ponte or Smith-Peterson Osteotomies (SPOs) to improve correction. The axial plane, or thoracic prominence also receives greater attention in pedicle screw based correction maneuvers. In order to determine the decrease in force needed to axially rotate the spine by posterior facetectomy or rib head resection a cadaver model was analyzed.

Methods: Four fresh-frozen human cadavers were instrumented with fixed angle pedicle screws in the thoracic spine. The torque needed to produce 25° axial deflection at individual spinal segments (levels T5-T11) was measured using a custom needle deflection torque device attached to commercially available vertebral rotating construct. After the intact specimen was tested, torque measurements were repeated following a full facetectomy (SPOs) and posterior rib head resection.

Results: Complete fasetectomy resulted in an 18% decrease of torque needed to produce 25° of axial deformity compared to the intact specimen (p<0.001). Rib resection added another 36% decrease in torque (p<0.001). [table 1]

Conclusion: Complete facetectomies (Ponte or Smith-Peterson osteotomies) decrease the force required to rotate spinal segments with respect to the axial plane by approximately one-fifth. Posterior rib head resection should be considered to further loosen the spine if additional axial correction is desired.

Level	Fasectomy Percent of Intact			Ribresection Percent of Intact			Ribresection Percent of Fasectomy		
	N	Mean (SE)	p-value ¹	N	Mean (SE)	p-value	N	Mean (SE)	p-value
T5	4	92 (12)	0.54	3	59 (8)	0.03	3	71 (1)	<0.001
T6	4	82 (4)	0.02	3	51 (9)	0.03	3	61 (6)	0.03
T7	4	68 (11)	0.06	3	44 (11)	0.04	3	58 (15)	0.11
T8	4	71 (2)	<0.001	4	40 (6)	0.002	4	57 (9)	0.02
T9	4	89 (9)	0.33	4	48 (6)	0.004	4	54 (6)	0.005
T10	4	83 (8)	0.12	4	55 (6)	0.006	4	66 (4)	0.004
T11	4	85 (7)	0.12	4	71 (14)	0.14	4	82 (11)	0.20
All levels	28	82 (3)	<0.001	25	53 (4)	<0.001	25	64 (3)	<0.001

¹All hypotheses test for differences from 100%.

E-Poster #58

Interest in Assessing 3D Postural Balance with Respect to the Gravity Line

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Introduction: Postural balance assessment may help diagnosis, planification and follow up in cases of spine disorders. This paper explores the interest of quantifying postural balance in clinical routine, using 3D reconstruction from biplanar X-ray device in combination with a force plate.

Methods: 82 patients were enrolled consecutively, divided into three groups (Scoliosis, Kyphosis and Other) and compared with 22 asymptomatic subjects. Head to knee X-rays were taken while the subject was on a force plate in free standing position. Head position was controlled using a mirror at eyes' level. Merging of the gravity line (GL) with 3D reconstruction yielded the relative position of the center of acoustic meati (CAM) and T1 vertebral body. The inclination of the axis linking the CAM to the hip axis center (HAC) on the sagittal plane was also calculated. Pearson correlation coefficient between the postero-anterior offset of the CAM to GL and the sagittal inclination was calculated for each group.

Results: Observing the position of the CAM with respect to the gravity line highlighted different pattern according to several kind of pathology. The distance of CAM to GL was inferior to 40mm by asymptomatics

while it could reach respectively 90mm and 130mm by scoliotic and hyperkyphotic patients. The mean distance from T1 to GL is similar in the 'Asymptomatic', 'Scoliosis' and 'Other' groups with 25 ± 15 mm. The sagittal CAM-HAC inclination is correlated with the position of the CAM in all pathological groups ('Scoliosis'- $r=0.90$, 'Kyphosis'- $r=0.81$ and 'Other'- $r=0.80$) but not by 'Asymptomatic' ($r=0.51$).

Conclusion: Transversal distance from CAM to GL has never been assessed in free standing position but highlights more postural trouble than the distance from T1 to GL. The correlation between the sagittal CAM-HAC inclination and the CAM-GL sagittal offset by patients may allow a similar analysis without force plate. Observing postural balance in 3D with respect to the gravity provides clinically relevant information and may help better understand the mechanisms related to specific pathologies. Either CAM position with respect to the gravity line or CAM-HAC inclination could help in assessment of postural balance.

E-Poster #59

The Usefulness and limitations of the Nash and Moe Rotational Grading Method in Predicting Vertebral Rotation

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Introduction: Nash and Moe (NM) is a commonly used method to determine vertebral rotation. Previous studies have reported correlation between the NM grade and vertebral rotation. Ho, et al and Kuklo, et al have provided mathematical formulae establishing this relationship. We have also reported reasonable correlation between the two. However, each of these studies was limited by small numbers.

Methods: We assessed patients with AIS with thoracic or thoraco-lumbar curves who were candidates for surgical correction and who had preoperative CT scans on file. All measurements were obtained by two independent observers. The apex vertebra of each curve was assigned a rotation grade via the Nash & Moe technique based on standard standing films. The same vertebra was similarly graded on a scout CT (supine) view. Direct measurement of angular rotation was performed on the axial CT slice containing the apex vertebra, as described by Ho et al.

Results: 83 patients (143 curves) were assessed. The group was 77.1% female, with mean age of 14.4 years. Mean coronal Cobb angle was 46 degrees, and mean CT axial rotation was 19.5 degrees. Paired t-tests showed no significant interobserver differences for any of the measured variables. There was a significant difference between Nash & Moe grades in standing films compared to the same vertebrae on supine views ($p=0.000001$). A linear regression did not strongly correlate the Nash & Moe grade as seen on supine CT scout view with direct angular rotation ($R = 0.49$).

Conclusion: Both Nash & Moe grading and Ho et al's technique of CT measurement were found to have good interobserver reliability. However, a significant difference in NM grading is seen with changes in patient position. The previously reported correlation of NM grading and CT scan rotation was found to be weaker in larger samples. This correlation remained unchanged regardless of patient positioning. Previously described formulae establishing this relationship could not be validated.

Significance: Little information can be obtained from the Nash and Moe measurements and surgeons must be aware of its limitations.

E-Poster #60

Incidence of Spinal Injuries and Their Surgical Treatment in Children and Adolescents: A Population Based Study from 1997 to 2006 in Finland

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Introduction: Epidemiological data on spinal injuries and their treatment in children is sparse, and only few population based data exist on the subject. Aims of the current study were: to define incidences of

children's spinal fractures and spinal cord injuries and to evaluate the need for surgical interventions in a population based epidemiological study in Finnish children and adolescents.

Methods: All spinal fractures and spinal cord injuries in children under 18 years of age treated in hospital between 1997-2006 in Finland were included. The data on injuries, hospitalizations, and surgical treatment were collected from the National Hospital Discharge Register which includes all in-patient treatment periods. Fatal spinal injuries were derived from the Official Cause-of-Death Statistics of Finland.

Results: The overall incidence of spinal fractures remained rather stable during the follow-up period, averaging 66 per million children and representing 2.3% of all pediatric fractures. The proportions of cervical, thoracic, and lumbar spine injuries altered with age. In younger children (<8 years of age), cervical spine was most often affected, and cervical spine dislocation was the most common injury. In the older children, lumbar (42%) and thoracic spine injuries (33%) were more common than cervical. Annual incidence of pediatric spinal cord injuries was 4.3 per million children and 1.9 if prehospital fatalities were excluded. Cervical spinal cord injury with or without cervical spine fractures accounted for 80% of the fatalities. One-third of the spinal injuries required surgical treatment. Most common procedures were posterior lumbar spine stabilization, anterior cervical spine decompression and stabilization, and posterior thoracic spine stabilization.

Conclusion: Pediatric spine and spinal cord injuries are rare. Prevention of spinal cord injuries is part of the overall prevention of severe accidents

Significance: In contrast to previous literature, the most commonly affected area in pediatric spinal injuries was lumbar spine. One-third of the injuries require surgical intervention.

Table 1. Spinal injuries leading to hospital treatment in Finnish children and adolescents (below 18 years of age) between 1997 and 2006.

Parameter	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Spine fractures	83	54	85	69	63	85	74	67	83	86	75
Cervical spine	21	12	29	22	16	21	19	23	24	27	21
Thoracic spine	28	19	23	23	18	32	21	21	28	23	25
Lumbar spine	34	23	33	24	29	32	34	23	31	36	30
Spinal cord injuries	2	3	1	5	1	1	3	2	1	2	2.1
Surgical treatment	18	11	28	22	20	27	27	22	22	24	22
Cervical spine	4	3	10	6	9	4	9	8	6	6	6.5
Thoracic spine	2	2	2	8	3	8	6	5	6	7	4.9
Lumbar spine	12	6	16	8	8	15	12	9	10	11	11
Fatal spinal injuries	5	1	2	2	7	3	3	1	2	1	2.7

E-Poster #61

Ten Years Follow-Up of Thoracoscopically Assisted Treatment of Thoracolumbar Fractures

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Introduction: Although there are many studies that show good outcomes regarding the follow up of thoracoscopically treated patients with fractured spine, there are no single available study concerned with the long-term follow up of such patients (after reviewing Medline, Pubmed, and Ovid).

Methods: Between May 1994 and August 1998 forty four patients with spinal fractures were operated upon in our hospital using thoracoscopically-assisted technique. Out of those, thirty patients were available for late follow up. Clinical and radiological outcomes of these patients were evaluated after a mean follow up period of 11.57 years (range 10-13 years). Those patients underwent posterior stabilization plus anterior thoracoscopically assisted decompression and fusion. Of these 30 patients 15 were operated in lateral decubitus position and 15 in prone position. The ODI (Oswestry Disability Index) was used for subjective

clinical evaluation, combined with clinical examination evaluating range of motion, local tenderness, scars condition, and neurological status. Plain x-ray in two views (anteroposterior and lateral) was used for the radiological evaluation.

Results: Fusion rate was 100%. The ODI ranged from zero to 18 with a mean of 4.66. With the exception of one patient, there were no restrictions of range of motion. All patients showed no local tenderness and excellent scar condition. The neurological status was not changed compared with that 2 years after surgery. Although patients operated in prone position showed better initial correction and less loss in correction in follow up, but the difference was statistically insignificant. There is no statistically significant difference between cases operated in lateral position and those operated in prone position as regarding ODI, and fusion rate.

Conclusion: The use of thoracoscopy in cases of spinal fractures showed a good long term results regarding both clinical and radiological evaluation in either lateral or prone position. In comparison to open thoracotomy, our results were better in form of better fusion rate and less incidence of long-term complications.

Significance: To our knowledge, this is the first study with a minimum of 10 years follow up of thoracoscopically treated patients with fractured spine.

E-Poster #62

A Novel Neuromonitoring Phenomenon May Anticipate MEP Loss and Avoid Further Spinal Cord Insult During Surgery

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Introduction: We report a novel phenomenon: suprasegmentally generated electromyographic discharges (SEDs) which can predict transcranial motor evoked potential (MEP) loss during spinal surgery at spinal cord level.

Methods: The records of 184 patients undergoing cervical (173) or thoracic (11) decompression were retrospectively reviewed. The same intramuscular recordings were used for electromyography (EMG) and MEP. Severe SEDs, seen at least two segments below the operative site, were defined as frequent, complex bursts or prolonged, repetitive (tonic) EMG discharges. At a minimum during active spinal cord decompression, MEP's were recorded after each major surgical intervention or manipulation. In the event of severe SEDs, a report of possible spinal cord impact was made and surgery paused for MEP recording.

Results: Lost MEP was observed in 15 (8.2%) cases, 7 of whom had severe SEDs prior to MEP loss. Interventions included patient re-positioning, increased BP, instrumentation adjustment, wake-up test, or surgical pause. MEP recovered in 10 cases; 5 patients lost MEP without recovery and with worsened post-operative neurological examination (2.7% true positive). Severe SEDs were seen in a total of 15 cases and anticipated MEP loss in 7/15. In 13/15 cases, manipulations near dura were the proximate cause of severe SED's. The positive predictive value of severe SED occurrence for MEP loss was 0.47; the negative predictive value of severe SED absence for MEP preservation was 0.95.

Conclusion: When severe SEDs are identified during active spinal cord decompression, the risk of MEP loss approaches 50%. If severe SEDs are observed, spinal cord impact may have occurred. At a minimum, surgical pause and MEP performance are recommended.

Significance: We report a novel diagnostic phenomenon: suprasegmentally generated electromyographic discharges (SEDs) which can predict transcranial motor evoked potential (MEP) loss during spinal surgery at spinal cord level and help avoid further spinal cord insult during surgery

E-Poster #63

Critical Values of Sagittal Balance Associated with Deterioration of Health-Related Quality of Life in Adult Scoliosis

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Introduction: There can be a wide variability in sagittal balance in the normal population. It is therefore difficult to define strict criteria of sagittal balance to achieve when treating patients with spinal deformity. Most clinicians measure spinal balance through the C7 plumbline, but the use of the gravity line is also gaining interest in the evaluation of global balance. The objective of the current study is to determine if there are specific critical values of C7 plumbline and/or gravity line that can predict a poor HRQOL.

Methods: A total of 73 consecutive patients with adult scoliosis and no prior surgery needing full spine standing radiographs were evaluated using a force plate in order to simultaneously assess the gravity line. All patients also completed the Oswestry disability index (ODI) questionnaire. Sagittal spinal and global balance was evaluated from the C7 plumbline and gravity line, respectively. C7 plumbline and gravity line were both assessed with respect to the postero-superior corner of the S1 vertebral body.

Results: Sagittal spinal (C7 plumbline) and global (gravity line) balance, as well as their relative position were significantly related to the ODI. A poor HRQOL (ODI greater than 34) was associated with a sagittal C7 plumbline greater than 6 cm, a sagittal gravity line greater than 6 cm, and a C7 plumbline in front of the gravity line.

Conclusion: Sagittal spinal and global balance was strongly related to the ODI in adults with scoliosis. The observed correlation coefficients were higher than those reported in previous studies suggesting the detrimental association of positive sagittal balance on ODI in adult spinal deformity.

Significance: This study underlines the relevance of C7 plumbline and gravity line in the evaluation of spinal and global balance. Three specific critical values of sagittal C7 plumbline and gravity line associated with a poor HRQOL are also proposed.

E-Poster #64

A Comprehensive Biomechanical Analysis of a New Variation in S2 Sacroiliac Fixation. An In-Vitro Human Cadaveric Model

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Introduction: This in-vitro biomechanical study served to investigate the multidirectional flexibility and load to failure properties of a new S2-Alar-Iliac fixation technique versus conventional methods of lumbosacral fixation.

Methods: A total of twenty-one human lumbopelvic spines were equally randomized into three groups based on reconstruction condition: 1) S1+S2 screws (S12); 2) S1+Iliac screws (S1I), and 3) S1+S2 alar-iliac screws (S2AI). Non-destructive multi-directional flexibility was performed and utilized moments of $\pm 12\text{Nm}$ for axial rotation, flexion-extension and lateral bending. Fatigue loading was performed for 10,000 cycles and static analysis repeated. Final destructive testing included anterior flexural load to failure. Quantification of lumbosacral and sacroiliac range of motion (ROM) were normalized to intact spine (100%) and failure loads reported in Nm.

Results: Iliac fixation significantly reduced ROM in axial rotation at L4-L5 and L5-S1 compared to S12 screws (29% vs. 59% vs. 36%) and at L5-S1 (28% vs. 37% vs. 41%) ($p < 0.05$). S2AI significantly lowered flexion-extension ROM at L5-S1 (42%) vs. S12 (18%) and S1I (10%) ($p < 0.05$). The S1+S2 reconstruction produced significantly higher SI joint flexion and lateral bending ROM compared to intact ($p < 0.05$), while S2AI and S1I demonstrated minor decreases in sacroiliac motion. The S12 group failed under destructive testing at $105 \pm 24\text{Nm}$ while S2AI and S1I failed at 119 and 120 Nm ($p > 0.05$). S12 failed by fracture through the SI joint or

screw pullout; S2AI by iliac wing fracture away from screw, and S1I by delamination of the ilium or lumbar screw pullout.

Conclusion: Based on the current results, conventional S12 fixation increases sacroiliac motion, while S2AI and S1I significantly reduce flexibility at L4-L5-S1 ($p < 0.05$). The latter two methods have similar biomechanical features while S2AI reduces flexion-extension motion at L4-L5-S1 compared to all other treatments ($p < 0.05$). From a biomechanical standpoint, the use of the S2-Alar-Iliac fixation technique is biomechanically equivalent to S1-iliac screws and offers lower prominence and ease of assembly compared to conventional sacroiliac stabilization.

E-Poster #65

Closure of Patent Foramen Ovale Before AIS Surgery: Is It Safe?

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Introduction: Patent foramen ovale (PFO) has been proposed as a potential source of paradoxical cerebral fat, thrombus or air microembolization through a right-to-left shunt. The presence of a PFO in the adult population may be as high as 15% to 25%. A few reports have documented severe complications in AIS surgery due to embolization from a PFO. The objective of the current study is to evaluate the frequency of PFO in patients with AIS undergoing surgery, the preoperative management at our institution and the clinical outcome and complications associated with PFO in AIS surgery.

Methods: This is a prospective consecutive case series of all patients undergoing surgical correction of AIS between March 2006 and January 2009. All patients were investigated pre-operatively using a contrast echocardiography with a Valsalva maneuver. Closure of a PFO was suggested based on the size of the PFO and/or the presence of more than 25 bubbles with Valsalva. Patients were then operated at a later date for their scoliosis.

Results: A total of 84 consecutive patients (64 girls, 20 boys) had a contrast echocardiography before their scoliosis surgery; 7 patients (8.3%) with a definitive PFO and 2 (2.4%) with a suspected PFO were identified. Mean age of patients was 15.3 (SD: 2.3), and mean Cobb angle of 61.3 (SD: 13.6). 3 of the 7 patients with definitive PFO had closure of the defect before their scoliosis surgery by a transcatheter method (Amplatz). Mean waiting time between contrast echocardiogram and scoliosis surgery was more important for operated PFO (406.5 days \pm 198.7) compared to PFO not operated (75 days \pm 76). No patient had a peri-operative complication. Contrast echocardiography identified 14 patients (16.7%) with cardiac defects other than PFO.

Conclusion: PFO was found in only 8.3% of patients with AIS pre-operatively. Simple transcatheter closure did not result in any significant complications in this series but did delay significantly the surgery.

Significance: The theoretical risk of paradoxical cerebral embolus probably warrants pre-operative evaluation for this defect using contrast echocardiography, and closure of PFO prior to AIS surgery, considering the low risk of complication associated with the procedure

E-Poster #66

Grafting Stem Cells to the Injured Spinal Cord: Is Lumbar Puncture Better than IV?

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Introduction: Stem cell therapy is a promising strategy for the treatment SCI. To translate this application to the clinic, the mode of cell delivery is crucial. Injections directly into the parenchyma may further damage already compromised tissue; therefore, less invasive methods like LP or IV delivery are preferable. This report compares LP vs IV delivery of MSCs in a rat model of SCI.

Methods: Twelve rats underwent a cervical hemisection SCI and were randomized to receive MSCs either

via LP or IV. Purified MSCs from a human donor were transplanted into the CSF at the lumbar region (LP) or the femoral vein (IV). Animals were sacrificed at early (4 days) and late (21 days) time points. Tissue sections were analyzed for graft size, tissue sparing, host immune response, and glial scar formation.

Results: Graft volumes after LP delivery were 4.1% at 4 days and 3.4% at 21 days, significantly larger than 2.3% and 1.6%, respectively, for IV delivery ($p < .05$, Figure 1). Analysis of spared white and gray matter around the injury site revealed that LP-delivered cells resulted in increased tissue sparing compared to IV-delivered cells at the early time point with values of 92.7% and 85.3% ($p < .05$). In addition, the LP delivered animals demonstrated less glial scar and host immune response.

Conclusion: LP is an excellent technique to deliver stem cell transplants to the injured spinal cord. It is superior to IV delivery and, together with the potential for autologous transplantation with MSCs, lends itself to clinical application in patients with SCI.

Significance: LP is superior to IV for the clinical translation of promising stem cell strategies for patients SCI.

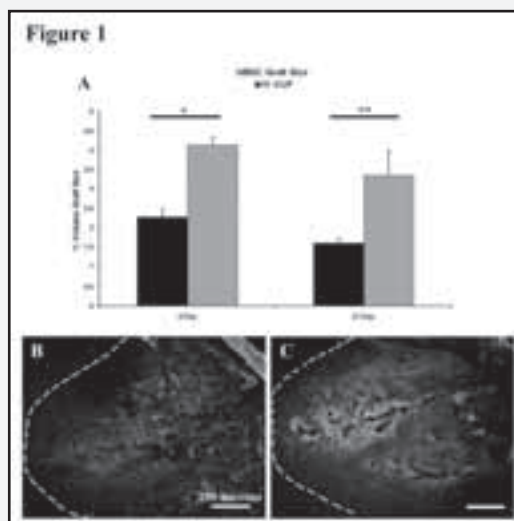


Figure 1: (A) LP delivery showed increased graft volume compared to IV at 4 and 21 days; * $p < 0.005$; ** $p < 0.05$. (B and C) Representative micrographs of tissue sections with MSC transplants delivered via IV (B) or LP (C) at 4 days. Dashed outline indicates injury border.

E-Poster #67

Usefulness of EMG Compared to CT Scans in Pedicle Screw Placement

Jose A. Herrera-Soto, MD (Arnold Palmer Hospital for Children); Michael F. Duffy, MD; Jonathan H. Phillips, MD; D. Raymond Knapp, MD

Introduction: The accurate placement of pedicle screws is of importance. The purpose of this study was to evaluate the accuracy of neuromonitoring data in regard to predicting pedicle screw position in comparison to postoperative CT scans.

Methods: 30 pediatric surgeries (329 screws) were reviewed with intraoperative EMG data. Value on the hole $< 6\text{mA}$ was considered 'at risk' and the screw was redirected or abandoned. Retained screws were again stimulated. Every patient underwent postoperative CT scan. CT scans were assessed by all 4 surgeons, and each pedicle screw was classified as being: intrapedicular, 0-2 mm breach, 2-4 mm breach or anterior. Negative predictive value of an EMG potential $> 6\text{mA}$ was calculated.

Results: No neurologic, vascular or pulmonary complications. Screw placement accuracy of 93% was obtained, with an accurate screw described as intrapedicular or less than 2 mm breach either medial or lateral on CT scans. One retained screw had > 2 but < 4 mm medial breach. 9 screws were removed intraoperatively based on obvious radiographic evidence of medial pedicle wall breach. The mean EMG potential for all placement classes of screws was not statistically different. The negative predictive value was 0.93 in the lumbar spine, and 0.92 in the thoracic spine.

Conclusion: Pedicle screws are a safe option in pediatric scoliosis. Comparison of intraoperative EMG potentials and postoperative CT scans showed no statistical significant difference in mean EMG potentials for all classes of screws. Any EMG value less than 6 mA should alert the surgeon to critically assess the screw using intraoperative radiography/fluoroscopy, and possible removal of that screw, especially in the lumbar spine. A value greater than 6 mA has a high likelihood of that screw being in the 'safe zone'.

Significance: Triggered EMG potentials are a useful means to assess pilot holes and implanted screws, more so in the lumbar spine. A low threshold of a pilot hole should alert the surgeon to re-examine and possibly redirect the intended screw path. Used in conjunction with intraoperative radiographic guidelines

of pedicle screw placement and manual probing of a screw tract, triggered EMG potentials increase the accurate placement of pedicle screws.

E-Poster #68

Fluoroscopic Radiation Exposure in Spinal Surgery In Vivo Evaluation for Operating Room Personnel

Daniel S. Mulconrey, MD (Midwest Orthopaedic Center)

Introduction: No study has performed an in vivo examination of fluoroscopic radiation exposure to the surgeon and operating room personnel. Previous studies employed older versions of fluoroscopy and increased fluoro times with instrumentation (2.5-6.3 min). Greatest concern for radiation is the unprotected regions of the body including the hands and eyes with recommended annual permissible doses of 15rem (eye) and 50rem (hand/body organ). This was a prospective in vivo investigation to quantify total radiation dosage and identify techniques to maintain safe levels of exposure.

Methods: Thirty-five surgeries (standard, open technique) were evaluated in 18 males and 17 females (mean age 52.4yrs). This included 37 lumbar levels fused, 45 lumbar decompressions, 8 anterior cervical fusions, 19 TLIF procedures. All fusion procedures included instrumentation (104 lumbar pedicle screws, 14 iliac, 22 anterior cervical). Fluoroscopy was obtained for localization, instrumentation, verification of decompression, and/or final image. Radiation dosimetry was acquired through unprotected badges (1) surgeon's chest (2) first assistant chest (3,4) cranial and caudal end of operating table.

Results: Total fluoroscopic time was 37.01 minutes. Mean time with lumbar instrumentation was greater than decompression alone (1.74 min vs 0.22min). Total fluoroscopic radiation exposure was obtained for surgeon (1225 mrem), first assistant (369 mrem), cranial table (92 mrem), caudal table (150 mrem). Mean dose/min (mrem/min) was calculated for surgeon (33.1), first assistant (9.97), cranial table (2.48), caudal table (4.05). To remain below the maximum yearly permissible level of radiation, the estimated total number of minutes for the surgeon would be 453 (eye) and 1592 (hand/organ).

Conclusion: Fluoroscopic radiation exposure to the operating room personnel is minimal and dosage to the spine surgeon remains below the acceptable maximum of occupational radiation exposure. Increasing distance from the source led to a diminished dosimetry reading. However, lead shielding for the operating staff remains highly recommended. By minimizing fluoroscopic time and maintaining a safe distance from the source, radiation contact to the spine surgeon is within safety standards.

E-Poster #69

Post-Operative Wound Infections after Spinal Deformity Surgery in Neuromuscular and Idiopathic Patient Populations: Risk Factors And Outcomes

Brian Hsu, MB BS, FRACS (Children's Hospital at Westmead); Andrew Cree, MD; Corinne Bridge; John Cummine, MD

Introduction: The rate of postoperative wound infection is much lower in idiopathic scoliosis (IDS) patient populations than neuromuscular scoliosis (NMS). In this study, we report the outcomes of spinal deformity surgery in both these patient populations and the risk factors for postoperative wound infections

Methods: Between 1998 and 2008, 473 patients underwent spinal surgery for a variety of indications. Included in this study are 336 consecutive patients who had surgery for NMS or IDS. The clinical records were reviewed and all complications recorded. Pre-operative and post-operative radiographs were also reviewed

Results: There were 188 patients with IDS and 148 patients with NMS. Post-operative infection occurred in 10.6% of NMS and 2.6% of IDS. The infection was confirmed by wound swab and blood tests (CRP, ESR) and blood cultures. Fifty percent of the NMS infections required a return to surgery for treatment. The remainder were managed with intravenous antibiotics. Only 1 patient in the IDS group required surgical management

of the infection. The most common organisms isolated were *S aureus*, methicillin-resistant *S Aureus* and *E Coli*. All infections occurred in the first 7 weeks after surgery except three patients in the NMS group who had a wound infection at 6 months, 8 months and 2 years after surgery. There were no new neurologic deficits in either group. Only 2 patients required removal of implants, both were delayed presentations

Conclusion: When comparing NMS to IDS patients, there is a four-fold infection rate in NMS patients. However, not all patients require surgical debridement and removal of implants. There was no difference in the infection rate contributable to the length of surgery, length of hospital admission before surgery or types of implant used. The NMS group had a higher incidence of use of allograft bone, cognitive impairment and non-ambulation

Significance: Early detection and aggressive antibiotic therapy may give adequate control of wound infection without return to surgery. The implant retention rate in those treated early for infection is much higher (100%) compared with those who present late (33%)

E-Poster #70

Cortical Wall Thickness is a Stronger Predictor of Allograft Femoral Ring Strength than Bone Mineral Density or Donor Age

Jeremy Tesar, BS (Oregon Health and Science University); Timothy Bahney, BS, ME; Rafe Sales, MD; Adam Cabalo, MD; Kara Lanning, BS; Robert A. Hart, MD

Introduction: Structural allograft bone functions as a mechanical spacer and biological scaffolding. For optimal clinical function, structural allograft bone must be able to support substantial loads, taking into account the temporary loss of mechanical strength which occurs during remodeling. Fractures of structural allograft following lumbar spine fusion have been reported, often requiring revision surgery. Despite the clinical importance of these issues, no standards currently exist to guide donor screening and tissue processing by allograft tissue banks.

Methods: Seventeen femora were obtained with 5 matched pairs and 7 individual specimens. Each femora was cut into ten 20-millimeter pieces. All specimens were tested in axial compression on a mechanical testing apparatus (Instron Corporation, Canton, MA) at a constant loading rate of 5 millimeters per minute. Bone mineral density, femoral graft geometry, and donor age were recorded for each specimen. A linear regression model (Pearson correlation, "PCorr") compared ultimate compressive load with bone mineral density, minimum and maximum cortical thickness, outer ring diameter, and gender-specific donor age.

Results: The correlations between the maximal load to failure and minimum and maximum wall thickness are statistically significant (PCorr = 0.67 and PCorr = 0.72 respectively; $p < 0.001$). Outer ring diameter (PCorr = -0.15), inner ring diameter (PCorr = 0.14), BMD (PCorr = -0.35) and age (PCorr = -0.07) correlated modestly with ultimate compressive strength but did not reach statistical significance.

Conclusion: These results demonstrate that cortical wall thickness is strongly correlated with the ultimate failure load of structural femoral allograft. Minimum values for cortical wall thickness could be established as a guideline for structural allograft providers, and would serve better as a screening parameter than diameter, BMD, or donor age.

E-Poster #71

Reliability Testing of the Shriners Pediatric Instrument for Neuromuscular Scoliosis (SPINS): A Quality of Life Questionnaire for Children with Spinal Cord Injuries

Louis N. Hunter, PT, MS; Fred Molitor, PhD; Mary Jane Mulcahey, PhD; Randal R. Betz, MD(Shriners Hospitals for Children, Philadelphia); Lawrence C. Vogel, MD; Prof. Craig McDonald

Introduction: The SPINS is a 92-item questionnaire that assesses function, satisfaction, and importance for the domains of sitting balance, activities of daily living (ADLs)/self-care, bowel/bladder management, mobility, and sports/recreation/leisure. It also assesses the domains: pain, cosmesis, skin integrity, thoracic-lumbar-

sacral orthosis (TLSO) effectiveness, and surgery. There is a parent version for children less than 10 years old as well as a child/adolescent version for children 11-18 years old. The purpose of this study was to report the test-retest reliability of the SPINS.

Methods: A convenience population of 45 children with SCI completed the SPINS as part of a multi-center study examining its validity and reliability. Of those 45 subjects, 15 children (ages 5-17 years old) completed the SPINS twice. The theoretical range of scores for each domain is 0-100 with higher scores representing better quality of life and outcomes. Both Pearson correlation and Lin's concordance coefficients were calculated, with the former more commonly reported but the latter representing a superior statistic to assess reliability.

Results: SPINS demonstrated excellent reliability (> 0.90 for both Pearson and Lin's) with assessing function for bowel/bladder management and mobility; and acceptable reliability (> 0.80 for Lin's) for sitting balance, self-care, sports/recreation/leisure, and skin integrity. When these same coefficients were calculated using weighted values for satisfaction and importance, excellent reliability was found with self-care only (0.95); Lin's concordance coefficients for sitting balance, bowel/bladder management, mobility, and sports/recreation/leisure ranged from 0.67 to 0.77. Excellent reliability was also found for cosmesis (0.90), and acceptable reliability was found for skin integrity (0.81). Pain domain yielded unacceptable reliability (0.64).

Conclusion: With the exception of assessing pain, the SPINS has been shown to be comprehensible and demonstrates acceptable to excellent reliability. With further psychometric testing, the SPINS will serve as an outcomes instrument that can measure the health-related quality of life of children with SCI with neuromuscular scoliosis. Support: Shriners Hospitals for Children Grant #9155.

E-Poster #72

Comparative Analysis of Minimally Invasive Lumbar Posterolateral Fusion with Transcutaneous Pedicle Screws vs. Conventional Approach for Degenerative Spondylolisthesis

Yoshihisa Kotani, MD (Hokkaido University Graduate School of Medicine); Kuniyoshi Abumi, MD; Manabu Ito, MD; Hideki Sudo, MD; Yoshihiro Hojo, MD; Prof. Akio Minami

Introduction: To minimize the perioperative invasiveness and improve the quality of life, we have performed the minimally invasive lumbar posterolateral fusion (MIS-PLF) with transcutaneous pedicle screw fixation for degenerative spondylolisthesis. This study prospectively compared the clinical result of MIS-PLF with that of conventional PLF (Open-PLF) with emphasis on perioperative invasiveness and patients' quality of life.

Methods: The total of sixty-five patients received single-level PLF for lumbar degenerative spondylolisthesis. There were thirty-five cases of MIS-PLF and thirty cases of Open-PLF. The surgical technique of MIS-PLF includes 4 cm of main incision and transcutaneous pedicle screwing and rod insertion followed by posterolateral iliac bone graft. Analyzed parameters included the operation time, intra and postoperative blood loss, Oswestry-Disability Index (ODI), Roland-Morris Questionnaire (RMQ), JOA score, and VAS scores of low back pain.

Results: The average follow-up period was forty-three months postoperatively (12-47). The intra and postoperative blood loss was significantly smaller in MIS-PLF group (180cc) when compared to open-PLF group (479cc). The ODI and RMQ score rapidly decreased at initial two weeks postoperatively in MIS-PLF group, which was significantly different from those in open-PLF group. The VAS score demonstrated further rapid decreases on postoperative day 3, 5, and 14, which was significantly different from those in open-PLF group. The fusion was obtained in all two groups, and no major complications were demonstrated.

Conclusion: The minimally invasive lumbar posterolateral fusion with transcutaneous pedicle screw system successfully decreased the perioperative invasiveness when compared to conventional open-PLF. The reduction of postoperative pain led to early extension of ADL, demonstrating the rapid improvement of several QOL parameters.

Significance: The minimally invasive posterior lumbar fusion does not necessarily require the interbody fusion with the presented technique. Even in the minimum access surgery, the use of interbody fusion should be carefully considered based on the degree of segmental instability and spinal alignment.

E-Poster #73

What Does a Scoliometer Really Measure?

Patrick J. Cahill, MD (Shriners' Hospital for Children); Ashish Ranade, MD; Amer Samdani, MD; Jahangir Asghar, MD; M. Darryl Antonacci, MD; David H. Clements, MD; MD; Randal R. Betz, MD

Introduction: A scoliometer, also known as an inclinometer or level, is a non-invasive and easily applied clinical tool used to measure trunk asymmetry. The most accurate measurement of vertebral rotation is by CT axial imaging. However, concerns exist over the radiation exposure associated with computed tomography. There is a desire to objectively assess the amount of vertebral body derotation correction following surgery for AIS. Research on the efficacy of various surgical derotation maneuvers has used the scoliometer as a way to quantify results without verifying the accuracy of the scoliometer by comparing it to the "gold standard" of CT imaging. This report looks at the mathematical correlation between the two measurements.

Methods: A retrospective review of 29 patients with AIS was performed. Apical trunk rotation as measured by a scoliometer was obtained in a prospective manner. Rotation of the apical lumbar and thoracic vertebrae were measured on pre-operative CT scan. Statistical correlation analysis between the two measurements was performed.

Results: A statistically significant correlation between vertebral rotation as measured on CT scan and scoliometer could not be established. The Pearson's product moment correlation coefficient for the thoracic curves was 0.266. For lumbar curves, the Pearson's product moment correlation coefficient was -0.388. Neither of these correlations was statistically significant ($p > 0.05$).

Conclusion: There was no statistically significant correlation between vertebral rotation as measured on CT scan and trunk rotation as measured by scoliometer. Vertebral body rotation is only one factor that contributes to side-to-side trunk asymmetry. Other factors that influence trunk shape may include adipose tissue coverage of bony structures, differences in rib morphology, and muscle mass asymmetry.

Significance: A scoliometer cannot be used as an alternative to axial CT scans for measurement of vertebral rotation.

E-Poster #74

Prevalence and Clinical Significance of Superficial Abdominal Reflex Abnormalities in Patients with Spinal Deformity

Taichi Tsuji, MD (Meijo Hospital); Noriaki Kawakami, MD; Kazuyoshi Miyasaka, MD; Tetsuya Ohara, MD; Ayato Nohara, MD; Michiyoshi Sato, MD; Kenyu Ito, MD

Introduction: To determine the prevalence and significance of superficial abdominal reflexes in patients with spinal deformity.

Methods: Since 1990, three thousand four hundred and one consecutive patients with spinal deformity underwent physical examination in our clinic. Bilateral absent reflexes or asymmetric reflexes were regarded as "abnormal". MRI was performed on most of the patients who needed surgical intervention and showed abnormal symptoms and/or atypical curve patterns, or abnormal neurological findings.

Results: Three hundred seventy-four (11%) patients exhibited superficial abdominal reflex abnormalities. One hundred ninety-two patients (51%) had bilaterally absent abdominal reflex. Others (49%) had asymmetric reflexes. MRI demonstrated Chiari malformations in 38 patients (10%). Of the 38 with Chiari malformation, 31 patients (82%) had asymmetric reflexes. The other seven patients with Chiari malformation had bilaterally absent reflexes. Of the 182 patients who exhibited asymmetrical abdominal reflexes, 151 had no Chiari malformations. Only 7 of 192 patients (4%) who showed bilaterally absent reflexes had Chiari malformations.

Conclusion: Superficial abdominal reflex was a useful indicator of underlying cord abnormalities, such as Chiari malformations and/or syringomyelia, although further analysis of the reliability of these results needs to be done.

E-Poster #75

Thoracoplasty in Adolescent Idiopathic Scoliosis - It Doesn't Make a Difference!

B. Stephens Richards, MD(Texas Scottish Rite Hospital for Children); *Daniel J. Sucato, MD, MS; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; Mohammad Diab, MD; Spinal Deformity Study Group*

Introduction: This study investigated the impact of thoracoplasty in adolescent idiopathic scoliosis (AIS) patients' clinical and radiographic appearance, and their outcome measures. To avoid the argument that pedicle screw constructs may obviate the need for thoracoplasty, only patients treated with hybrid constructs were included.

Methods: 103 patients with thoracic (Lenke types 1-4) curves who underwent posterior spinal fusion (PSF) using hybrid constructs were studied. There was a minimum 2-year followup. 21 of these patients had thoracoplasty (Group A) and 82 did not (Group B). Thoracic curve magnitude, clinical rotation as measured by scoliometer, radiographic rotation (Nash-Moe), body mass index, and SRS-30 measures (appearance, satisfaction, pain) were evaluated preoperatively and two years postoperatively.

Results: Preoperatively, the curve magnitudes were significantly greater in the thoracoplasty group (62.00 vs 57.50). Despite this, there were no significant differences between groups (A/B) with regard to clinical thoracic rotation (15.3/14.7) or radiographic thoracic rotation. Body mass index was similar (21.9/21.8). Of the three SRS domains tested, the preoperative satisfaction score was higher in the thoracoplasty group, but no differences were found in pain or appearance scores. Two years postoperatively, the curve magnitude remained significantly greater in the thoracoplasty group (28.60/22.20). There were no significant differences between groups (A/B) with regard to clinical rotation (12.2/11.3), radiographic rotation, body mass index (22.5/22.6), or any of the three SRS domain scores.

Conclusion: Over time, when AIS patients treated with PSF and thoracoplasty were compared to those who did not undergo thoracoplasty, there were no differences between groups in residual clinical rotation (as measured by scoliometer), radiographic rotation, or SRS domains of appearance, satisfaction, or pain. Knowing that there will be no recognizable improvements in these parameters when a thoracoplasty is performed, surgeons should provide other reasons if they consider thoracoplasty to be indicated in the surgical treatment of AIS.

Significance: Thoracoplasty adds little, if any, benefit to the outcome of surgery in adolescent idiopathic scoliosis.

E-Poster #76

The Rate of Posterior-Only Surgery in Adolescent Idiopathic Scoliosis has Dramatically Increased over the Past 15 Years with Less Complications: A Multicenter Analysis

Lawrence G. Lenke, MD (Washington University School of Medicine); *Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; Keith H. Bridwell, MD; Timothy R. Kuklo, MD, JD; John B. Emans, MD; Michael F. O'Brien, MD; Brenda Sides, MA; Spinal Deformity Study Group*

Introduction: To compare the changing role of an isolated anterior spinal fusion (ASF), posterior spinal fusion (PSF), and circumferential (ASF/PSF) fusion in the surgical treatment of adolescent idiopathic scoliosis (AIS) between 1992 and 2006.

Methods: A multicenter (n=30) evaluation of major thoracic (MT) (Lenke types 1A, 1B, 3A, 3B) and thoracolumbar/lumbar (TL/L) (5C) "overhang" curves were evaluated. 580 cases treated between 1992 and 2000 were retrospectively evaluated (Early) group, while 585 cases treated between 2001 and 2006 (Recent) group were prospectively evaluated. The Early group had a mean age of 13.9 vs 14.3 years in the Recent group (p=0.02). The mean preop MT curve was 51.8° in the Early group vs 55.8° in the Recent group (p<0.0001), and the mean TL/L curve was 43.2° in the Early group vs 49.6° in the Recent group (p<0.0001).

Results: The corresponding number and percent of ASF alone, PSF alone, ASF/PSF procedures were 221 (38.1%), 320 (55.2%), 39 (6.7%) in the Early group vs 117 (20%), 452 (77.3%), 16 (2.7%) in the Recent group (p<0.001 for all 3 comparisons). The most common anterior procedure performed in both groups was an

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open ASF with a single rod in 178 (68.5%) of all ASF cases (30.6% of total) in the Early group declining to 62 (47.3%) of all ASF cases (10.6% of total) in the Recent group ($p < 0.05$). VAT instrumented ASF procedures declined from 39 (15.0%) of all ASF cases (6.7% of total) in the Early group to 10 (7.6%) of all ASF cases (1.7% of total) in the Recent group ($p < 0.05$). The ultimate postop corrections were not statistically different between the 2 groups (postop MT Cobb 21° early vs 22° Recent; postop TL/L Cobb 14° Early vs 16° Recent; both comparisons $p > 0.05$). Although complication rates did not differ significantly by surgical approach between the groups; the Recent group had an overall significantly lower complication rate of 5.5 vs 9.5% ($p = 0.009$).

Conclusion: Over the past 15 years, the role of ASF and ASF/PSF procedures in AIS has declined significantly with a corresponding increase in PSF only procedures, despite an increasing preoperative major curve magnitude. These changes in surgical approach have occurred without sacrificing postop coronal correction and with lower complication rates.



San Antonio
Texas

About SRS

Goals and Mission Statement

Scoliosis Research Society Mission Statement

The purpose of Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

Goals and Aspirations of the Scoliosis Research Society

The Scoliosis Research Society is composed of physicians and scientists who, prior to becoming members, have concentrated on the problems of spinal deformities and who, as members, make a continuing commitment to solve the problems of spinal deformity, to participate in research and to contribute to the Society's educational and service efforts.

The business of the Scoliosis Research Society is knowledge. The Society is concerned with the development of new knowledge, the continuing education of its members, and the communication of knowledge to others. Because knowledge brings responsibility, members are committed to the highest standards of ethical practice and professional service to the Society and the community.

Research, education and care of patients are the central activities through which members channel their expertise. It is expected that members will be active to some extent in each of these areas, but with different emphasis based on individual interests and talents.

Research

It is not by accident that the word "research" occupies a central place in the name of our Society. The members of the Society are committed to research in spinal deformities.

All members participate in some research activity which leads to increased knowledge. The one Society-sponsored research project in which every member can participate is the Morbidity and Mortality Report. This project has produced more useful information for the Society than any other single research program.

Other means of participation in research include individual basic scientific or clinical studies, inter-institutional studies or Society-sponsored projects. In all forms of research, members strive for objectivity and meticulous honesty.

Education of Members

New data and new techniques evolve rapidly in the medical and surgical care of spinal disorders. The members of the Scoliosis Research Society take responsibility for their own continuing medical education. In addition, the Society provides structured educational experiences through printed material, IMAST, worldwide conferences and the Annual Meeting. These educational efforts are focused on the members of the Society, who already possess a high degree of expertise, and their value depends on the member's willingness to participate. Members contribute to the education of others by reporting on cases from their own practices in the open forums of the Annual Meeting and IMAST.

Education of Residents and Fellows

We believe that the possession of specialized knowledge and expertise carries with it the responsibility to transmit this to others. The members of the Society, collectively and individually, will participate in the design and structuring of residency and fellowship programs. We expect Society members to be active in AAOS and comparable educational programs in spinal deformities for orthopaedists.

Public Education

The Scoliosis Research Society recognizes a responsibility to public education and the need for effective liaison with lay organizations dedicated to some aspect of the prevention and treatment of spinal deformities. We believe that we have a responsibility to be the leading resource for information and encouragement to these groups.

The Society has dedicated time and resources to the development of educational programs for the public. We expect members to support and participate locally in those programs with which the Society cooperates.

Ethical Practice

The members of the Scoliosis Research Society are dedicated to the highest standards of ethical practice. Members strive to:

1. Develop thoughtful diagnoses and treatment plans based on common sense, scientific principles and data.
2. Recognize personal, technical and cognitive limitations.
3. Charge fair and appropriate fees for the services performed and assist in providing health care to all members of the community.
4. Distinguish appropriate alternative treatment plans from ill conceived ones when giving opinions and not disparage physicians who recommend other acceptable treatments.
5. Recognize that the assessment of evolving technology is difficult and therefore maintain a degree of caution about new techniques, using these to improve patient care rather than to gain a competitive advantage.

Acknowledging Support

The Society as a whole and individual members have benefited from the generous support of private and corporate sponsors. We will give full acknowledgment for this support without concern that such recognition of assistance may be misinterpreted.

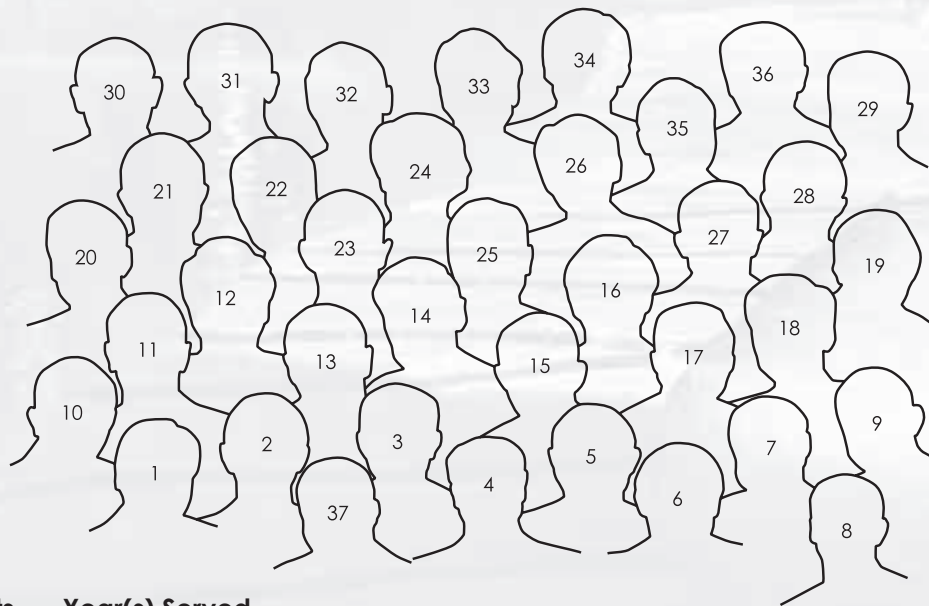
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2	Harry L. Shufflebarger	2000	15	John H. Moe	1966-68	28	Alvin H. Crawford	2001
3	Vernon T. Tolo	1996	16	Daniel R. Benson	1992	29	Edgar G. Dawson	1995
4	John E. Lonstein	1991	17	Allen S. Edmonson	1985	30	Jessie H. Dickson	1990
5	Theodore R. Waugh	1982	18	David S. Bradford	1984	31	John Carlisle Brown	1993
6	Robert N. Hensiger	1989	19	Kenton D. Leatherman	1975	32	John E. Hall	1960-70
7	James W. Ogilvie	2004	20	Denis S. Drummond	2002	33	G. Dean MacEwen	1977-78
8	Randal R. Betz	2005	21	Ronald L. DeWald	1988	34	Donald P.K. Chan	1998
9	Paul R. Harrington	1973	22	Robert B. Winter	1974	35	Courtney W. Brown	1999
10	Behrooz A. Akbarnia	2006	23	Marc A. Asher	1997	36	David B. Levine	1979
11	Gordon L. Engler	1994	24	Keith H. Bridwell	2003	37	George H. Thompson	2008
12	Wilton H. Bunch	1986	25	Edward H. Simmons	1976			
13	Clyde Lester Nash, Jr.,	1983	26	William J.Kane	1980			

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2nd Annual Meeting

1967 – Minneapolis, MN, USA

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President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
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President	John H. Moe
President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson Louis A. Goldstein Paul R. Harrington David B. Levine Jacquelin Perry

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Sept. 4-6, 1969 – Anaheim, CA, USA

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Secretary-Treasurer	William J. Kane
Past President	John H. Moe
Directors	Allen S. Edmonson Richard M. Kilfoyle Jacquelin Perry James W. Tupper

5th Annual Meeting

Sept. 10-12, 1970 – Toronto, ON, CANADA

President	John E. Hall
President-Elect	G. Dean MacEwen
Secretary-Treasurer	William J. Kane
Sec.-Treas.-Elect	David B. Levine
Past President	John H. Moe
Directors	Robert P. Keiser Theodore R. Waugh, Jr. Robert C. Zuege

6th Annual Meeting

Sept. 8-10, 1971 – Hartford, CT, USA

President	G. Dean MacEwen
President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Past President	John E. Hall
Directors	Charles H. Herndon John C. Kennedy John H. Moe Frank C. Wilson, Jr.

7th Annual Meeting

1972 – Wilmington, DE, USA

President	G. Dean MacEwen
President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Treasurer-Elect	James H. Hardy
Past President	John E. Hall
Directors	Kenton D. Leatherman Lawrence Noall Albert C. Schmidt

8th Annual Meeting

1973 – Gothenburg, SWEDEN

President	Paul R. Harrington
President-Elect	Robert B. Winter
Secretary	David B. Levine
Treasurer	James H. Hardy
Past President	G. Dean MacEwen
Directors	Gordon W.D. Armstrong Kenton D. Leatherman Lawrence Noall

9th Annual Meeting

Sept. 11-13, 1974 – San Francisco, CA, USA

President	Robert B. Winter
President-Elect	Kenton D. Leatherman
Secretary	David B. Levine
Secretary-Elect	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Past President	Paul R. Harrington
Directors	Gordon W.D. Armstrong R. Kirkin Ashley Wilton H. Bunch

10th Annual Meeting

Sept 10-12, 1975 – Louisville, KY, USA

President	Kenton D. Leatherman
President-Elect	Edward H. Simmons
Secretary	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Past President	Robert B. Winter
Directors	R. Kirkin Ashley Wilton H. Bunch Ronald L. DeWald

Past Meetings and Officers

11th Annual Meeting

Sept. 4-6, 1976 – Ottawa, ON, CANADA

President	Edward H. Simmons
President-Elect	Louis A. Goldstein
Secretary	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Treasurer-Elect	Wilton H. Bunch
Past President	Kenton D. Leatherman
Directors	Ronald L. DeWald Robert B. Winter

12th Annual Meeting

Oct. 24-27, 1977 – HONG KONG

President	R. Kirklin Ashley
President (9/76-10/76)	Louis A. Goldstein
Secretary	Theodore R. Waugh, Jr.
Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Jesse H. Dickson Kenton D. Leatherman Marr P. Mullen

13th Annual Meeting

Sept. 13-15, 1978 – Boston, MA, USA

President	R. Kirklin Ashley
President-Elect	David B. Levine
Secretary	Theodore R. Waugh, Jr.
Secretary-Elect	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Marr P. Mullen Clyde L. Nash, Jr.

14th Annual Meeting

Sept. 11-14, 1979 – Seattle, WA, USA

President	David B. Levine
President-Elect	William J. Kane
Secretary	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	R. Kirklin Ashley
Directors	James E. Holmblad Donald A. Jones S. Henry LaRocca Clyde L. Nash, Jr.

15th Annual Meeting

Sept. 17-19, 1980 – Chicago, IL, USA

President	William J. Kane
President-Elect	Gordon W.D. Armstrong
Secretary	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Treasurer-Elect	John C. Brown
Past President	David B. Levine
Directors	James E. Holmblad Donald A. Jones

16th Annual Meeting

Sept. 16-18, 1981 – Montreal, QC, CANADA

President	Gordon W.D. Armstrong
President-Elect	Theodore R. Waugh, Jr.
Secretary	Allen S. Edmonson
Treasurer	John C. Brown
Past President	William J. Kane
Directors	James E. Holmblad Gordon L. Engler David S. Bradford

17th Annual Meeting

Sept. 22-25, 1982 – Denver, CO, USA

President	Theodore R. Waugh, Jr.
President-Elect	Clyde L. Nash, Jr.
Secretary	Allen S. Edmonson
Secretary-Elect	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Gordon W.D. Armstrong
Directors	Gordon L. Engler David S. Bradford Morris A. Duhaime Harold K. Dunn

18th Annual Meeting

Sept. 28-Oct. 1, 1983 – New Orleans, LA, USA

President	Clyde L. Nash, Jr.
President-Elect	David S. Bradford
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Theodore R. Waugh, Jr.
Directors	Morris A. Duhaime Harold K. Dunn Edgar G. Dawson John P. Kostuik

19th Annual Meeting

Sept. 19-22, 1984 – Orlando, FL, USA

President	David S. Bradford
President-Elect	Allen S. Edmonson
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Treasurer-Elect	Gordon L. Engler
Past President	Clyde L. Nash, Jr.
Directors	Edgar G. Dawson John P. Kostuik Thomas I. Lowry

Past Meetings and Officers

20th Annual Meeting

Sept. 17-20, 1985 – San Diego, CA, USA

President	Allen S. Edmonson
President-Elect	Wilton H. Bunch
Secretary	Robert N. Hensinger
Treasurer	Gordon L. Engler
Past President	David S. Bradford
Directors	Thomas I. Lowry Marc A. Asher L. Ray Lawson Albert B. Schultz

21st Annual Meeting

Sept. 21-25, 1986 – Hamilton, BERMUDA

President	Wilton H. Bunch
President-Elect	John P. Kostuik
Secretary	Robert N. Hensinger
Secretary-Elect	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Allen S. Edmonson
Directors	Marc A. Asher L. Ray Lawson Robert Gillespie John E. Lonstein

22nd Annual Meeting

Sept. 15-19, 1987 – Vancouver, BC, CANADA

President	John P. Kostuik
President-Elect	Ronald L. DeWald
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Wilton H. Bunch
Directors	Robert Gillespie Rae R. Jacobs John E. Lonstein Stuart L. Weinstein

23rd Annual Meeting

Sept. 21-25, 1988 – Baltimore, MD, USA

President	Ronald L. DeWald
President-Elect	Robert N. Hensinger
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Treasurer-Elect	Edgar G. Dawson
Past President	John P. Kostuik
Directors	Ralph W. Coonrad Denis S. Drummond Rae R. Jacobs Stuart L. Weinstein

24th Annual Meeting

Sept. 17-22, 1989 – Amsterdam, NETHERLANDS

President	Robert N. Hensinger
President-Elect	Jesse H. Dickson
First Vice President	John E. Lonstein
Secretary	William P. Bunnell
Treasurer	Edgar G. Dawson
Past President	Ronald L. DeWald
Directors	Daniel R. Benson Ralph W. Coonrad Denis S. Drummond Thomas S. Renshaw

25th Annual Meeting

Sept. 23-27, 1990 – Honolulu, HI, USA

President	Jesse H. Dickson
President-Elect	John E. Lonstein
First Vice President	Daniel R. Benson
Secretary	William P. Bunnell
Secretary-Elect	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Robert N. Hensinger
Directors	Robert W. Gaines, Jr. Thomas S. Renshaw Susan M. Swank Stephen J. Tredwell

26th Annual Meeting

Sept. 24-27, 1991 – Minneapolis, MN, USA

President	John E. Lonstein
President-Elect	Daniel R. Benson
First Vice President	John C. Brown
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Jesse H. Dickson
Directors	Alvin H. Crawford Robert W. Gaines, Jr. Stanley D. Gertzbein Stephen J. Tredwell

27th Annual Meeting

Sept. 23-26, 1992 – Kansas City, MO, USA

President	Daniel R. Benson
President-Elect	John C. Brown
First Vice President	Gordon L. Engler
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Treasurer-Elect	Courtney W. Brown
Past President	John E. Lonstein
Directors	Alvin H. Crawford Stanley D. Gertzbein Donald P.K. Chan Susan W. Swank

Past Meetings and Officers

28th Annual Meeting

Sept. 18-23, 1993 – Dublin, IRELAND

President	John C. Brown
President-Elect	Gordon L. Engler
First Vice President	Edgar G. Dawson
Past President	Daniel R. Benson
Secretary	Vernon T. Tolo
Treasurer	Courtney W. Brown
Directors	Donald P.K. Chan Susan W. Swank Behrooz A. Akbarnia John A. Herring

29th Annual Meeting

Sept. 21-24, 1994 – Portland, OR, USA

President	Gordon L. Engler
President-Elect	Edgar G. Dawson
First Vice President	Vernon T. Tolo
Past President	John C. Brown
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	Behrooz A. Akbarnia John A. Herring William A. Carr Dennis R. Wenger

30th Annual Meeting

Sept. 13-16, 1995 – Asheville, NC, USA

President	Edgar G. Dawson
President-Elect	Vernon T. Tolo
First Vice President	Marc A. Asher
Past President	Gordon L. Engler
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	William A. Carr Dennis R. Wenger Thomas F. Kling, Jr. Jack K. Mayfield

31st Annual Meeting

Sept. 25-28, 1996 – Ottawa, ON, CANADA

President	Vernon T. Tolo
President-Elect	Marc A. Asher
First Vice President	Donald P.K. Chan
Past President	Edgar G. Dawson
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Treasurer-Elect	William A. Carr
Directors	Thomas F. Kling, Jr. Jack K. Mayfield Keith H. Bridwell Thomas R. Haheer

32nd Annual Meeting

Sept. 25-27, 1997 – St. Louis, MO, USA

President	Marc A. Asher
President-Elect	Donald P.K. Chan
First Vice President	Courtney W. Brown
Past President	Vernon T. Tolo
Secretary	Harry L. Shufflebarger
Secretary-Elect	Denis S. Drummond
Treasurer	William A. Carr
Directors	Keith H. Bridwell Thomas R. Haheer R. Mervyn Letts Michael G. Neuwirth

33rd Annual Meeting

Sept. 16-20, 1998 – New York, NY, USA

President	Donald P.K. Chan
President-Elect	Courtney W. Brown
First Vice President	Harry L. Shufflebarger
Past President	Marc A. Asher
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	R. Mervyn Letts Michael G. Neuwirth John B. Emans James W. Ogilvie

34th Annual Meeting

Sept. 23-25, 1999 – San Diego, CA, USA

President	Courtney W. Brown
President-Elect	Harry L. Shufflebarger
First Vice President	Alvin H. Crawford
Past President	Donald P.K. Chan
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	John B. Emans James W. Ogilvie John V. Banta Thomas G. Lowe

35th Annual Meeting

Oct. 18-21, 2000 – Cairns, AUSTRALIA

President	Harry L. Shufflebarger
President-Elect	Alvin H. Crawford
First Vice President	Denis S. Drummond
Past President	Courtney W. Brown
Secretary	John B. Emans
Treasurer	William A. Carr
Treasurer-Elect	Behrooz A. Akbarnia
Directors	John V. Banta Thomas G. Lowe John P. Lubicky George H. Thompson

Past Meetings and Officers

36th Annual Meeting

Sept. 19-22, 2001 – Cleveland, OH, USA

President	Alvin H. Crawford
President-Elect	Denis S. Drummond
First Vice President	Keith H. Bridwell
Past President	Harry L. Shufflebarger
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	John P. Lubicky George H. Thompson Stewart I. Bailey Thomas S. Whitecloud, III

37th Annual Meeting

Sept. 18-21, 2002 – Seattle, WA, USA

President	Denis S. Drummond
President-Elect	Keith H. Bridwell
First Vice President	James W. Ogilvie
Past President	Alvin H. Crawford
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	Stewart I. Bailey Thomas S. Whitecloud, III Randal R. Betz Howard A. King

38th Annual Meeting

Sept. 10-13, 2003 – Quebec City, Canada

President	Keith H. Bridwell
President-Elect	James W. Ogilvie
First Vice President	Randal R. Betz
Past President	Denis S. Drummond
Secretary	John B. Emans
Secretary-Elect	Thomas R. Hafer
Treasurer	Behrooz A. Akbarnia
Treasurer-Elect	Richard E. McCarthy
Directors	Howard A. King Hubert H.L. Labelle John P. Dormans David W. Polly, Jr.

39th Annual Meeting

Sept. 6-9, 2004 – Buenos Aires, Argentina

President	James W. Ogilvie
President-Elect	Randal R. Betz
First Vice President	Behrooz A. Akbarnia
Past President	Keith H. Bridwell
Secretary	Thomas R. Hafer
Treasurer	Richard E. McCarthy
Directors	John P. Dormans David W. Polly Oheneba Boachie-Adjei Michael A. Edgar

40th Annual Meeting

Oct. 27-30, 2005 – Miami, FL, USA

President	Randal R. Betz
President-Elect	Behrooz A. Akbarnia
Vice President	George H. Thompson
Past President	James W. Ogilvie
Secretary	Thomas R. Hafer
Treasurer	Richard E. McCarthy
Directors	Oheneba Boachie-Adjei Michael A. Edgar Steven M. Mardjetko Mark Weidenbaum

41st Annual Meeting

Sept. 13-16, 2006 – Monterey, CA, USA

President	Behrooz A. Akbarnia
President-Elect	George H. Thompson
Vice President	Thomas G. Lowe
Secretary	Thomas R. Hafer
Treasurer	Richard E. McCarthy
Past President	Randal R. Betz
Past President	James W. Ogilvie
Past President	Keith H. Bridwell
Directors	Steven M. Mardjetko Mark Weidenbaum Paul D. Sponseller Nobumasa Suzuki

42nd Annual Meeting

Sept. 5-8, 2007 – Edinburgh, SCOTLAND

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	Thomas R. Hafer
Treasurer	Steven M. Mardjetko
Secretary-Elect	David W. Polly, Jr.
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Paul D. Sponseller Nobumasa Suzuki Lawrence G. Lenke B. Stephens Richards

43rd Annual Meeting

Sept. 10-13, 2008 – Salt Lake City, UT, USA

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	David W. Polly, Jr.
Treasurer	Steven M. Mardjetko
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Azim Hamzaogiu Lawrence G. Lenke B. Stephens Richards James W. Roach

SRS Committees

Board of Directors

Oheneba Boachie-Adjei, President	2009
Richard E. McCarthy, President-Elect	2009
Lawrence G. Lenke, Vice President	2009
David W. Polly, Jr., Secretary	2009
Steven M. Mardjetko, Treasurer	2009
George H. Thompson, Past President I	2011
Behrooz A. Akbarnia, Past President II	2010
Randal R. Betz, Past President III	2009
Azmi Hamzaoglu, Director	2009
James W. Roach, Director	2009
Kamal Ibrahim, Director	2009
Kenneth MC Cheung, Director	2009

Adult Deformity Committee

Standing Committee – 2 per year, with 4 year terms

Mark Weidenbaum, Chair	2009
William C. Horton, Past Chair	2009
Kyu-Jung Cho (C)	2009
Khaled Kebaish (C)	2009
James Manzanara (C)	2009
Frank J. Schwab, Chair Elect	2010
Christopher I. Shaffrey	2010
Sigurd H. Berven	2011
Clifford B. Tribus	2011
Mark B. Dekutoski	2012
Hossein Mehdiian	2012

Council: Research

Board Liaison: Oheneba Boachie-Adjei

Staff Liaison: Megan Kelley

Back-up: Nadine Couto

Advocacy and Public Policy Committee

Standing Committee – 2 per year with 4 year terms

Mark A. Lorenz, Chair	2009
Bruce E. van Dam, Past Chair	2009
David W. Polly, BOS/COSS Liaison	2009
Jeffrey S. Kanel	2009
Michael D. Daubs (C)	2009
Jason Lowenstein (C)	2009
Daniel W. Green, Chair Elect	2010
Marco Brayda-Bruno	2010
William C. Lauerman	2011
John P. Lubicky	2011
Richard Holt	2012
Vishwas Talwalker	2012

Joseph P. O'Brien, advisory

Stanley E. Sacks, advisory

RAPID RESPONSE TEAM

George Thompson, Chair	Mark Lorenz
Oheneba Boachie-Adjei	Richard McCarthy
Steven Glassman	David Polly
Lawrence Lenke	

Council: Governance

Board Liaison: David W. Polly

Staff Liaison: Megan Kelley

Back-up: Katie Agard

Awards & Scholarship Committee

Standing Committee – 3 per year, with 3 year terms

K. Daniel Riew, Chair	2009
Jay Shapiro, Past Chair	2009
Charles T. Mehlman (Global Outreach)	2009
Peter O. Newton (Program)	2009
Kit M. Song (Research)	2009
Lori Ann Karol	2009
Barton L. Sachs	2009
Arya Nick Shamie (C)	2009
Hilali H. Noordeen	2010
Jeffrey L. Stambough, Chair Elect	2010
Dennis Crandall	2010
Vincent Arlet	2011
Andrew M. Casden	2011
Ensor E. Transfeldt	2011

Council: Education

Board Liaison: Steven M. Mardjetko

Staff Liaison: Nilda Toro

Back-up: Amy Miller

Bylaws & Policies Committee

Standing Committee – 1 per year, with 4 year terms

J. Abbott Byrd, Chair	2009
Eric T. Jones, Past Chair	2009
Philip S. Anson (C)	2009
Robert J. Huler, Chair Elect	2010
Michael McMaster	2011
Michael C. Albert	2012

Council: Governance

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Nilda Toro

Back-up: Tressa Goulding

CME Committee

Standing Committee – Pres Elect, Vice Pres, Program, Education, IMAST, Website & WWC Chairs, Chairs Elect, immediate past Chairs, Past Presidents I, II & III

Richard E. McCarthy, Chair	2009
Randal R. Betz, PP III	2009
R. Jay Cummings (Education PCh)	2009
Paul D. Sponseller (Program PCh)	2009
Daniel J. Sucato (Website PCh)	2009
Behrooz A. Akbarnia, PP II	2010
Peter O. Newton (Program)	2010
Andrew A. Merola (Website)	2010
Allen W. Carl (Education)	2010
Lawrence G. Lenke (IMAST), Chair Elect	2013
Kamal I. Ibrahim (WWC)	2011
Joseph H. Perra (Education ChE)	2011
Noriaki Kawakami (Program ChE)	2011
George H. Thompson, PP I	2011
Michael J. Yaszemski (Program ChE)	2011
John F. Sarwark (Website ChE)	2011
Todd J. Albert (IMAST)	2012
Oheneba Boachie-Adjei, Past Chair	2012

Council: Education

Board Liaison: Oheneba Boachie-Adjei

Staff Liaison: Amy Miller

Back-up: Nadine Couto & Megan Kelley

SRS Committees

Coding Committee

Standing Committee – 1 per year, with 4 year terms

James T. Bennett, Chair	2009
Richard J. Haynes, Past Chair	2009
David B. Cohen (C)	2009
Mark D. Rahm (C)	2009
Barton L. Sachs, Chair Elect	2010
Jeffrey B. Neustadt	2011
R. Dale Blasier	2012

Council: Governance
Board Liaison: George H. Thompson
Staff Liaison: Nadine Couto
Back-up: Megan Kelley

Education Committee

Standing Committee – 2 per year, with 4 year terms

Allen W. Carl, Chair	2009
R. Jay Cummings, Past Chair	2009
Peter O. Newton (Program)	2009
Kuniyoshi Abumi	2009
Philip S. Anson (C)	2009
Ryan C. Goodwin (C)	2009
Amer Samdani (C)	2009
Lawrence L. Haber	2010
Joseph H. Perra, Chair Elect	2010
Ahmet Alanay	2011
Kamal N. Ibrahim	2011
Mark Dekutoski	2012
Eric T. Jones	2012

Council: Education
Board Liaison: Behrooz A. Akbarnia
Staff Liaison: Amy Miller
Back-up: Nadine Couto

Endowment Committee

Standing Committee – 3 Past Presidents, plus 9 other members – 3 per year, with 3 year terms

Baron S. Lonner, Chair	2009
Jeffery L. Stambough, Past Chair	2008
Randal R. Betz, PP3	2009
Albert E. Sanders	2009
Daniel J. Sucato	2009
Robert F. Heary (C)	2009
Behrooz A. Akbarnia, PP2	2010
Frances A. Farley, Chair Elect	2010
Eldin Karaikevic	2010
James Mooney	2010
George H. Thompson, PP1	2011
Alvin H. Crawford	2011
Matthew B. Dobbs	2011
Karl E. Rathjen	2011

Council: Finance
Board Liaison: Richard E. McCarthy
Staff Liaison: Amy Miller
Back-up: Nadine Couto

Ethics Committee

Standing Committee – 1 per year, with 4 year terms

Marc A. Asher, Chair	2009
Donald P.K. Chan (E), Past Chair	2009
Dennis S. Drummond (E), Chair Elect	2010
Bettye A. Wright (E)	2011
Michael A. Edgar	2012
Michael Bolesta	2013

Council: Governance
Board Liaison: David W. Polly, Jr.
Staff Liaison: Tressa Goulding
Back-up: Nilda Toro

Evidence Based Outcomes Committee

Standing Committee – 3 appointed members, 1 per year with 3 year terms, plus Research Chair

Douglas C. Burton, Co-Chair	2009
Reginald Q. Knight, Co-Chair	2010
Mark F. Abel, Patient Outcomes Past Chair	2009
Brian D. Snyder, EBM Past Chair	2009
Vincent Arlet	2009
Frank J. Schwab	2009
David B. Cohen (C)	2009
Ki Soo Hwang (C)	2009
Ron El-Hawary (C)	2009
Kit M. Song (Research)	2009
Dale V. Hoekstra	2010
James V. Raso (Assoc)	2010
James O. Sanders, Chair Elect	2010
Richard F. Bowen	2011
Robert B. Campbell	2011
William A. Phillips	2011
Dilip K. Sengupta	2011

Council: Research
Board Liaison: Kenneth M.C. Cheung
Staff Liaison: Amy Miller
Back-up: Megan Kelley

Fellowship Committee

Elected members – 1 per year, 4 year term

J. Abbott Byrd, Chair	2009
David S. Marks, Past Chair	2009
Mark Weidenbaum, Chair Elect	2010
Serena S. Hu	2011
Carlos Tello	2012

Council: Governance
Board Liaison: Steven M. Mardjetko
Staff Liaison: Nilda Toro
Back-up: Tressa Goulding

SRS Committees

Finance Committee

Treasurer, Treasurer-Elect, Presidential Line

Steven M. Mardjetko, Chair	2011
Oheneba Boachie-Adjei	2009
Richard E. McCarthy	2010
Lawrence G. Lenke	2011
Tressa Goulding, Executive Director	Ad Hoc
Dan Nemeec, Accounting Director	Ad Hoc

Council: Finance

Board Liaison: Richard E. McCarthy

Staff Liaison: Tressa Goulding

Back-up: Amy Miller

Global Outreach Committee

Standing Committee – 3 per year, with 3 year terms

Charles T. Mehlman, Chair	2009
Munish C. Gupta, Past Chair	2009
Richard H. Gross	2009
Isador H. Lieberman	2009
Francisco Sanchez Perez-Grueso	2009
Saumyajit Basu (C)	2009
Ron El-Hawary (C)	2009
Linda P. d'Andrea	2010
Federico P. Girardi	2010
Peter F. Sturm, Chair Elect	2010
Kamal Ibrahim (Worldwide Course)	2010
David H. Clements	2011
Hossein Mehdiian	2011
Theodore A. Wagner	2011

Council: Education

Board Liaison: Kamal N. Ibrahim

Staff Liaison: Katie Agard

Back-up: Amy Miller

Growing Spine Committee

Standing Committee – 3 per year, with 4 year terms

Francisco S. Perez-Grueso, Chair	2009
Muharrem Yazici, Past Chair	2009
Richard E. McCarthy	2009
George H. Thompson	2009
Hazem B. Elsebaie (C)	2009
John Tis (C)	2009
Behrooz A. Akbarnia, Chair Elect	2010
Alain Dimeglio (H)	2010
Vincent F.X. Deeney	2010
Laurel C. Blakemore	2011
Lawrence I. Karlin	2011
Carlos A. Tello	2011
Bruce L. Gillingham	2012
Eric T. Jones	2012
Suken Shah	2012

Council: Research

Board Liaison: George H. Thompson

Staff Liaison: Nadine Couto

Back-up: Katie Agard

Historical Committee

Standing Committee – Chaired by Historian, who is Board appointed for 3 year renewable term. Members: 1 per year, 3 year terms, plus PP3 (one year term)

Nathan H. Lebwohl, Historian	2011
Behrooz A. Akbarnia, Chair Elect	2009
Randal R. Betz, PP3	2009
Jason E. Lowenstein (C)	2009
Daniele A. Fabris-Monterumici	2010
John J. Grayhack	2011
David H. Clements	2012

Council: Governance

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Katie Agard

Back-up: Nilda Toro

IMAST Committee

Standing Committee – 1 per year, 4 year terms

Chair to serve a 4 year term, then 2 years as Past Chair

Chair Elect to serve a 2 year term

Todd J. Albert, Chair	2012
Lawrence G. Lenke, Past Chair	2010
Francis H. Shen (C)	2009
Robert Wienecke (C)	2009
Azmi Hamzaoglu	2009
Timothy R. Kuklo	2010
B. Stephens Richards	2011
Michael F. O'Brien	2012

Council: Education

Board Liaison: Lawrence G. Lenke

Staff Liaison: Megan Kelley

Back-up: Nadine Couto

Industry Relations Committee

Standing Committee – President, Treasurer, PPI, President Elect, Vice President, plus 3 appointed members with 3 year terms: PPI to serve as Chair

George H. Thompson, Chair	2009
Behrooz A. Akbarnia, Past Chair	2009
John E. Lonstein	2009
Eric H. Buchl (C)	2009
Oheneba Boachie-Adjei, Chair Elect	2010
J. Bradley Williamson	2010
Steven M. Mardjetko	2011
Richard E. McCarthy	2011
Vincent Arlet	2011
John P. Dormans	2011
Hansen A. Yuan	2011
Lawrence G. Lenke	2012

Council: Governance

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Tressa Goulding

Back-up: Megan Kelley

SRS Committees

Long Range Planning Committee

Standing Committee of president, past presidents 1, 2 & 3, Chairs of IMAST, Global Outreach, Worldwide Course. PP1 to Chair.

George H. Thompson, Chair	2010
Behrooz A. Akbarnia, Past Chair	2009
Charles T. Mehlman (Global Outreach)	2009
Randal R. Betz, PP3	2009
Kamal Ibrahim (Worldwide Course).	2010
Todd J. Albert (IMAST)	2012
Oheneba Boachie-Adjei, Chair Elect	2012

Council: Finance

Board Liaison: Lawrence G. Lenke

Staff Liaison: Tressa Goulding

Back-up: Megan Kelley & Nadine Couto

Marketing & Public Relations Committee

*Ad Hoc Committee (may decide to change to Standing)
7 members with one year terms*

Alan Moskowitz, Chair	2009
Dennis G. Crandall, Co-Chair.	2009
Paul A. Glazer	2009
Michael O. LaGrone	2009
Ian Bruce McPhee (I).	2009
Arya Nick Shamie (C)	2009

Council: Governance

Board Liaison: Steven M. Mardjetko

Staff Liaison: Megan Kelley

Back-up: Amy Miller

Morbidity & Mortality Committee

Standing Committee – 2 per year, 4 year terms

Joseph H. Perra, Chair.	2009
William F. Donaldson III, Past Chair.	2009
Reinhard D. Zeller	2009
Yongjung J. Kim (C)	2009
Robert A. Hart (C)	2009
D. Raymond Knapp, Chair Elect	2010
Hilali H. Noordeen	2010
Sigurd H. Berven	2011
Michael J. Goytan	2011
Paul A. Broadstone	2012
Theodore J. Choma.	2012

Council: Research

Board Liaison: Steven M. Mardjetko

Staff Liaison: Nilda Toro

Back-up: Katie Agard

Newsletter Committee

Standing Committee – 1 per year, 3 year terms: Chair serves a 3 year renewable term as Newsletter Editor

Vicki Kalen, Chair & Editor.	2010
Mario Turi.	2009
Kathy Blanke (A).	2010
Marinus de Kleuver	2010
John P. Lubicky.	2011

Council: Governance

Board Liaison: Randal R. Betz

Staff Liaison: Katie Agard

Back-up: Megan Kelley

Nominating Committee

Standing Committee – 1 year terms

George H. Thompson, Chair.	2009
Laurel C. Blakemore.	2009
Bruce E. Van Dam	2009
James O. Sanders	2009
John R. Dimar, II.	2009

Council: Reports to Board

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Tressa Goulding

Back-up: Nilda Toro

Non-Operative Management Committee

Standing Committee – 2 per year, 3 year terms

Raymond D. Knapp, Jr, Chair.	2009
Timothy A. Garvey, Past Chair	2009
Mario Turi	2009
Ki Soo Hwang (C).	2009
Brian G. Smith, Chair Elect.	2010
Jeffrey D. Thomson.	2010
Richard H. Gross	2011
John G. Thometz	2011

Joe P. O'Brien - Advisory

Council: Research

Board Liaison: George H. Thompson

Staff Liaison: Nadine Couto

Back-up: Katie Agard

Patient Education Committee

Standing Committee – 3 per year, 3 year terms

John T. Killian, Chair	2009
Linda P. d'Andrea, Past Chair	2009
Daniel W. Green.	2009
Scott D. Hodges	2009
Craig P. Ebersson (C)	2009
Robert Wienecke (C).	2009
Ram Mudiyan, Chair Elect.	2010
Vishwas R. Talwalkar	2010
Connie Poe-Kochert (Assoc)	2010
Toni Cawley (Assoc)	2011
Walter F. Krengel	2011
Jay Shapiro	2011

Joe P. O'Brien – Advisory

Stanley E. Sacks – Advisory

Council: Education

Board Liaison: David W. Polly, Jr.

Staff Liaison: Katie Agard

Back-up: Nadine Couto

SRS Committees

Program Committee

Standing Committee – 3 per year, 3 year terms, plus reviewers with one year terms

Peter O. Newton, Chair	2009
Paul D. Sponseller, Past Chair	2009
Lawrence G. Lenke (IMAST Past Chair)	2009
Douglas C. Burton	2009
Andrew G. King	2009
Patrick J. Connolly	2010
Noriaka Kawakami, 2010 Co-Chair Elect	2010
Michael J. Yaszemski, 2010 Co-Chair Elect	2010
Laurel Blakemore	2011
Andrew M. Casden	2011
Marinus de Kleuver	2011
Todd J. Albert (IMAST Chair)	2012

Council: Education

Board Liaison: Richard E. McCarthy

Staff Liaison: Amy Miller

Back-up: Nadine Couto

Reviewers:

Michael Albert	Alan Moskowitz
Michael Coscia	Michael F. O'Brien
Dennis Crandall	Kenneth Paonessa
Yasser El Miligui (C)	B. Stephens Richards
Paul Glazer	Michael Roh
Azmi Hamzaoglu	Arya Nick Shamie (C)
Henry Iwinski	Francis Shen (C)
Hak-Sun Kim (C)	Harwart Singh
Yongjung J. Kim (C)	Brian Smith
Timothy Kuklo	Joseph Verska
Michael Lagrone	Jean Marc Vital (C)
Alexander L'Heureux	Robert Wienecke (C)
Isadore Lieberman	

Research Grant Committee

Standing Committee – 3 per year, 4 year terms

Kit M. Song, Chair	2009
Kenneth M.C. Cheung, Past Chair	2009
Nathan H. Lebowhl	2009
Marc J. Moreau	2009
Stefan Parent (C)	2009
Robert A. Hart (C)	2009
Benjamin A. Alman	2010
Nancy Hadley Miller, Chair Elect	2010
Cathleen L. Raggio	2010
Dilip K. Sengupta	2011
Peter P. Masso	2011
Matthew B. Dobbs	2011
Federico P. Girardi	2012
John F. (Jack) Flynn	2012
Siavash Haghghi	2012

Council: Research

Board Liaison: Kenneth M.C. Cheung

Staff Liaison: Amy Miller

Back-up: Nilda Toro

Spinal Deformity Curriculum Committee

Ad Hoc Committee – 5 members with 1 year terms

James W. Ogilvie, Chair	2009
Denis S. Drummond, Co-Chair	2009
Todd J. Albert	2009
John P. Dormans	2009
Stephen L. Ondra (C)	2009

Council: Education

Board Liaison: Lawrence G. Lenke

Staff Liaison: Katie Agard

Back-up: Amy Miller

SRS / Spine Liaison Committee

Standing Committee – 2 per year, 3 year terms, with one being the next in line to serve as Program Chair; Committee should include past, present & upcoming chairs of the Program Committee

Paul D. Sponseller, Chair (Program Past Ch)	2009
Panagiotis Korovessis	2009
Allen W. Carl, Chair Elect (Education Chair)	2010
Munish C. Gupta	2010
Joseph W. Perra (Education Chair Elect)	2011

Keith H. Bridwell – Spine Liaison

Council: Education

Board Liaison: James W. Roach

Staff Liaison: Amy Miller

Back-up: Megan Kelley

3D Scoliosis

Ad Hoc Committee with one year renewable terms

Hubert Labelle, Chair	2009
Carl Eric Aubin, Co-Chair	2009
Lawrence G. Lenke	2009
Roger P. Jackson	2009
Peter O. Newton	2009
Ian A.F. Stokes	2009

Ad Hoc Members

Mark F. Abel	2009
Kenneth M.C. Cheung	2009
Howard A. King	2009
Richard E. McCall	2009
Michael J. Mendelow (C)	2009
Reinhard D. Zeller (I)	2009

Council: Research

Board Liaison: Lawrence G. Lenke

Staff Liaison: Megan Kelley

Back-up: Nilda Toro

SRS Committees

Website Committee

Standing Committee – 2 per year, 4 year terms

Andrew A. Merola, Chair	2009
Daniel J. Sucato, Past Chair	2009
John T. Killian (Patient Education)	2009
Allen L. Carl	2009
Michael O. LaGrone	2009
Mark D. Rahm (C)	2009
John K. Ratliff (C)	2009
John F. Sarwark, Chair Elect	2010
Dale E. Rowe	2010
Michael F. O'Brien	2011
Kit M. Song	2011
Matthew Geck	2012
Anthony S. Rinella	2012

*Council: Education
Board Liaison: Randal R. Betz
Staff Liaison: Amy Miller
Back-up: Katie Agard*

Worldwide Conference Committee

*Standing Committee –4 per year, with 4 year terms, plus
Chairs of Education and Global Outreach Committees;
Chair to serve a 4 year term, then 2 years as Past Chair;
Chair elect to serve a 2 year term*

Kamal N. Ibrahim, Chair	2010
Allen W. Carl (Education)	2009
Charles T. Mehlman (Global Outreach)	2009
Yutaka Hiraizumi	2009
Donald P.K. Chan	2009
John F. Sarwark	2009
Peter F. Sturm	2009
Yasser El Miligui (C)	2009
Michael Ruf (C)	2009
Norbert Passuti	2010
Khalil Kharrat	2010
Carlos Tello	2010
Ahmet Alanay, Chair Elect	2011
William C. Horton	2011
Victor Rositto	2011
Charles E. Johnston II	2011
Christopher L. Hamill	2012
Suken A. Shah	2012
Ensor E. Transfeldt	2012
Muharrem Yazici	2012

*Council: Education
Board Liaison: Kamal N. Ibrahim
Staff Liaison: Megan Kelley
Back-up: Amy Miller*

Global Affairs Advisory Board

Azmi Hamzaoglu, Chair	2009
Oheneba Boachie-Adjei, Co- Chair	2009
Carlos Tello (The Americas)	2009
Osmar Avanzi (The Americas)	2012
Ernesto Bersusky (The Americas)	2012
Marinus de Kleuver (Europe)	2009
Dietrich Schlenzka (Europe)	2012
Nobumasa Suzuki (Asia)	2009
Kenneth Cheung (Asia)	2012
Hee Kit Wong (Asia)	2012
Kamal Ibrahim (Middle East/Africa)	2009
Khalil Kharrat (Middle East/Africa)	2012

*Council: Governance
Board Liaison: Azmi Hamzaoglu
Staff Liaison: Katie Agard
Back-Up: Nilda Toro*

BOS Representatives (formerly COMSS)

Oheneba Boachie-Adjei (Presidential Line)	2009
Richard E. McCarthy (Communications)	2010
George H. Thompson (Health Policy)	2011
Peter O. Newton (Research)	2011
Steven D. Glassman (Education)	2012
Tressa Goulding (Executive Director)	indefinite

COSS Representatives

David W. Polly	2010
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FOSA Representatives

Timothy R. Kuklo	March 2011
R. Jay Cummings	Mar. 08-Feb. 09
Allen W. Carl	Feb. 09-Mar. 10

Hibbs Society Liaison

Robert W. Gaines	2009
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SRS Committees

Education Council – *Steven D. Glassman, Chair - 2009*

Awards & Scholarship K. Daniel Riew
CME Richard E. McCarthy
Education Allen W. Carl
Global Outreach Charles T. Mehlman
IMAST Todd J. Albert
Patient Education John T. Killian
Program Peter O. Newton
Spinal Deformity Curriculum James W. Ogilvie
SRS/Spine Liaison Paul D. Sponseller
Web site Andrew A. Merola
Worldwide Conference Kamal N. Ibrahim

Staff Liaison: Megan Kelley

Back-up: Amy Miller

Finance Council – *Steven M. Mardjetko, Chair*

Endowment Baron S. Lonner
Finance Steven M. Mardjetko
Long Range Planning George H. Thompson

Staff Liaison: Tressa Goulding

Back-up: Katie Agard

Governance Council – *David W. Polly, Jr., Chair*

Advocacy & Public Policy Mark A. Lorenz
Bylaws & Policies J. Abbott Byrd
Coding James T. Bennett
Ethics Marc A. Asher
Fellowship J. Abbott Byrd
Historical Nathan H. Lebowohl
Industry Relations George H. Thompson
Marketing & PR Alan Moskowitz
Newsletter Vicki Kalen
Global Affairs Advisory Board Azmi Hamzaoglu

Staff Liaison: Tressa Goulding

Research Council – *Peter O. Newton, Chair*

Adult Deformity Mark Weidenbaum
Evidence Based Outcomes Douglas C. Burton
Growing Spine Francisco S. Perez-Gruesso
Morbidity & Mortality Joseph H. Perra
Non-Operative Management Raymond D. Knapp Jr.
Research Grant Kit M. Song
3D Spinal Classification Lawrence G. Lenke

Staff Liaison: Amy Miller

Previous SRS Award & Research Grant Recipients

Exhibit Awards

- 1982** **Ronald L. DeWald, Mary Faut Rodts, James S. Fister**
The Management of Unstable Burst Fractures of the Thoracic and Lumbar Spine
- 1984 (Blount)** **R. Mervyn Letts and G.J.Gouw**
Scoliosis in the Head Injured Child
- 1985 (Blount)** **Kiyoshi Kaneda, Tomoyuki Hashimoto, Shigenobu Satoh, Kuniyoshi Abumi**
Late Progressive Neurologic Deficit Following Thoracolumbar Spine Fractures
- 1986 (Blount)** **Greg Houghton, Anne McInerny, Tony Tew**
Compliance Monitoring System for Spinal Braces
- 1987** **Jeffrey H. Owen, Keith H. Bridwell**
Motor (MEPs) and Somatosensory Evoked Potentials (SEPs) in Animals and Humans: Sensitivity and Specificity
- 1991** **Ian A.F. Stokes, Mack Gardner-Morse, Jeffrey P. Laible**
The Biomechanics of Surgical Derotation
- 1992** **Tali Siegal, Tzony Siegal**
Neoplastic Spinal Cord Compression: Manipulation of Vasogenic Edema by Ketanserin, a 5-HT₂ Receptor Blocker
- 1993** **Kristian Høy, S.M. Jespersen, E.S. Hansen, K.Ø. Christensen, B.E. Lindblad, S.Z. He, C. Bungert**
Hemodynamics of the Spinal Cord, Cauda Equina, Nerve Roots and the Dural Sac During Exercise - An Experimental Study
- 1994 (Moe)** **Kirkham B. Wood, Timothy A. Garvey, Cooper Gundry, Kenneth Heitoff**
Thoracic MRI Evaluation of Asymptomatic Individuals
- 1995 (Moe)** **Michael P. Chapman, Christopher L. Hamill, Keith H. Bridwell, Lawrence G. Lenke, Kathy Blanke, Christy Baldus**
Can We Lordose the Spine with Zielke Instrumentation Anteriorly?
- 1996 (Moe)** **Sakae Sato, Marc A. Asher**
Comparison of Lamina Hook to Pedicle Screw Anchors for Correction of Double Structural Adolescent Idiopathic Scoliosis
- 1997 (Moe)** **Tatsuto Takeuchi, Kuniyoshi Abumi, Itaru Oda, Yasuhiro Shono, Kiyoshi Kaneda**
Biomechanical Evaluation of Thoracic Spinal Stability: A Significance of Costovertebral Joints in Providing Stability
- 1998 (Moe)** **Itaru Oda, Bryan W. Cunningham, Charles J. Haggerty, Kiyoshi Kaneda, Paul C. McAfee**
An In-Vitro Study Investigating the Stability of Reconstruction Methods Following Total Spondylectomy
- 1999 Moe - Basic Science** **Edward P. Southern, Howard S. An, Charles E. Edmiston, Jr., Larry Newman, Michael Goheen, Dawn Zuelke, Sharon Sinski, Gary Seabrook**
A Microbiology and Lint Study in the Orthopaedic Surgery Operating Room
- 1999 Goldstein Clinical** **Christian Fräs, Twee Do, Stephen Burke, Bernard Rawlins, Roger Widmann, Oheneba Boachie-Adjei**
Routine Preoperative MRI in Adolescent Idiopathic Scoliosis: A Prospective Study of 327 Patients
- 2000 Moe – Basic Science** **R.K. Wilcox, T.O. Boerger, R.M. Hall, D.C. Barton, D.L. Limb, R.A. Dickson**
Canal Pressure Measurements and Video Recording of Thoracolumbar Burst Fractures
- 2000 Goldstein Clinical** **Makoto Tokunaga, Shohei Minami, Hiroshi Kitahara, Yoshinori Nakata, Hideshige Moriya**
Neurologic Complications in Scoliotic Patients with Syringomyelia
- 2001 Moe – Basic Science** **P.C. McAfee, B.W. Cunningham, A.E. Dmitriev, N. Shimamoto, J.C. Seftor, I.L. Fedder**
General Principles of Porous Ingrowth Total Disk Replacement Arthroplasty Compared to Diarthrodial Total Joint Arthroplasty. A Non-Human Primate Model – Part 1
- 2001 Goldstein Clinical** **Mohammed J. Al-Sayyad, Charles T. Mehlman, Alvin H. Crawford**
Effectiveness of Spinal Release and Halo-Femoral Traction in the Management of Severe Spinal Deformity

Previous SRS Award & Research Grant Recipients

- 2002 Moe – Basic Science** **Andrew A. Merola, Michael F. O'Brien, Amit Lamba, Gregorio Chejfec, Thomas R. Maher, Andrew Castro, Franco Givna, Sameer Mathur, Mario Brkavic, David A.B. Smith, James M. Eule, N. Joseph Espot, Thomas G. Lowe, Thomas F. Dwyer**
Attenuation of Ciliary Neurotrophic Factor (CNTF) in Acute Spinal Cord Injury (ASCI) Treated with Intravenous Methylprednisolone (MP)
- 2002 Goldstein Clinical** **Behrooz A. Akbarnia, David S. Marks, Oheneba Boachie-Adjei, Marc A. Asher, Alistair G. Thompson, Richard C. Rooney, Chatupon Chotigavanichaya**
Dual Rod Posterior Instrumentation Without Fusion for the Treatment of Progressive Early Onset Scoliosis: A Multicenter Study
- 2003 Moe – Basic Science** **William W. Lu, Kenneth M.C. Cheung, Keith D.K. Luk, John C.Y. Leong**
A Novel Sr-HA Bioactive Bone Cement for Vertebroplasty
- 2003 Goldstein Clinical** **Athanasios I. Tsirikos, Freeman Miller, Wei-Ning Chang, Kirk W. Dabney, Joseph Glutting**
Life Expectancy in Pediatric Patients with Cerebral Palsy and Neuromuscular Scoliosis who Underwent Spinal Fusion
- 2004 Moe – Basic Science** **Vikas V. Patel, Li Zhao, Pamela Wong, Ben Bhupendra Pradhan, Linda Kanim, Hyun W. Bae, Rick B. Delamarter**
Controlling BMP-Simulated Bone Growth Using Fibrin Glue
- 2004 Goldstein Clinical** **André van Ooij, F. Chumhur Oner, Ab J. Verbout**
Complications of Artificial Disc Replacement: A Report of 45 Patients with an Unconstrained Disc Prosthesis
- 2005 Goldstein Clinical** **Gene Cheh, Lawrence G. Lenke, Keith H. Bridwell, Young-Jung J. Kim**
"Decompression Alone vs. Decompression and Limited Fusion for the Treatment of Degenerative Lumbar Scoliosis"
- 2005 Moe – Basic Science** **Cathy Xiao Xi Guo, Kenneth McCheung, Danny Chan, Michael Irwin**
"Comparison of the Effect of Non-Selective NSAID and Cyclooxygenase-2 (COX-2) Selective NSAID on Bone Formation – Implications for Spinal Fusion"
- 2006 Goldstein Clinical** **Clayton L. Dean, Josue P. Gabriel, Michael J. Bolesta, Ezequiel Cassinelli, Henry H. Bohlman**
Degenerative Spondylolisthesis of the Cervical Spine. A Long Term Follow-up Study
- 2006 Moe – Basic Science** **Nancy Hadley Miller, Beth Marosy, Marie Helene Roy-Gagnon, Kimberly F. Doheny, Elizabeth W. Pugh, Alexander F. Wilson, Cristina M. Justice**
Familial Idiopathic Scoliosis: Defining Genomic Loci on Chromosomes 9 and 16 Utilizing Custom SNP Panels
- 2007 Moe – Basic Science** **Jonathan G. Schoenecker, Nicholas Mignemi, Heidi Hamm, Herbert Schwartz, Ginger Holt, Gregory Mencio**
Aprotinin Inhibits Bone Formation In Vitro
- 2007 Goldstein – Clinical** **Mark J. Sokolowski, Timothy A. Garvey, John Perl, Amir A. Mehbod, Burak Akesen, Margaret S. Sokolowski, Ensor E. Transfeldt**
Prospective Study of Post-Operative Lumbar Epidural Hematoma: Does Size Really Matter?
- 2008 Moe – Basic Science** **Chi Wai Gene Man; Hiu Yan Yeung, PhD; Wei Jun Wang, MPHIL; Kwong Man Lee, PhD; Bobby KW Ng, MD; Vivian W. Hung; Yong Qiu, MD; Jack Chun Yiu Cheng, MD**
A Study on the Effect of Melatonin Toward the Proliferation and Differentiation of Osteoblasts in Adolescent Idiopathic Scoliosis
- 2008 Goldstein - Clinical** **Daniel J. Sucato, MD, MS; Timothy R. Kuklo, MD, JD; Mohammad Diab, MD; B. Stephens Richards, III, MD; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Spinal Deformity Study Group**
Risk Factors for Critical Intraoperative Neuromonitoring Changes During AIS Surgery

Best Discussor

- 1984** Harold K. Dunn, MD
1985 Dennis R. Wenger, MD
1986 Vernon T. Tolo, MD
1988 Thomas F. Kling, Jr., MD
1989 J. Andy Sullivan, MD
1991 John E. Hall, MD
1992 Gordon L. Engler, MD

Previous SRS Award & Research Grant Recipients

Hibbs Award for Best Basic Science Presentation

- 1980 Kazuhiko Satomi, Jens Axelgaard**
Effects of Selective Cord Transections on Spinal Evoked Potentials
- 1981 Ensor E. Transfeldt, Edward H. Simmons**
Functional and Pathological Biomechanics of the Spinal Cord: An In Vivo Study
John A. Herring
Early Complications of Segmental Spinal Instrumentation
- 1982 R.G. Burwell, J.J. James, F. Johnson, J.K. Webb, Y.G. Wilson**
Standardized Trunk Asymetry Scores: A New Method and a Study of Normality
Roger P. Jackson, E.J. Simmons, D. Stripinis
Structural Changes Correlating with Back Pain in Scoliosis
- 1983 Robert Barrack**
Proprioception in Idiopathic Scoliosis
- 1984 Cohen, Solomons, Lowe**
Altered Platelet Calmodulin Activity in Idiopathic Scoliosis
D. Hoppenfeld, Gross and Andrews
The Ankle Clonus Test
- 1985 Thomas F. Kling, Jr, P.M. Spargo, Robert N. Hensinger, P.R. Knight III**
The Effect of Nitroglycerin Induced Hypotension With and Without Spine Distraction on Canine Spinal Cord Blood Flow
- 1986 William C. Schrader, Daniel Bethem, Vladimir Scerbin**
The Chronic Local Effects of Sublaminar Wires - An Animal Model
- 1987 Jeffrey H. Owen, John Laschinger, Keith Bridwell, Shelle Shimon, Carl Nielsen, Janet Dunlap**
Sensitivity and Specificity of Somatosensory and Neurogenic-Motor Evoked Potentials in Animals and Humans
- 1988 Steve K. Salzman, A.A. Mendez, A.S. Fonseca, E.B. Ingersol, G.M. Freeman, I.H. Choi**
Effects of Anesthesia on Outcome After Experimental Spinal Trauma: Halothane has a Protective Effect
- 1989 Rick B. Delamarter, Henry H. Bohlman, D. Bodner, C. Biro**
Urologic Function Following Experimental Cauda Equina Compression: Cystometrograms vs. Cortical Evoked Potentials
- 1990 Steven K. Salzman, Michael A. Puniak, Zhong-jun Liu, Richard P. Maitland-Heriot, Gina M. Freeman, Cynthia A. Agresta, Laura Van Newkirk**
Pharmacological Treatment of Acute Spinal Trauma I: Mechanisms of Action of the Serotonin Antagonist Mianserin
- 1991 Dale Dalenberg, Marc A. Asher, Gopal Jayaraman, Ralph Robinson**
The Effect of a Stiff Spinal Implant and Its Loosening on Bone Mineral Content in Canines
- 1992 Sanford E. Emery, Mark S. Brazinski, Anuradah Koka, Jay S. Bensusan, Sharon Stevenson**
The Biological and Biomechanical Effects of Irradiation on Anterior Spinal Bone Grafts - A Canine Model
- 1993 Stephen D. Cook, Thomas S. Whitecloud, Jeannette E. Dalton, D.C. Rueger**
In Vivo Evaluation of Recombinant Human Osteogenic Protein (rhOP-1) as a Bone Graft Substitute for Spine Fusions
- 1994 Jeffrey H. Schimandle, Scott D. Boden, W.C. Hutton**
Experimental Spine Fusion with Recombinant Human Bone Morphogenetic Protein (rhBMP-2)
- 1995 Douglas M. Petraco, Jeffrey M. Spivak, Joseph G. Cappadona, Frederick J. Kummer, Michael G. Neuwirth**
An Anatomic Evaluation of L5 Nerve Stretch in Spondylolisthesis Reduction
- 1996 S.B. Tan, J.T.H. Chew, R. Fortune, H.H. Tan, K.P. Tan, R.T.H. Ng, I.C. Song**
Allograft Vertebral Disc Transplantation in a Porcine Model
- 1997 Keith M. Bagnall, Cian O'Kelly, Marc Moreau, James Raso, Xiaoping Wang**
Scoliosis Development Following Pinealectomy in Young Chickens, Rats and Hamsters
- 1998 John R. Dimar II, Steven Glassman, George Raque, Y. Ping Zhang, Christopher Shields**
The Influence of Canal Narrowing and Timing of Decompression on Neurological Recovery Following Spinal Cord Contusion in the Rat Model
- 1999 Jeffrey C. Wang, Stephen Yoo, Linda E.A. Kanim, Paula L. McAllister, Scott D. Nelson, Edgar G. Dawson, Jay R. Lieberman**
Gene Therapy for Spinal Fusion: Transformation of Marrow Cells with an Adenoviral Vector to Produce BMP-2

Previous SRS Award & Research Grant Recipients

- 2000** **K.D. Riew, J. Lou, N.M. Wright, S.-L. Cheng, T. Bae, L.V. Avioli**
Thoracoscopic Intradiscal Spine Fusion Using Gene Therapy
- 2001** **M. Darryl Antonacci, Manu Nothias, Catherine Humphreys, Richard Frisch, Marion Murray**
Axonal Regeneration Using Transplants of Genetically Engineered Fibroblasts in Spinal Cord Injury
- 2002** **Kohei Goshi, Oheneba Boachie-Adjei, Bernard A. Rawlins, Ronald G. Crystal, Chisa Hidaka**
Genetically Modified Marrow Cells Enhance Spine Fusion
- 2003** **M. Darryl Antonacci, Jean Nothias, Tom Parks, Richard Fritsch, Chris Cawley, Marion Murray**
Human Marrow Stromal Cell Transplants in a Collagen Matrix Support Axonal Regeneration of Descending Pathways Across Complete Spinal Cord Transections
- 2004** **William C. Horton, Chaiwat Kraiwattanapong, Tomoyuki Akamaru, Akihito Minamide, Moon-Soo Park, William Hutton**
The Role of the Sternum, Costosternal Articulations, Intervertebral Disc, and Facets in Thoracic Sagittal Plane Biomechanics and Deformity Correction: A Comparison of Three Different Sequences of Surgery
- 2005** **Brian K. Kwon, Jie Liu, Clarrie Lam, Loren W. Oschipok, Armin Blesch, Wolfram Tetzlaff**
"Brain Derived Neurotrophic Factor Gene Transfer with Adeno-Associated Viral and Lentiviral Vectors Prevents Rubrospinal Neuronal Atrophy and Stimulates Regeneration Associated Gene Expression after Acute Cervical Spinal Cord Injury"
- 2006** **Howard S. An, Kei Miyamoto, Jesse G. Kim, Nozomu Inoue, Koji Akeda, Gunnar Andersson, Koichi Masuda**
An Intradiscal Injection of Osteogenic Protein-1 Restores the Viscoelastic Properties of Degenerated Intervertebral Discs in the Rabbit Anular Puncture Model
- 2007** **Kenneth J. Hunt, John T. Braun, Bryt A. Christensen**
The Effect Of Two Clinically Relevant Fusionless Scoliosis Implant Strategies On The Health of the Intervertebral Disc
- 2008** **Hemal Mehta, MSc; Brian D. Snyder, MD, PhD; Stephen R. Baldassarri, BA; Melissa J. Hayward, MD; Michael J. Giuffrida, MD; Supriya P. Bansal, BS; Vahid Entezari, MD; Nipun D. Patel, MS; Andrew C. Jackson, PhD**
VEPTR Improves Pulmonary Hypoplasia in a Postnatal Rabbit Model of Thoracic Insufficiency Syndrome

Hibbs Awards for Best Clinical Presentation

- 1981** **John A. Herring, Dennis R. Wenger**
Early Complications of Segmental Spinal Instrumentation
- 1982** **Roger P. Jackson, Edward H. Simmons, D. Stripinis**
Structural Changes Correlating with Back Pain in Scoliosis
- 1984** **Hoppenfeld, Gross and Andrews**
The Ankle Clonus Test
- 1985** **Bert Mandelbaum, Vernon Tolo, Paul McAfee, Peggy Buresh**
Nutritional Deficiencies After Staged Anterior and Posterior Spinal Surgery
- 1986** **Paul D. Sponseller, Mark S. Cohen, John E. Hall, Alf L. Nachemson**
Long-Term Follow-Up of Adult Scoliosis Treated Surgically
- 1987** **Christine S. O'Donnell, William P. Bunnell, Randal R. Betz, Cynthia R. Tipping**
Electrical Stimulation in the Treatment of Idiopathic Scoliosis
- 1988** **John E. Lonstein, Robert B. Winter**
Milwaukee Brace Treatment of Adolescent Idiopathic Scoliosis - Review of 939 Patients
- 1989** **J.P. Thompson, Ensor E. Transfeldt, David Bradford, Oheneba Boachi-Adjei**
Evaluation of Spinal Imbalance and Shoulder Elevation Following Cotrel-Dubousset Instrumentation with Special Reference to Uncoupling
- 1990** **David M. Apel, G. Marrero, W.D. Goldie, J. King, Vernon T. Tolo, George S. Bassett**
Avoiding Paraplegia During Anterior Spinal Surgery: The Role of SSEP Monitoring During Temporary Occlusion of Segmental Spinal Arteries
- 1991** **Lawrence G. Lenke, Keith H. Bridwell, Christy Baldus, Kathy Blanke**
Preventing Decompensation in King Type II and III Curves Treated with Cotrel-Dubousset Instrumentation (CDI): 24 to 64 Month Follow-Up
- 1992** **D. Holte, Robert Winter, John Lonstein, Francis Denis**
Hemivertebra Excision and Wedge Resection in the Surgical Treatment of Patients with Congenital Scoliosis
- 1992** **Shanti S. Upadhyay, P. Sell, B. Sell, M.J. Saji, E.K.W. Ho, J.Y.C. Leong**
Seventeen Year Prospective Study of Surgical Management of Tuberculosis of the Spine: A Controlled Trial Comparing Anterior Debridement with Hong Kong Radical Operation
- 1993** **Mark Goldberg, Nancy Mayo, Benoit Poitras, Susan Scott, James Hanley**
The Ste-Justine Adolescent Idiopathic Scoliosis (AIS) Cohort Study I & II: Description of the Cohort Health Outcomes and Back Pain

Previous SRS Award & Research Grant Recipients

- 1994** **Thomas Haher, R. Zipnick, D. Manor, Andrew Merola, John Gorup, J. Dryer, R. Nucci, J. Orchowski, C. Kaufmann**
Meta-Analysis of Surgical Outcome in Scoliosis: A Thirty One Year Review of Eleven Thousand Patients
- 1995** **Howard H. Ginsburg, L. Goldstein, P. William Haake, Shannon Perkins, K. Gilbert**
Longitudinal Study of Back Pain in Postoperative Idiopathic Scoliosis: Long-Term Follow-Up, Phase IV
- 1996** **James O. Sanders, David G. Little, B. Stephens Richards**
Prediction of the Crankshaft Phenomenon by the Peak Growth Age
- 1997** **John P. Kostuik**
The Development of a Preoperative Scoring Assessment System of Metastatic Spine Disease
- 1998** **Stuart L. Weinstein, Lori Dolan, Kevin Spratt, Kirk Peterson, Mark Spoonamore**
Natural History of Adolescent Idiopathic Scoliosis: Back Pain at 50-Year Follow-Up
- 1999** **Marc A. Asher, Sue Min Lai, Douglas C. Burton**
Further Development and Validation of the SRS Outcomes Instrument
Hiroshi Taneichi, Kiyoshi Kaneda, Kuniyoshi Abumi, Manabu Ito
Radiological Differentiation Between Benign and Malignant Vertebral Body Collapse
- 2000** **R. Jhanjee, K. Wood, G. Buttermann, T. Garvey, R. Kane, V. Sechreist, A. Mehbod**
Operative Vs. Nonoperative Treatment of Thoracolumbar Burst Fractures without Neurological Deficit: A Randomized, Prospective Study
- 2001 – TIE** **Aina J. Danielsson, I. Wiklund, K. Pehrsson, Alf L. Nachemson**
Health-Related Quality of Life in Patients with Adolescent Idiopathic Scoliosis – A Matched Follow-Up at Least Twenty Years After Treatment with Brace or Surgery
Harry L. Shufflebarger, Cynthia Clark
The Posterior Approach for Lumbar and Thoracolumbar Adolescent Idiopathic Curves: Posterior Shortening and Pedicle Screws
- 2002** **C. Barrios, C. Pérez-Encinas, J.I. Maruenda, P. Renovell, N. de Bernardo, L. García del Moral, J.A. Martín-Benlloch, M. Laguía**
Significant Ventilatory Functional Restriction in Adolescents with Mild or Moderate Scoliosis During Maximal Exercise Tolerance Test
- 2003** **Eric J. Wall, Donita Bylski-Austrow, Ronald Kolata, Alvin H. Crawford**
Endoscopic Mechanical Spinal Hemiepiphysiodesis Modifies Spine Growth
- 2004** **Christopher Hulen, H. Temple, Allaaddin Mollobashy, Frank Eismont**
Oncological and Functional Outcome Following Sacrectomy for Sacral Tumors
- 2005** **Ilkka Helenius, Tommi Lamberg, Kalevi Österman, Dietrich Schlenzka, Timo Yrjönen, Seppo Seitsalo, Mikko Poussa, Ville Remes**
"Posterolateral, Anterior or Circumferential Fusion In-Situ for High-Grade Spondylolisthesis in Young Patients: A Long-Term Evaluation using SRS Questionnaire"
- 2006** **Joshua D. Auerbach, Daniel M. Schwartz, Denis S. Drummond, Kristofer J. Jones, John M. Flynn, Yaser El-Gazzar, Thomas McPartland, J. Andrew Bowe, Samuel Laufer, Peter D. Pizzutillo, J. Richard Bowen, John P. Dormans**
Detection Of Impending Neurologic Injury During Surgery For Adolescent Idiopathic Scoliosis: A Comparison Of Transcranial Motor And Somatosensory Evoked Potential Monitoring In 1121 Consecutive Cases
- 2007** **Lawrence G. Lenke; Brenda A. Sides; Linda Koester; Marsha Hensley; Kathy Blanke**
Posterior Vertebral Column Resection (VCR) for Severe Pediatric and Adult Spinal Deformity: Indications, Results, and Complications of 43 Consecutive Cases
- 2008** **Michael D. Daubs, MD; Alpesh Patel, MD; Darrel S. Brodke, MD**
Clinical Instinct vs. Standardized Questionnaire: The Spinal Surgeon's Ability to Detect Psychological Distress

Walter P. Blount Humanitarian Award

1987	Marc A. Asher, MD	2001	Charles F. Heinig, MD
1989	Howard and Barbara Schulman	2002	James E. Holmblad, MD
1992	Laura Gowen	2006	Oheneba Boachie-Adjei, MD
1996	David B. Levine, MD	2007	Professor John CY Leong
1997	Albert E. Sanders, MD	2008	Behrooz A. Akbarnia, MD
1998	L. Ray Lawson, MD		

Lifetime Achievement Awards

2008	John E. Hall, MD Jacqueline Perry, MD, DSc
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Previous SRS Award & Research Grant Recipients

SRS Travelling Fellows

- 1970** John D. King, California
Jen Fang Wang, Taiwan
- 1971** Donald P.K. Chan, Vermont
Gourish R. Palekaar, India
- 1993** **Medtronic Sofamor Danek
Traveling Fellows**
Robert B. Winter, MD, Senior Fellow
George S. Bassett, MD, Junior Fellow
J. Kenneth Burkus, MD, Junior Fellow
Ensor E. Transfeldt, MD, Junior Fellow
- 1995** **Medtronic Sofamor Danek
Traveling Fellows**
John E. Hall, MD, Senior Fellow
Howard S. An, MD, Junior Fellow
Hubert H.L. Labelle, MD, Junior Fellow
Lawrence G. Lenke, MD, Junior Fellow
- 1997** **Medtronic Sofamor Danek
Traveling Fellows**
Ronald L. DeWald, MD, Senior Fellow
Vincent Arlet, MD, Junior Fellow
Allen L. Carl, MD, Junior Fellow
Michael F. O'Brien, MD, Junior Fellow
- 1999** **Medtronic Sofamor Danek
Traveling Fellows**
Clyde L. Nash, MD, Senior Fellow
Serena S. Hu, MD, Junior Fellow
Joseph Y. Margulies, MD, PhD, Junior Fellow
Rolando M. Puno, MD, Junior Fellow
Kirkham B. Wood, MD, Junior Fellow
- 2000** **DePuy AcroMed International Traveling Fellows**
Ufuk Aydinli, MD, Turkey
Henry F.H. Halm, MD, Germany
Yutaka Hiraizumi, MD, PhD, Japan
- 2001** **Medtronic Sofamor Danek Traveling Fellows**
John P. Kostuik, MD, Senior Fellow
Peter O. Newton, MD, Junior Fellow
Richard M. Schwend, MD, Junior Fellow
Edward P. Southern, MD, Junior Fellow

- 2002** **DePuy AcroMed International Traveling Fellows**
Bruce F. Hodgson, FRACS, New Zealand
Jin-Hyok Kim, MD, Korea
Muharrem Yazici, MD, Turkey
(Note: Tamás Illés, MD, Hungary, was originally selected but unable to participate)
- 2003** **Medtronic Sofamor Danek Traveling Fellows**
Courtney W. Brown, MD, Senior Fellow
Timothy R. Kuklo, MD, Junior Fellow
Daniel J. Sucato, MD, Junior Fellow
Alexander R. Vaccaro, MD, Junior Fellow
- 2004** **DePuy Spine International Traveling Fellows**
Ahmet Alanay, MD, Turkey
Kenneth M.C. Cheung, MD, Hong Kong
Ulf R. Liljenqvist, MD, Germany
- 2005** **Medtronic Sofamor Danek Traveling Fellows**
Donald P.K. Chan, MD, Senior Fellow
Matthew B. Dobbs, MD, Junior Fellow
Charles T. Mehlman, MD, Junior Fellow
Suken Shah, MD, Junior Fellow
- 2006** **DePuy Spine International Traveling Fellows**
Theodoros B. Grivas, MD, Greece
Ashok Johari, MD, India
Reinhard D. Zeller, MD, France
- 2007** **Medtronic Traveling Fellows**
James Ogilvie, MD, Senior Fellow
Youngjung Kim, MD, Junior Fellow
Praveen Mummaneni, MD, Junior Fellow
Jean Ouellet, MD, Junior Fellow
- 2008** **DePuy Spine International Traveling Fellows**
Kyu-Jung Cho, MD, South Korea
Kan Min, MD, Switzerland
Avraam Ploumis, MD, Greece
- 2009** **Medtronic Spine International Traveling Fellows**
Alvin H. Crawford, MD - Senior Traveling Fellow
Jacob Buchowski, MD, MS
Frank LaMarca, MD
Francis Shen, MD

Previous SRS Award & Research Grant Recipients

Research Grant Recipients

In the last ten years, SRS, in conjunction with OREF and the Cotrel Foundation have provided more than \$1.8 million for spinal deformity research projects. The following are previous SRS Research Grant recipients:

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- 1998**
Nancy Hadley Miller, MD
Genetic Analysis of Etiologic Factors of AIS
\$50,000 – 2 years
- John A. Szivek, PhD**
Monitoring Spinal Fusion in Scoliosis Patients: A Biomechanical & In Vivo Study
\$54,000 – 2 years
- Jack Engsberg, PhD**
Comparison of Outcome Measures in Adult Scoliosis Patients Undergoing an Extended Spinal Fusion to L5 or Sacrum or Revision of Previous Long Spinal Deformity Fusion
\$80,308 – 3 years
- William A. Vannah**
Longitudinal Study of Balance & Other Factors in AIS
\$10,887.50 – 2 years
-
- 1999**
Jack C.Y. Cheng, MD
The Loss of Synchronous Coupling of Endochondral and Membranous Ossification in AIS: The Morphological and Biological Evidences
\$35,400 – 1 year
- James O. Sanders, MD**
A Determination of Maturity in Girls with Idiopathic Scoliosis: A Pilot Study
\$48,252 - 2 years
-
- 2000**
Keith Bagnall, PhD
The Relationship Between Serum Melatonin & Growth Hormone in Pinealectomy Model
\$14,250 – 2 years
- Oheneba Boachie-Adjei, MD w/ Dr. Raymond Clarke**
Developmental Basis of the Klippel-Feil Syndrome
\$60,000 – 3 years
- Frances Farley, MD**
Prediction of Curve Progression in Congenital Scoliosis Using a Mouse Model
\$44,926 – 2 years
- Carol A. Wise, PhD**
Localization of a Gene for Susceptibility To Idiopathic Scoliosis
\$36,066.50 – 2 years
- Nancy Hadley Miller, MD**
Genetic Linkage of Familial Idiopathic Scoliosis – A Complex Orthopaedic Disorder
\$50,000 – 2 years
-
- Thomas Lowe, MD**
Platelet Calmodulin Levels in AIS: A Predictor of Curve Progression and Severity
\$42,070 – 2 years
-
- 2001**
Jack C.Y. Cheng, MD
Relationship between Postural Balance, Somatosensory Evoked Potential and the Progression of Scoliotic Deformity in the AIS
\$70,800 – 2 years
-
- 2002**
Carol Wise, PhD
Localization & Analysis of Candidate Genes of Idiopathic Scoliosis
\$36,666.50 – 2 years
-
- 2003**
Jack. C.Y. Cheng, MD
Are VDR, Era and PTHR1 Genes Associated With The Occurrence as well As Abnormality In Bone Growth And Sexual Maturation In Adolescent Idiopathic Scoliosis
\$70,800 – 2 years
- John Kostuik, MD**
Adult Onset of Scoliosis: Relationship between Osteoporosis and Deformity
\$30,000 – 2 years
- Matthew Dobbs, MD**
Idiopathic Scoliosis: Gene Mapping Identification
\$47,177 – 2 years
-
- 2004**
Philip Giampietro, MD, PhD
Mutation Analysis in Human Congenital Scoliosis and Vertebral Malformations
\$77,077 – 2 years
- Carol Wise, PhD**
Localization and Analysis of Candidate Genes for Idiopathic Scoliosis
\$50,000 – 2 years
- Ralph Marcucio, PhD**
A Comparison of the Expressions of Melatonin, Calmodulin and 5-HT4 in Paravertebral Muscle and Platelets of Patients with and without Adolescent Idiopathic Scoliosis
\$50,000 – 2 years

Previous SRS Award & Research Grant Recipients

2005

Kenneth Cheung, MD

Surface Modification of Nitinol by Plasma Immersion ION Implantation
\$100,000 – 2 years

Robin Patel, MD

Biofilms and Spinal Instrumentation
\$99,850 – 2 years

Alf Nachemson, MD, PhD

A Continuation of the "SRS Study for Brace Treatment of Adolescent Idiopathic Scoliosis" – Follow-up of the Swedish Patients at Least 10 Years After Maturity
\$47,020 – 2 years

Brian Snyder, MD, PhD

How does VEPTA Affect Pulmonary Function: An In-vivo Assessment using the Rabbit Scoliosis Model
\$34,408 – 1 year

Stefan Parent, MD, PhD

Analysis of Local 3-D Measurements of the Curve as Predictive Factors for Curve Progression in AIS
\$25,000 – 1 year

Francis Shen, MD

Can We Eliminate the Need for Autologous Bone Graft Harvest? The Use of Multipotential Adipose-derived Stromal Cells in an Activated Matrix for Posterolateral Spinal Fusions
\$25,000 – 1 year

Andrew Merola, MD

Association between an Aggrecan Gene Polymorphism and AIS
\$10,000 – 1 year

Anthony Florschutz, MD

Experimental Scoliosis Using Vertebral Body Implanted Magnets in an Immature Goat Model
\$10,000 – 1 year

Stefan Parent, MD, PhD

Growth Modulation of the Chest Case in a Pre-Natal Ovine Model: A Preliminary Study
\$10,000 – 1 year

Andrew Mahar, MS

How Does Increasing Curve Magnitude in Scoliotic Deformity Affect the Biomechanics of the Spine with Implications Toward Curve Correction?
\$10,000 – 1 year

Donita Bylski-Austrow, PhD

Mechanobiology of Growth: In-Vivo Growth Plate Pressures
\$10,000 – 1 year

Felix Breden, BA, MSc, PhD

The Guppy 'Curveback' Mutant as a Model for Spinal Deformity
\$10,000 – 1 year

Jack C.Y. Cheng, MD

Abnormal Differential Longitudinal Growth of Vertebral Column and Spinal Cord in AIS – A Morphological and Functional Study
\$77,000

Brian K. Kwon, MD, PHD, FRCSC

Neuroprotection for Acute Spinal Cord Injury: The Preclinical Evaluation of Drugs That Are Currently Used in Human Non-Spinal Applications
\$24,881.60 – 2 years

2006

Carol Wise, PhD

Identification of Genetic Susceptibility in Idiopathic Scoliosis
\$19,000 – 2 years

Shane Burch, MD FRCSC

The Role of Hypoxic Stress on the Vertebral Growthplates of the Developing Spine and its Potential Role in Pathogenesis of Scoliosis
\$10,000 – 1 year

Vedat Deviren, MD

The Minimal Clinically Important Difference (MCID) for Spinal Disorders: Finding the Threshold of Clinically Significant Change
\$24,996 – 1 year

2007

Jeffrey Shilt, MD; Peter Apel, MD

Temporary Unilateral Paraspinal Muscle Paralysis on the Prevention and Progression of Scoliosis: Investigation in a Chicken Model
\$9,740 - 1 year

Mohammad Diab, MD

Comparison of Extended-Release Epidural Morphine, Patient-Controlled Epidural Analgesia and Patient-Controlled Intravenous Analgesia for Postoperative Pain after Posterior Spinal fusion in Adolescents
\$24,245 – 2 years

Frank Schwab, MD

Adult Deformity: Development of an Effective Treatment Algorithm Based upon Outcomes Analysis
\$50,000 – 2 years

John Lonstein, MD

Long-term Function Outcomes of Early Fusions for Congenital Scoliosis
\$75,450 – 2 years

Michael Vitale, MD

CT Analysis of Pedicle Screw Placement in Pediatric Patients
\$20,595 – 1 year

Vidyadhar Upasani, MD

The Effect of Increasing Construct Rigidity on Intervertebral Disc Health: A Pilot Study in a Porcine Anterior Spinal Growth Modulation Model
\$10,000– 1 year

Xudong Li, MD

Nucleus Pulposus Regeneration with Genetically Engineered Fat-derived Stem Cells
\$50,000 – 2 years

Previous SRS Award & Research Grant Recipients

Josh Auerbach, MD

An in vivo Porcine Animal Model to Detect Spinal Cord Vascular Flow in Spinal Deformity Surgery using Transcranial Motor Evoked Potential Monitoring
\$10,000 – 1 year

2008

David Aronsson, MD

The Contribution of Asymmetric Growth and Vertebral Remodeling to Apical Wedging
\$41,829 – 2 years

Sigurd Berven, MD

Impact of Spinal Disorders on Health Related Quality of Life
\$5,000 – 1 year

Andrew Briggs, MD

Measurement of Vertebral Subregional Bone Mineral Density using Lateral-Projection DXA: Establishing Concurrent and Predictive Validity
\$10,000 – 1 year

Shane Burch, MD

Monitoring of Nerve Root Injury Using Transcranial Motor-Evoke Potentials in a Pig Model
\$23,255 – 2 years

Qian Chen, PhD

The Potential Role of Fibronectin in the Pathogenesis of Congenital Scoliosis
\$25,000 – 1 year

Daniel Y.T. Fong, MD

Single-Blind Comprehensive Cohort Study Incorporating A Randomized Controlled Design on Bracing in AIS: A Feasibility Study
\$25,000 – 2 years

Safdar Khan, MD

Utilizing a Novel MRI-based (Dense-FSE) Technique to Characterize Spatial Strain Distributions in an Established Model of Intervertebral Disc Degeneration: Implications for Tissue Engineering
\$10,000 – 1 year

Hubert Labelle, MD

Towards a 3D Classification of Adolescent Idiopathic Scoliosis
\$49,600 – 2 years

Carol Wise, PhD

Identification of Genetic Susceptibility in Idiopathic Scoliosis
\$60,000 – 1 year

SRS Bylaws

Bylaws of Scoliosis Research Society (An Illinois Not-For-Profit Corporation)

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- Section 9.2 Education Committee
- Section 9.3 Fellowship Committee
- Section 9.4 Program Committee
- Section 9.5 Bylaws and Policies Committee
- Section 9.6 Nominating Committee

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- Section 12.1 Annual Dues
- Section 12.2 Exemption from Dues

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- Section 15.2 Checks, Drafts, Etc.
- Section 15.3 Deposits
- Section 15.4 Gifts

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ARTICLE XVIII: SEAL

ARTICLE XIX: INDEMNIFICATION

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- Section 20.1 Trademarks
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SRS Bylaws

Bylaws of Scoliosis Research Society

(An Illinois Not-For-Profit Corporation)

ARTICLE I

NAME

The name of this corporation shall be the "Scoliosis Research Society" (hereinafter referred to as the "Society"). The Society is a nonstock, not-for-profit corporation organized under the Illinois Revised Statutes.

ARTICLE II

OBJECTIVES, PURPOSES AND POWERS

Section 2.1 Objectives and Purposes. The Society has been organized, and shall at all times be operated, exclusively for charitable, educational and scientific purposes within the meaning of section 501(c)(3) of the Code (as defined in Section 20.3, below), which purposes shall include, but not be limited to, the fostering, promotion, support, augmentation, development and encouragement of (a) investigative knowledge of the causes, cures and prevention of Scoliosis and related spinal deformities; (b) standardization of medical terminology in Scoliosis and related spinal deformities; (c) basic research in the field of Scoliosis and related spinal deformities; (d) the teaching and education of the same by developing, publishing and copyrighting educational material and providing specialized training for orthopaedic surgeons, neurosurgeons, and other members of the medical profession; and (e) education of the public with respect to the recognition and prevention of Scoliosis and related spinal deformities.

Section 2.2 Powers. The Society shall possess all powers which a corporation organized under the General Not-For-Profit Corporation Act of the State of Illinois, as the same from time to time may be amended shall possess; all powers which are not in conflict with said purposes; provided, however, the Society shall not engage in any business which would disqualify it from being exempt from taxation under Sections 501(a) or (c) (3) of the Code.

Section 2.3 Prohibited Practices. Notwithstanding anything in these Bylaws or the Society's Articles of Incorporation to the contrary, the Society shall exercise only those powers or engage in or carry on only those activities permitted to be exercised, engaged in or carried on by an organization exempt from federal income tax under Sections 501(c) (3) and 509(a) (1) of the Code and by an organization contributions to which are deductible under Section 170(c) (2) of the Code. The Society shall not engage in any activities which would result in the imposition of federal tax under Sections 4941 through 4945, inclusive, of the Code. No part of the net earnings of the Society shall inure to the benefit of any private individual, except that the Society shall be authorized and empowered to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the exempt purposes set forth in Section 2.1 of these Bylaws. No substantial part of the activities of the Society shall consist of carrying on propaganda or otherwise attempting to influence legislation, except as otherwise provided in subsection 501(h) of the Code, and the Society shall not participate or intervene in, including the publication or distribution of statements, any political campaign on behalf of or in opposition to any candidate for public office. In the pursuit of its purposes and the exercise of its powers, the Society shall make its services and activities available to the community that it serves regardless of, and shall not discriminate on the basis of, race, color, gender, sexual orientation, creed, religion or national origin.

ARTICLE III

OFFICES

Section 3.1 Principal and Business Offices. The Society may have such principal and other business offices as the Board of Directors may designate. The current principal offices are located at 555 East Wells Street, 11th Floor, Suite 1100, Milwaukee, Wisconsin 53202.

Section 3.2 Registered Agent. The Society shall maintain a registered agent as required by the Illinois Revised Statutes whose address may be, but need not be, identical with the principal office of the Society. The name and address of the registered agent may be changed from time to time by the Board of Directors.

SRS Bylaws

Section 3.3 Records. The Board of Directors may keep the books of the Society in such place or places, including, without limitation, an authorized agent, as they may from time to time determine in accordance with the Illinois Revised Statutes.

ARTICLE IV

CLASSES OF FELLOWSHIP

Section 4.1 Identification of Fellow Classes. The Society shall have members, which shall hereinafter be referred to as "Fellows." There shall be six (6) classes of membership (such term herein after referred to as "Fellowship") in the Society, namely, Candidate, Active, Inactive, Associate, Emeritus, and Honorary. Any reference to Fellows in these Bylaws refers to all six (6) classes of Fellowship, unless otherwise specified. Only Active Fellows shall have the right to vote on matters submitted to a vote of the members of the Society, hold office or serve on the Board of Directors. Otherwise, Fellows of any class shall have the same rights and responsibilities including the right to attend meetings and serve on Committees or Councils. Fellowship status in any class shall be a privilege, not a right, and is dependent upon the applicant for any class of Fellowship demonstrating compliance with the requirements for such Fellowship as defined in the Bylaws and otherwise as determined by the Board of Directors of the Society.

The Board of Directors may from time to time, in its sole discretion, establish membership criteria, rules and procedures applicable to Fellowship in any class in order to implement and carry out the provisions of this Article IV, including, without limitation, specific membership criteria, requirements and procedures for application to Fellowship in any class, and procedures and requirements for transfer between such classes of Fellowship; provided, however, that no such criteria, rules or procedures shall be established which alter the membership criteria and/or classifications set forth in these Bylaws. All determinations whether an individual has met the requirements for or otherwise qualified for membership of any class shall be made by the Board of Directors in its sole discretion after receiving and taking into account the recommendation of the Fellowship Committee (as defined in Section 9.3, below).

Section 4.2 Candidate Fellowship. The following individuals shall be eligible to be Candidate Fellows of the Society: (a) orthopaedic surgeons and neurosurgeons in active clinical practice who have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities; and (b) scientists in a field related to Scoliosis and/or related spinal deformities who have a demonstrated interest and involvement in, and commitment to, scientific research and investigation in the field of Scoliosis and/or related spinal deformities. A Candidate Fellow shall be eligible to be considered for Active Fellow status after five (5) years of membership as a Candidate Fellow in good standing.

Section 4.3 Active Fellowship. Individuals who have been Candidate Fellows in good standing for five (5) years shall be eligible to become Active Fellows of the Society upon application made by such individual.

Section 4.4 Inactive Fellowship. Any Active Fellow who has become disabled by sickness or accident or otherwise becomes incapacitated for a period of more than fifteen (15) consecutive calendar months and who is unable to engage in his or her normal professional activities that give rise to his or her eligibility for Active Fellow status may apply to the Board of Directors for a transference to Inactive Fellow status. Individuals whose applications for Inactive Fellow status are approved shall be Inactive Fellows, in which event any rights and privileges accorded to any such individual as Active Fellow shall be suspended for such period as such individual is an Inactive Fellow. An individual who is an Inactive Fellow may apply to the Board of Directors for resumption of Active Fellow status as the case may be, once such individual resumes his or her normal professional activities which qualified him or her as an Active Fellow.

Section 4.5 Associate Fellowship. Individuals engaged in professional, scientific or academic activities and/or allied health specialties who:

- (a) have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities but who are not otherwise eligible for Candidate Fellow or Active Fellow status; or
- (b) are eligible for Candidate Fellow or Active Fellow status but do not desire to become, Candidate Fellows or Active Fellows shall be eligible to be Associate Fellows of the Society.

Section 4.6 Emeritus Fellowship. An Active Fellow or Associate Fellow who has retired from the active conduct of his or her profession or vocation regardless of age or who has otherwise reached the age of sixty-five (65) shall be eligible to apply to the Board of Directors for a transfer to Emeritus Fellowship status. Membership dues shall be waived for Emeritus Fellows.

Section 4.7 Honorary Fellowship. Honorary Fellowship may be conferred, upon the recommendation of the Fellowship Committee and approval by the Board of Directors by a two-thirds (2/3) vote thereof, upon an individual who has contributed significantly to, or is otherwise preeminent in, the field of Scoliosis and/or related spinal deformities. Honorary Fellows shall not be required to pay dues. Honorary Fellows may be issued a certificate, in the discretion of the Board of Directors, signifying their admission as Honorary Fellows.

Section 4.8 Annual Meeting. The annual meeting of the Society shall be held at such time and place each year as may be determined by the Board of Directors from time to time (which time and place shall be specified in a notice of meeting), in order to elect new directors and officers, conduct such scientific sessions and discussions as the Board of Directors may determine and transact such other business as shall come before such meeting.

Section 4.9 Special Meetings. Special meetings of the members may be called for any purpose by (a) the President; (b) the Board of Directors by majority vote thereof; or (c) the written petition of five percent (5%) of the number of Active Fellows delivered to the Secretary of the Society.

Section 4.10 Voting. Each Active Fellow in good standing, and only Active Fellows in good standing, shall be entitled to vote in person on all matters to be voted on by members of the Society, including, without limitation, electing directors and officers of the Society as provided herein. Any matter to be decided by a vote of the members of the Society shall, except as otherwise provided in the Illinois Revised Statutes or as expressly provided herein, be decided by a majority of Active Fellows voting in person at a duly held meeting of Active Fellows at which a quorum is present. Cumulative voting or placing all votes for a particular candidate or a particular issue is prohibited. Whenever within these Bylaws an individual is specified as an Ex-Officio member of a board or committee, said Ex-Officio member shall not have the right to vote as such unless otherwise expressly provided in these Bylaws.

Section 4.11 Quorum. The presence in person of not less than twenty percent (20%) of the total number of Active Fellows shall constitute a quorum for the transaction of business at any annual or special meeting of Active Fellows of the Society. If a quorum is not present at any such meeting, a majority of the Active Fellows present thereat may adjourn the meeting from time to time, without further notice. The Active Fellows present in person at a duly organized meeting at which a quorum is present may continue to transact business until adjournment, notwithstanding the withdrawal during the meeting of that number of Active Fellows whose absence would cause less than a quorum.

Section 4.12 Notice of Meetings. Written notice stating the place (which may be within or without the state of Illinois), day and time of any meeting of Active Fellows (including, without limitation, any annual meeting) shall be signed by the President or Secretary of the Society and shall be delivered either personally or by first class United States mail, electronic mail or facsimile, to each member entitled to vote at such meeting, not less than thirty (30) days nor more than sixty (60) days before the date of such meeting. In case of a special meeting or when otherwise required by Illinois Revised Statutes or by these Bylaws, such notice shall also include the purpose or purposes for which the meeting is called. In the case of a special meeting, no business other than that specified in the notice of such meeting shall be transacted at any such meeting. If mailed, the notice of meeting shall be deemed to be delivered when deposited in the United States mail addressed to the member at his or her address as it appears on the records of the Society, with postage thereon prepaid. If such notice is given by electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the member at his or her electronic mail address or facsimile telephone number, as the case may be.

Section 4.13 Induction of New Fellows. Induction of new Fellows of any class shall take place at each annual meeting.

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ARTICLE V

MEMBER COVENANTS

Section 5.1 Confidential Information. Members, directors, officers, committee members and staff of the Society shall abide by such confidentiality policies relating to confidential information of the Society as the Board of Directors may establish from time to time.

Section 5.2 Conflicts of Interest/Disciplinary Process. The Board of Directors may establish from time to time such rules or policies with respect to the ethical conduct of its members, including without limitation, procedures and policies for dealing with conflicts of interest and the discipline of its members in the event of a breach of any rules or policies of the Society.

ARTICLE VI

BOARD OF DIRECTORS

Section 6.1 General Powers and Responsibilities. The Board of Directors shall have full responsibility for the management, direction and control of the business, policies and affairs of the Society, subject only to the limitations set forth in these Articles of Incorporation, these Bylaws, or by applicable law.

Section 6.2 Number, Tenure and Qualification. The Board of Directors shall, except as otherwise provided in this Section, consist of twelve (12) members and shall be composed of (a) the President, the President-Elect, the Vice President, the Secretary and the Treasurer; (b) the three most immediate Past Presidents; and (c) four (4) at-large directors. In years when there is a Treasurer-Elect and/or Secretary-Elect, as more fully described below, said officers shall also be directors and the number of directors comprising the Board of Directors shall be expanded accordingly. The President, President-Elect, Vice-President, Secretary, Treasurer, Treasurer-Elect and Secretary-Elect shall, by virtue of their positions as such, automatically be members of the Board of Directors for so long as they hold their respective offices. The above-referenced immediate Past-Presidents shall serve on the Board of Directors for terms of three (3) years each immediately after the completion of their respective terms as President, which terms shall not be renewable. At-large directors shall serve for terms of two (2) years, which terms shall be non-renewable. The terms of at-large directors shall be staggered so that, as nearly as possible, the terms of one-half of the at-large directors then in office expire each year. Only Active Fellows of the Society in good standing shall be eligible to be directors of the Society. At-large directors shall be nominated and elected in accordance with, and as part of, the procedure for electing officers of the Society as set forth in Section 7.2, below.

Section 6.3 Regular Meetings. Regular Meetings of the Board of Directors shall be held prior to or after but in conjunction with each annual meeting of the Society and/or at such other times as the President may designate for the transaction of such business that may come before the meeting. The Board of Directors may provide by resolution the time and place, either within or without the State of Illinois, for the holding of additional regular meetings of the Board of Directors without other notice than such resolution.

Section 6.4 Special Meetings. Special Meetings of the Board of Directors may be called by or at the request of the President or any two (2) other directors by delivering such request in writing to the Secretary, designating the time and place, either within or without of the State of Illinois, for such meeting to be held and stating the purpose for such meeting or the items to be considered. In the event the Secretary fails, neglects or refuses to distribute proper notice of such requested special meeting, the persons requesting the meeting may schedule or convene such meeting by proper notice to all directors then in office.

Section 6.5 Notice of Meetings. Notice of any Special Meeting of the Board of Directors shall be given at least 48 hours previous thereto by written notice delivered personally or sent by United States mail, electronic mail or facsimile to each director at his address as shown on the records of the Society. If mailed, such notice shall be deemed to be delivered when deposited in the United States mail in a sealed envelope so addressed with postage thereon prepaid. If notice is given by electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the director at his or her electronic mail address or facsimile telephone number, as the case may be. Any director may waive notice of any meeting. The attendance of a director at any meeting shall constitute a waiver of notice of such meeting, except where a director attends a meeting for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened. Neither the business to be transacted at, nor the purpose of, any regular or special meeting of the Board of Directors need be specified in the notice or waiver of notice of such meeting, unless specifically required by law or by these Bylaws.

Section 6.6 Quorum. A majority of the number of directors in office shall constitute a quorum for the transaction of business at any meeting of the Board of Directors. If the number of directors necessary to constitute a quorum shall fail to attend at the time and place fixed for any regular or special meeting of the Board of Directors, the directors in attendance may adjourn from time to time without notice or other announcement at the meeting until the requisite number of directors to constitute a quorum shall attend.

Section 6.7 Manner of Acting. The act of a majority of the number of directors present at a meeting at which a quorum is present shall be the act of the Board of Directors, except where otherwise provided by applicable law, the Articles of Incorporation of the Society, or by these Bylaws.

Section 6.8 Officers of the Board of Directors. The President of the Society shall serve as Chairman of the Board of Directors. The Secretary of the Society shall serve as the Secretary of the Board of Directors.

Section 6.9 Informal Action by Directors. Unless specifically prohibited by the Articles of Incorporation or by the Bylaws, any action required to be taken at a meeting of the Board of Directors, or any other action which may be taken at a meeting of the Board of Directors, may be taken without a meeting if a consent in writing, setting forth the action to be taken, shall be signed by all Directors entitled to vote with respect to the subject matter thereof. Any such consent signed by all directors shall have the same effect as a unanimous vote of the Board of Directors.

Section 6.10 Meetings by Electronic Means of Communication. Notwithstanding any place set forth in the notice for a meeting of the Board of Directors, any director may participate in such meeting by, or through the use of, any means of communication by which (a) all participants may simultaneously hear each other, such as by conference telephone; or (b) all communication is immediately transmitted to each participant, and each participant can immediately send messages to all other participants. Before the commencement of any business at a meeting at which any director participates by electronic means, all participating directors shall be informed that a meeting is taking place at which official business may be transacted.

Section 6.11 Executive Committee. There shall be established and maintained an Executive Committee which shall have and may exercise, when the Board of Directors is not in session, the powers of the Board of Directors in the management of the affairs of the Society, except action in respect to election or removal of officers and directors or the filling of vacancies in the Board of Directors or committees created pursuant to this Bylaw, or acts contrary to prior action adopted by the Board of Directors in proper session. The Executive Committee shall consist of the following individuals: the President, the Immediate Past-President, the President-Elect, the Vice President, the Secretary, the Treasurer and, when in office, the Secretary-Elect and the Treasurer-Elect. All members of the Executive Committee shall have voting rights thereon. The Executive Committee may meet from time to time between meetings of the Board of Directors at the discretion of the President and shall be authorized to conduct such business of the Society as may be necessary, subject to the Board of Directors' general direction and the obligation to report to the full Board of Directors. Notwithstanding the foregoing provision, the Executive Committee shall not be authorized to take any of the following actions on behalf of the Board of Directors: (a) elect directors or officers; (b) hire or terminate the executive director, if any; (c) amend these Bylaws; (d) dissolve the Society; or (e) authorize or contract any loan or indebtedness on behalf of the Society other than in accordance with these Bylaws. Meetings of the Executive Committee may be called by the President and shall be called upon written petition of two (2) other members of the Executive Committee. Notice of the time and place of each Executive Committee meeting shall be given in writing to each member of the committee not less than twenty-four (24) hours before such meeting. At any meeting of the Executive Committee, a majority of the number of Executive Committee members then in office shall constitute a quorum for the transaction of any business. The act of the majority of the Executive Committee members present at a meeting at which a quorum is present shall be the act of the Executive Committee.

Section 6.12 Director Vacancies. In case of any vacancy in a directorship for any reason, including, without limitation, the death, resignation or removal, before the expiration of the term of such directorship, the Nominating committee shall, as soon as practicable after such vacancy occurs, recommend to the Board of directors for its approval a qualified individual to fill such a vacancy. The Board of Directors shall as soon as practicable after such recommendation act on such approval. If such recommended individual is so approved, he or she shall serve for the unexpired portion of the term of the vacant directorship.

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Section 6.13 Resignation/Removal of Directors. Any director may resign from the Board of directors at any time by giving written notice to the President. Any director may be removed from the Board of Directors with or without cause by the affirmative vote of at least two-thirds (2/3) of the Active Members present at a duly held meeting thereof.

ARTICLE VII

OFFICERS

Section 7.1 Officers/Eligibility. The officers of the Society shall be as follows: President, President-Elect, Vice-President, Secretary, Secretary-Elect, Treasurer, and Treasurer-Elect. The President, President-Elect, Vice-President, Secretary-Elect and Treasurer-Elect shall each serve for terms of one (1) year, which terms shall be non-renewable, except as provided in Section 7.10 below. The Secretary and Treasurer shall, except as provided in Section 7.10 below, each serve for terms of four (4) years, which terms shall be non-renewable (subject, however, to the proviso that individuals having previously served as Secretary and Treasurer respectively, shall be subject to returning to office as more fully described in Section 7.10, below, in the event of a vacancy in such office created by an immediate successor). The terms of the Secretary and Treasurer shall be staggered so that such terms alternatively expire every two (2) years. The President-Elect, the Vice-President, the Secretary-Elect and the Treasurer-Elect shall each automatically succeed to the office of President, President-Elect, Secretary or Treasurer, as the case may be, upon the expiration of the term of the individual then serving in such office. Only Active Fellows who are then serving or who have previously served as at-large directors shall be eligible to be nominated as Vice-President, Treasurer-Elect or Secretary-Elect.

Section 7.2 Election Procedure. At least sixty (60) days before each annual meeting of the Society, the Nominating Committee shall prepare, and submit for review to the Board of Directors, a list consisting of one individual recommended for each of the following offices: Vice-President, two (2) at-large directors and one (1) member of the Fellowship Committee. In the year immediately preceding any year in which the term of office of the Secretary or the Treasurer is to expire, the Nominating Committee shall also select one individual that it recommends for nomination to the office of Secretary-Elect or Treasurer-Elect, as the case may be. Should the Board of Directors have concerns about any individual on the proposed slate, those shall be conveyed to the Nominating Committee within twenty (20) days of receipt of the list. The Nominating Committee shall present a final slate of candidates to the SRS membership after investigation and review of any concerns. Candidates for the positions to which they were nominated shall be elected upon receiving a majority of the votes cast by Active Fellows at such annual meeting. The term of office for those individuals elected to a position at an annual meeting shall commence as of the close of such meeting.

Section 7.3 President. The President shall be the principal executive officer of the Society and shall, subject to the direction and control of the Board of Directors, supervise and be in charge of all the business affairs of the Society. The President shall preside at all general meetings of the Society and of the Board of Directors. The President may sign, with the Secretary or any other proper officer of the corporation authorized by the Board of Directors, any deeds, mortgages, bonds, contracts or other instruments which the Board of Directors has authorized to be executed, except in cases where the signing and execution thereof shall be expressly delegated to the Board of Directors or by these Bylaws with the approval of the Board of Directors and shall be Ex-Officio member of all Committees except the Fellowship and Nominating Committees. The President may fill any vacancies between annual meetings subject to the approval of the Board of Directors unless such vacancies are to be filled as otherwise specified. The President is authorized to act in the event of any contingency or emergency not covered by the Bylaws. The President shall, in general, perform all duties incident to the office of President and such other duties as may be prescribed by the Board of Directors from time to time. The President shall preside at all meetings of the Board of Directors and shall, except as otherwise provided under applicable law or these Bylaws, be responsible for scheduling all meetings of the Board of Directors and to determine the order of business to be conducted at meetings of the Board of Directors. The President shall serve for one (1) year term of office, except in circumstances outlined in Section 7.10.

Section 7.4 President-Elect. The President-Elect shall assume the duties of the President in the absence of the President or in the event of his/her death, inability or refusal to act and when so acting shall have the powers of and be subject to all the restrictions upon the President. The President-Elect shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. In addition, the President-Elect shall, as the President-Elect of the Society, carry out such duties in such capacity as the President or the Board of Directors may from time to time determine. The President-Elect shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The President-Elect shall automatically succeed to the office of President at the close of the annual meeting at which the current President's term expires, or as otherwise provided in Section 7.10.

Section 7.5 Vice-President. The Vice President shall assume the duties of the President-Elect in the absence of the President-Elect and in the event of his or her death or inability or refusal to act, and when so acting, shall have all the powers of and be subject to all of the restrictions upon the President-Elect. The Vice President shall also assume the duties of President in the absence of both the President and the President-Elect and in the event of death or inability or refusal to act of both of them, and when so acting the Vice President shall have all of the powers of and be subject to all of the restrictions upon the President. The Vice President shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. The Vice President shall be ex-officio member of all committees except the Fellowship and Nominating Committees. The Vice President shall automatically succeed to the office of President-Elect at the close of the annual meeting at which the current President-Elect's term expires, or as otherwise provided in Section 7.10 below.

Section 7.6 Secretary. The Secretary or its designee shall record the minutes of the meetings of the Society and of the Board of Directors and the Executive Committee; undertake to ensure that all notices of meetings are duly given in accordance with the provisions of these Bylaws or as required by applicable law; be custodian of the corporate records of the Society; and perform all duties incident to the office of Secretary. The Secretary shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The Secretary shall maintain a register of the post office address and electronic mail address of each Fellow of any class, which information shall be furnished to the Secretary by such Fellows. The Secretary shall maintain the correspondence of the Society and a record of the names of the Fellows, guests and visitors in attendance at any meeting of the Society.

Section 7.7 Secretary-Elect. The Secretary-Elect shall assume the duties of the Secretary in the absence of the Secretary or in the event of his or her death, inability or refusal to act. The Secretary-Elect shall perform the duties of the Secretary and when so acting shall have the power of and be subject to all the restrictions upon the Secretary. The Secretary-Elect shall automatically succeed to the office of Secretary at the close of the annual meeting at which the then-current Secretary's term of office expires, or as otherwise provided in Section 7.10 below. The Secretary-Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.8 Treasurer. The Treasurer shall be in charge and have custody of and be responsible for any and all funds, securities and other valuable assets of the Society and other assets of the Society and shall, at the request of the Board of Directors or as otherwise required by applicable law, post a bond at the expense of the Society for the faithful discharge of his or her duties in such sum and with such surety or sureties as the Board of Directors shall determine. The Treasurer shall oversee accurate accounts of the receipts and disbursements of the Board of Directors in books belonging to it. He or she shall ensure that all monies and other valuable effects are deposited in the name and to the credit of the Board of Directors in such accounts and in such depositories as may be designated by the Board of Directors. He or she shall check monthly the disbursements of funds of the Board of Directors in accordance with authority of the Board of Directors. The Treasurer shall render to the President and the Board of Directors whenever requested or otherwise required, a written detailed account of the transactions and of the financial condition of the Society, including a statement of all its assets, liabilities, and financial transactions. He or she shall perform such other duties as the Board of Directors, through the President, direct, and such other duties as usually pertain to the office of Treasurer. The Treasurer shall be relieved of all responsibility for any securities or monies or the disbursement thereof committed by the Board of Directors to the custody of any other person or the Society, or the supervision of which is delegated by the Board of Directors to any other officer, agent or employee, or for the performance of any other duties of the Treasurer delegated by the Board of Directors to any other officer, agent or employee, and he or she shall not be responsible for any actions of any other officer, agent or employee of the Board of Directors. The Treasurer shall be an Ex-Officio member of all committees except the Membership and Nominating Committees.

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Section 7.9 Treasurer-Elect. The Treasurer-Elect shall assume the duties of the Treasurer in the absence of the Treasurer or in the event of his or her death, inability or refusal to act and when so acting shall have the power of and be subject to all restrictions upon the Treasurer. The Treasurer-Elect shall automatically succeed to the office of Treasurer at the close of the annual meeting at which the then-current Treasurer's term of office expires or as otherwise provided in Section 7.10 below. The Treasurer-Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.10 Vacancies. In the event of the President's death, resignation or removal while in office, the President-Elect shall succeed to the office of President for the remainder of such term and shall continue to serve as President for the immediately succeeding one-year term. In such event, the Vice President shall succeed to the office of President-Elect serving the remainder of such term and shall continue as President-Elect for the immediately succeeding one year term.

In the event of the President-Elect's death, resignation or removal while in office, the Vice President shall succeed to the office of President-Elect for the remainder of such term and shall continue to serve in such office for the immediately succeeding one-year term. The current President shall finish his/her term and will be asked to serve the term originally designated for the President-Elect.

In the event that the Vice President ceases to serve in such office for any reason during his or her term, including, without limitation, by reason of death, resignation or succession to fill a vacancy of the President-Elect as described above, the Board of Directors may (taking into account any recommendations of the Nominating Committee as described in section 9.6 below) appoint a new Vice President to serve the remainder of that term who then becomes President-Elect at the Annual Meeting. In the event the Board of Directors does not appoint a qualified individual to replace the Vice President, a new Vice President shall be elected at the next annual meeting at which officers are elected in accordance with the procedures applicable to the election of officers generally.

In the event of the Secretary's death, resignation or removal while in office with less than six(6) months remaining before the expiration of the term, the immediate past Secretary will be asked to serve the balance of that term and one more additional year. The Secretary-Elect shall then succeed to the office of Secretary for the term for which he or she was originally slated. If the remaining term is greater than six months, then the Secretary-Elect will succeed to become Secretary as originally intended, and the additional year of service by the past Secretary will not be necessary.

In the event of the Secretary-Elect's death, resignation or removal while in office, the Board of Directors shall fill such vacancy as soon as practicable for the unexpired portion of that term and potentially one more year. The Secretary-Elect then becomes Secretary.

In the event of the Treasurer's death, resignation or removal while in office, the immediate past Treasurer will be asked to serve the balance of that term and then one additional year, if the remaining term is less than six months. If the remaining term is greater than six months, the one additional year will not be necessary. The Treasurer-Elect then succeeds to the office of Treasurer considering the above. Following succession of the Treasurer-Elect to the Treasurer, a new Treasurer-Elect is appointed by the Board of Directors as soon as practicable for the same time period.

In the event of the Treasurer-Elect's death, resignation or removal while in office, The Board of Directors will appoint a new Treasurer-Elect for the balance of that term and potentially one more year. This Treasurer-Elect will then become the Treasurer.

In the event of an At-Large Director's death, resignation or removal while in office, The Board of Directors will appoint a new Director in the appropriate category for the balance of that term.

Section 7.11 Resignation/Removal. Any officer may resign from such office at any time by giving written notice to the Secretary of the Society. Any officer may be removed from such office with or without cause by the affirmative vote of at least two-thirds (2/3) vote of the Active Fellows present at a meeting thereof.

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ARTICLE VIII

COUNCILS

The Society shall establish and maintain four (4) Councils, namely, the Education Council, the Research Council, the Governance Council and the Finance Council, which Councils shall oversee the functions and operations of those committees placed under their respective jurisdiction from time to time by the President with the approval of the Board of Directors. Councils shall function in the same manner and be subject to the same procedures and restrictions as committees of the Society and as may be otherwise determined by the Board of Directors from time to time. The membership of each such Council shall be comprised of the chairpersons of the committees under the jurisdiction of such Council and the President, with the approval of the Board of Directors, shall appoint a chairperson for each such Council from among such Members. The Board of Directors may, at any time, by resolution, create, combine, consolidate and/or terminate any Council and change the composition, terms of membership and any other attribute or aspect of any Council as it deems appropriate in its discretion.

ARTICLE IX

COMMITTEES

Section 9.1 Classification and Organization. There shall be established and maintained the following Standing Committees of the Society:

- (a) Education Committee;
- (b) Fellowship Committee;
- (c) Program Committee;
- (d) Bylaws and Policies Committee; and
- (e) Nominating Committee.

The President, with the approval of the Board of Directors, may from time to time designate other committees (including standing committees in addition to those described above, ad hoc committees and committees existing and operating under any Council), subcommittees, working groups and task forces. All Standing Committees and other committees, subcommittees, working groups and task forces (collectively referred to for purposes of this Article IX as "Committees") shall have the powers and duties as hereinafter set forth and/or other powers and duties delegated or assigned by the President, with the approval of the Board of Directors and shall make regular reports to President and the Board of Directors. All Committee chairpersons shall be appointed by the President, with the approval of the Board of Directors, except as otherwise provided in these Bylaws. Except for the Nominating Committee and the Fellowship Committee and as otherwise provided in these Bylaws, the President, with the approval of the Board of Directors, may determine the number of members to serve on each Committee and the eligibility requirements for same. Members of any such Committee shall be appointed by the President for such terms and on such terms as the President may determine from time to time, with the approval of the Board of Directors. The President, with the approval of the Board of Directors, shall establish such procedures for each Committee as he or she may determine in his or her discretion, with the approval of the Board of Directors. The Board of Directors may, at any time, by resolution, create, combine, consolidate or terminate any Committee (other than a Standing Committee described in subs. (a) through (e), above) as it deems appropriate in its discretion.

Section 9.2 Education Committee. The Education Committee shall be primarily responsible for the education of, dissemination of new information to, and public relations to promote a better understanding of Scoliosis and related spinal deformities including but not limited to availability of treatments and early symptoms of Scoliosis and related spinal deformities.

Section 9.3 Fellowship Committee. The Fellowship Committee shall be responsible for verifying the professional credentials and qualifications of the applicant for Fellowship in any class. All completed applications, except those for Honorary Fellowship, shall be forwarded by the Secretary of the Society to the Fellowship Committee. The Fellowship Committee shall conduct such investigation, personal interviews, or inquiries it deems necessary in order to determine the qualifications of an applicant for Fellowship in any class.

Section 9.4 Program Committee. The Program Committee shall be responsible for the initiation, organization, implementation and conduct of the annual meeting of the Society. The Program Committee shall be responsible to review all papers, exhibits and audiovisual materials to be used in connection with any program or event held in connection with any annual meeting of the Society, subject to such procedures as the Program Committee and the Board of Directors may establish from time to time.

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Section 9.5 Bylaws and Policies Committee. The Bylaws and Policies Committee shall be responsible for considering matters relating to the content of the Articles of Incorporation, the Bylaws and the policies and procedures of the Society, including amendments thereto, and to advise and make recommendations to the Board of Directors with respect to same.

Section 9.6 Nominating Committee. The Nominating Committee shall consist of five (5) Active Fellows, the Chairman of which shall be appointed by the President with the approval of the Board of Directors. The four (4) additional members shall be Active Members elected at each annual meeting of the Society by a majority of the Active Members present at such meeting. The term of each member of the Nominating Committee shall be one year, no Fellow may serve two (2) consecutive terms on the Nominating Committee. The Nominating Committee shall present to the Board of Directors a list of nominees as described in Section 7.2 and otherwise provide recommendations to the Board of Directors with respect to the filling of vacancies in any office or on the Board of Directors.

ARTICLE X COMPENSATION

No director, officer, Council or Committee member or any other private individual shall receive at any time any of the net earnings or pecuniary profit from the operations of the Society; provided that this provision shall not prevent the payment to any such person of such reasonable compensation for services rendered to or for the Society in effecting any of its purposes. No such person or persons shall be entitled to share in the distribution of any of the corporate assets upon the dissolution of the Society. Notwithstanding the foregoing, no director, officer or Council or Committee member shall receive compensation from the Society for serving in such capacity; provided, however, the Society may reimburse expenses of such persons in attending meetings and conducting other activities on behalf of the Society. Upon such dissolution or winding up of the affairs of the Society, whether voluntary or involuntary, the assets of the Society, remaining in the hands of the Board of Directors after all debts have been satisfied shall be distributed, transferred, conveyed, delivered, and paid over exclusively to charitable and/or educational organizations which would then qualify under the provisions of Section 501(c)(3) of the Internal Revenue Code and its Regulations as they now exist or as they may hereafter be amended.

ARTICLE XI AMENDMENTS

Amendments to these Bylaws or to the Articles of Incorporation of the Bylaws may be proposed by the Executive Committee, the Board of Directors on its own motion or the written petition of at least four (4) Active Fellows. Any such proposal must be submitted to the Secretary of the Corporation not less than ninety (90) days before an annual meeting of the Society in order to be eligible for consideration of approval at such annual meeting. Such proposed amendment, once submitted to the Secretary, shall be submitted to the Bylaws and Policies Committee for review and consideration, which Committee shall then make a recommendation with respect to same to the Board of Directors. The Board of Directors shall then make a determination regarding whether to submit such proposed amendment to a vote of the Active Fellows. Any proposed amendment submitted to the Secretary for consideration at least ninety (90) days before an annual meeting of the Active Fellows of the Society which the Board of Directors has determined to be submitted to a vote of the Active fellows as described above shall be submitted to the Active Fellows at least 30 days prior to the Annual Meeting at which they will be voted on.

Any such proposed amendment submitted to the Secretary less than ninety (90) days before such annual meeting which the Board of Directors has determined to be submitted to a vote of the Active Fellows shall be eligible to be considered for approval by the Active Fellows at the next subsequent annual meeting or at the discretion of the Board of Directors at a special meeting of the Active Fellows of the Society. The Secretary shall include a copy of the proposed amendment with the notice of the meeting at which such proposed amendment is to be considered for approval, together with a statement that the Board of Directors recommends such amendment for adoption. Any amendment to these Bylaws or the Articles of Incorporation of the Society shall require approval of the Active Fellows by at least a two-thirds (2/3) majority of the Active Fellows present in person at a duly held meeting at which a quorum is present.

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ARTICLE XII

DUES

Section 12.1 Annual Dues. Annual Dues, in amounts to be determined by the Board of Directors, shall be paid by Candidate Fellows, Active Fellows and Associate Fellows in accordance with such procedures as the Board of Directors may from time to time establish.

Section 12.2 Exemption from Dues. The Board of Directors may, in its discretion, exempt a Fellow of any class from dues for good cause in any particular instance.

ARTICLE XIII

RULES OF ORDER

Except to the extent otherwise provided in these Bylaws, all meetings of the Society, the Board of Directors, the Councils or any Committee (as that term is defined in Section 9.1, above) shall, as and when determined by the presiding officer of such body, be governed by the parliamentary rules and usages set forth in the most current edition of Robert's Rules of Order.

ARTICLE XIV

DISSOLUTION

The Board of Directors shall, after paying or making provisions for the payment of the Society's liabilities, if any, distribute the Society's net assets, to such Society(s), association(s), fund(s), and/or foundation(s) engaged in activities substantially similar to those of the Society as are designated by the Executive Committee and in such proportions as are determined thereby, subject to any order of court as provided by law, for charitable, educational or scientific purposes within the meaning of section 501(c)(3) of the Code. Notwithstanding any of the foregoing provisions of this Article, the distribution of any assets of the Society in liquidation shall be made in accordance with Illinois Revised Statutes.

ARTICLE XV

CONTRACTS, CHECKS, DEPOSITS AND GIFTS

Section 15.1 Contracts. The Board of Directors may authorize any officers, agent or agents of the Society, in addition to the officers so authorized by these Bylaws, to enter into any contract or execute and deliver any instrument in the name of and on behalf of the Society and such authority may be general or confined to specific instances.

Section 15.2 Checks, Drafts, Etc. All checks, drafts, or other orders for the payment of money notes or other evidence of indebtedness issued to the name of the Society, shall be signed by such officer or officers, agent or agents of the Society and in such manner as shall be determined by action of the Board of Directors.

Section 15.3 Deposits. All funds of the Society shall be deposited to the credit of the Society in banks, trust companies, or other depositories as the Board of Directors may select.

Section 15.4 Gifts. The Board of Directors may accept on behalf of the Society any contribution, gift, bequest or device for the general purposes or for any special purpose of the Society.

ARTICLE XVI

BOOKS AND RECORDS

The Society shall keep and maintain correct and complete books and records of account and shall also keep minutes of the proceedings of any meeting of the Active Members (including any business session), the Board of Directors and any Council or Committees, and shall keep and maintain at the principal office of the Society a record of the names and addresses of Fellows of any class.

ARTICLE XVII

FISCAL YEAR

The fiscal year of the Society shall be as determined by the Board of Directors from time to time.

SRS Bylaws

ARTICLE XVIII

SEAL

The Society shall have no seal.

ARTICLE XIX

INDEMNIFICATION

The Society shall, to the fullest extent provided by applicable law, indemnify every director, officer or Committee (as that term is defined in Section 9.1, above) or Council chair or member, and his or her heirs, executors and administrators who was or is a party or is threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative (other than an action by or in the right of the Society) by reason of the fact that he or she is or was a director, officer, employee or agent of the Society, or is or was serving at the request of the Society, partnership, joint venture, trust or other enterprise against expenses (including attorney's fees), judgements, fines and amounts paid in settlement actually and reasonably incurred by him or her in connection with such action, suit or proceeding if he or she acted in good faith and in a manner he or she reasonably believed to be in or not opposed to the best interests of the Society, and, with respect to any criminal action or proceeding, had no reasonable cause to believe his or her conduct was unlawful. The termination of any action, suit or proceeding by judgement, order, settlement conviction, or upon a plea of nolo contendere or its equivalent, shall not of itself, create a presumption that the person did not act in good faith and in a manner which he/she reasonably believed to be in or not opposed to the best interests of the Society, and with respect to any criminal action or proceeding, had no reasonable cause to believe that his or her conduct was unlawful.

ARTICLE XX

MISCELLANEOUS

Section 20.1 Trademarks. No member may use the Society's name or trademarks for personal, commercial purposes or funding purposes without prior approval of the Board of Directors.

Section 20.2 Interpretation. In interpreting these Bylaws, whenever the context so requires, (a) the singular shall include the plural and the plural shall include the singular, and (b) any gender shall include all genders.

Section 20.3 Definition of "Code." All references in these Bylaws to sections of the "Code" shall be considered references to the Internal Revenue Code of 1986, as from time to time amended, and to the corresponding provisions subsequently enacted.

Section 20.4 Headings. The headings in these Bylaws are intended for convenience only and should not affect the meaning or interpretation hereof.

Section 20.5 Executive Director. An Executive Director may be employed directly or by contract by the Board of Directors. The Executive Director shall have general charge of the day-to-day operations and management of the Society. The Executive Director may sign in the name of or on behalf of the Society any contract or agreement authorized by the Board of Directors and shall do and perform such additional duties as may be assigned by the Board of Directors and/or otherwise expressed in a management agreement.

Approved September 6, 2007, Amended September 11, 2008



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SRS Membership Directory

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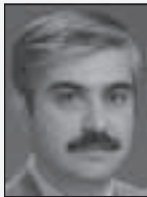
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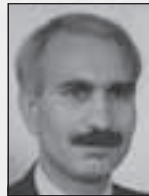
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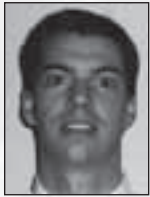
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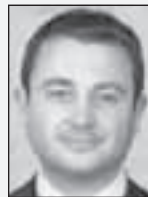
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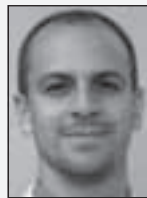
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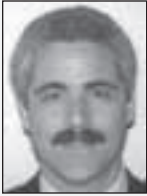
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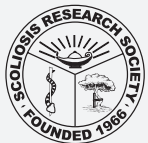
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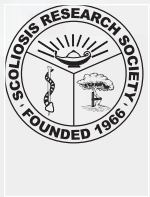
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AYDINLI, Ufuk, Bursa (ACTI)
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OZTURK, Cagatay Istanbul (CAND)
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BRAUN, John T., Burlington (ACTI)
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GOOD, Christopher R., Reston (CAND)
GRUBB, Stephen A., Christiansburg (ACTI)
HEINIG, Charles F., Ware Neck (EMER)
KOSTUIK, John P., Leesburg (ACTI)
NOGI, Jay, Glen Allen (EMER)
SHAFFREY, Christopher I., Charlottesville (ACTI)
SHEN, Francis H., Charlottesville (CAND)
SHIRLEY, Eric D., Portsmouth (CAND)
SMITH, Justin S., Charlottesville (CAND)
STIKLEATHER, Luke, Fairfax (ASSO)
SURATWALA, Sanjeev, Richmond (CAND)

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GUSTAFSON, Robert K., Olympia (EMER)
HANSCOM, David A., Seattle (CAND)
HURLEY, John H., Spokane (EMER)
KNIGHT, Reginald Quentin, Kirkland (ACTI)
KRENGEL, Walter F., Seattle (ACTI)
LAURNEN, Edwin L., Bellevue (EMER)
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In Memoriam

Date of Death

Antoniou, Dmitri	2007	Luque, Eduardo R.	2002
Arendar, Gregorio M.	2003	MacKinnon, W. B.	1978
Ashley, R. Kirklin.	1996	Makin, Mayer, FRCS.	2005
• Bianco, Jr., Anthony J.	2004	Manning, Charles	1982
• Bickel, William H.	1982	Martinez, Johnny H.	1990
• Blount, Walter P.	1992	May, Virgil R	2000
Bobechko, Walter P.	2007	• McKelvie, Allan M.	1994
Boyd, Basil M., Jr.	1995	• Moe, John H.	1988
Brown, Richard H.	2005	Murray, Horton L.	1993
Brussatis, Friedrich.	1990	Nachemson, Alf L.	2006
Cakirgil, Gungor S.	1990	Nadel, Charles I	2000
Cobb, John R.	1967	Nicastro, Joseph F.	2006
Cockrell, B Randolph.	1998	Nickel, Vernon L.	1993
Curtis, Burr H.	2001	• Noall, Lawrence	2001
Dawson, Edgar G.	2003	Olsen, Gerner	1984
Daymond, Keith	2000	Pickett, Justus C	1990
De Valderrama, Jose AF.	2006	Pinto, Waldemar Carvalho	2000
Dholakia, T.K.	2008	• Riseborough, Edward J.	1985
Doherty, John H.	1999	Risser, Joseph C.	1982
Domnisse, George F.	2001	Roaf, Robert	2007
Donaldson, William F.	2006	Rogala, Eugene J.	1982
Du Toit, Guillaume	2006	Sacks, Sidney	2002
Dwyer, Allen F.	1975	Savini, Romalo	1991
Eldridge, John C.	2004	• Schmidt, Albert C.	1982
Ferguson, Albert B., Sr.	1976	Scudese, Vincent A.	1992
Flawn, Laura B	2001	Shelokov, Alexis P.	2009
Fontanetta, Michael	1979	Simmons, Edward H.	2009
Garceau, George J.	1977	Snellman, Olai.	2004
Giannestras, Nicholas J.	1978	Stagnara, Pierre	1997
Gillespie, Robert	2001	Stauffer, E Shannon	2002
Godfrey, Joseph D.	1997	Stelling, Frank H. III	2003
Goldstein, Louis A.	1992	Stewart, Steele F.	1978
Graham, Jacob J.	2000	Swanson, Andrew Nicholas	2009
• Harrington, Paul R.	1980	Tatko, Robert W.	1993
• Herndon, Charles H.	1997	Teuffer, Aurelio P.	1989
Hillman, J. William	1970	Travaglini, Fiorenzo H.	2004
• Hollenberg, Charles	1996	Veliskakis, Kostas P., MD	2005
Hopkins, Richard J.	1989	Vesely, David G.	1988
Inoue, Shun-Ichl	1987	VonLackum, William H.	1969
Isaacson, Alvin	1997	Welply, W. R.	1970
Jacobs, Rae R.	1988	Whitecloud, Thomas S. III.	2003
James, J.I.P.	2001	Wilber, R. Geoffrey.	1996
• Keiser, Robert P.	1984	Willner, Stig V.	1999
Kendig, Ronald J.	2005	Wright, Alexander M.	2006
Kennedy, John C.	1983	Wu, Zhikang	1998
Kilfoyle, Richard M	2000	Yamada, Kengo.	1990
Klasic, Predrag J.	1996	Zorab, Philip A.	1983
Kruger, Leon M.	2007		
Labelle, Pierre	1994		
Lambert, Claude N.	1984		
LaRocca, S. Henry.	1973		
• Larsen, Loren J.	2002		
Laughlin Jr, Thomas T.	1996		
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Scoliosis Research Society

44th Annual Meeting & Course

September 23 - 26, 2009
Marriott Rivercenter Hotel
San Antonio, Texas, USA

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Dear Dr. Polly:

Please change the listing of my name and address to read as follows:

Full Name: _____

Office Address: _____

City: _____ State: _____ Zip: _____

Country: _____

Telephone: _____ Fax: _____

E-mail: _____

Spouse's Name: _____



Scoliosis Research Society

FUTURE EDUCATIONAL EVENTS

Save *the* Dates.....



17TH IMAST
July 21-24, **2010**
TORONTO, CANADA

45th Annual Meeting & Course
September, 22-25, **2010**
KYOTO, JAPAN



WORLDWIDE CONFERENCES



CAIRO, EGYPT December 14-15, **2009**

in conjunction with the
Egyptian Orthopedic Association Annual Congress

Meeting At A Glance

Monday, September 21, 2009

7:00 am – 5:00 pm	Board of Directors Meeting	Conference Rooms 17-18
12:00 – 1:00 pm	Board of Directors Lunch	Conference Room 16

Tuesday, September 22, 2009

7:00 am – 5:00 pm	SRS Committee Meetings	Conference Rooms 5, 6, 7, 10, 11
2:00 – 6:00 pm	Poster Set-Up by Authors	Salons A-C Foyers
2:00 – 6:00 pm	Registration Open	Registration Desk 1 & Foyer

Wednesday, September 23, 2009

6:30 am – 5:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
7:55 am – 12:00 pm	Pre-Meeting Course: Critical Concepts in Adult Deformity Surgery	Salons A-F
7:55 am – 5:05 pm	Pre-Meeting Course: Complications in Spinal Deformity Surgery	Salon I
12:20 – 1:00 pm	Lunchtime Symposium: Growing Spine	Salons A-F
12:20 – 1:00 pm	Lunchtime Symposium: Non-Operative Management	Salon I
6:30 – 7:30 pm	Opening Ceremonies	Salons A-F
7:30 – 9:00 pm	Welcome Reception	Salons D-E Foyer

Thursday, September 24, 2009

6:30 am – 4:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 12:18 pm	Scientific Program	Salons A-F
12:30 – 5:30 pm	Edgar Dawson Memorial Golf Tournament	Meet in Lobby at 12:20 pm
1:00 – 4:00 pm	Instructional Course Lecture: Coding	Salons A-F
1:00 – 4:00 pm	Instructional Course Lecture: Worldwide Conferences	Salon I-J
1:00 – 4:30 pm	Activity: Biking the Mission Trail	Meet in Lobby at 12:50 pm
1:00 – 5:00 pm	Tour: Highlights of San Antonio	Meet in Lobby at 12:50 pm

Friday, September 25, 2009

6:30 am – 5:15 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 5:15 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 5:00 pm	Scientific Program	Salons A-F
12:07 – 1:07 pm	Lunch Break	
12:10 – 1:00 pm	Lunchtime Symposium: Worldwide Conference/Global Outreach	Salons I-J
12:10 – 1:00 pm	Lunchtime Symposium: Evidence Based Outcomes	Salons A-F
1:00 – 5:00 pm	Tour: Cruisin' & Explorin' San Antonio	Meet in Lobby at 12:50 pm
1:00 – 5:00 pm	Tour: Spanish Mission Trail	Meet in Lobby at 12:50 pm
7:00 – 10:00 pm	Farewell Reception	Rio Cibolo Ranch Depart at 6:30 pm from Lobby

Saturday, September 26, 2009

6:30 am – 1:00 pm	Registration Open	Registration Desk 1 & Foyer
6:30 am – 1:00 pm	Internet Café, Poster & E-Poster Exhibits	Salons A-E Foyers
6:30 – 7:40 am	Members Business Meeting & Breakfast	Salons I-J
6:30 – 7:40 am	Non-Members Continental Breakfast	Salons D-E Foyers
6:30 – 9:00 am	Guest Hospitality Suite Open	Conference Room 12
8:00 am – 12:33 pm	Scientific Program	Salons A-F
12:33 pm	Meeting Adjourns	
1:00 pm – 3:30 pm	Board of Directors Meeting	Conference Rooms 17-18



Final Program • 44th Annual Meeting & Course

